

INTRODUCTION

S6A0073 is a dot matrix LCD driver & controller LSI which is fabricated by low power CMOS technology. It can display 1, 2 or 4 lines with 5×8 or 6×8 dots format.

FUNCTIONS

- Character type dot matrix LCD driver & controller
- Internal driver : 34 common and 60 segment signal output
- Easy interface with 4-bit or 8-bit MPU
- Clock synchronized serial Interface
- 5×8 or 6×8 dots matrix possible
- Extension driver interface possible
- Bi-directional shift function
- All character reverse display
- Display shift per line
- Voltage converter for LCD drive voltage : 13V max (2 times/3 times)
- Various instruction functions
- Automatic power on reset

FEATURES

- Internal Memory
 - Character Generator ROM (CGROM) : 9,600 bits (240 characters \times 5×8 dot)
 - Character Generator RAM (CGRAM) : 64×8 bits (8 characters \times 5×8 dot)
 - Segment Icon RAM (SEGRAM) : 16×8 bits (96 icons max.)
 - Display Data RAM (DDRAM) : 80×8 bits (80 characters max.)
- Low power operation
 - Power supply voltage range: 2.7 to 5.5V (V_{DD})
 - LCD Drive voltage range: 3.0 to 13.0V ($V_{DD} - V_5$)
- CMOS process
- Programmable duty cycle : 1/17, 1/33 (refer to Table 1)
- Internal oscillator with an external resistor
- Low power consumption
- TCP or bare chip available

Table 1. Programmable Duty Cycles

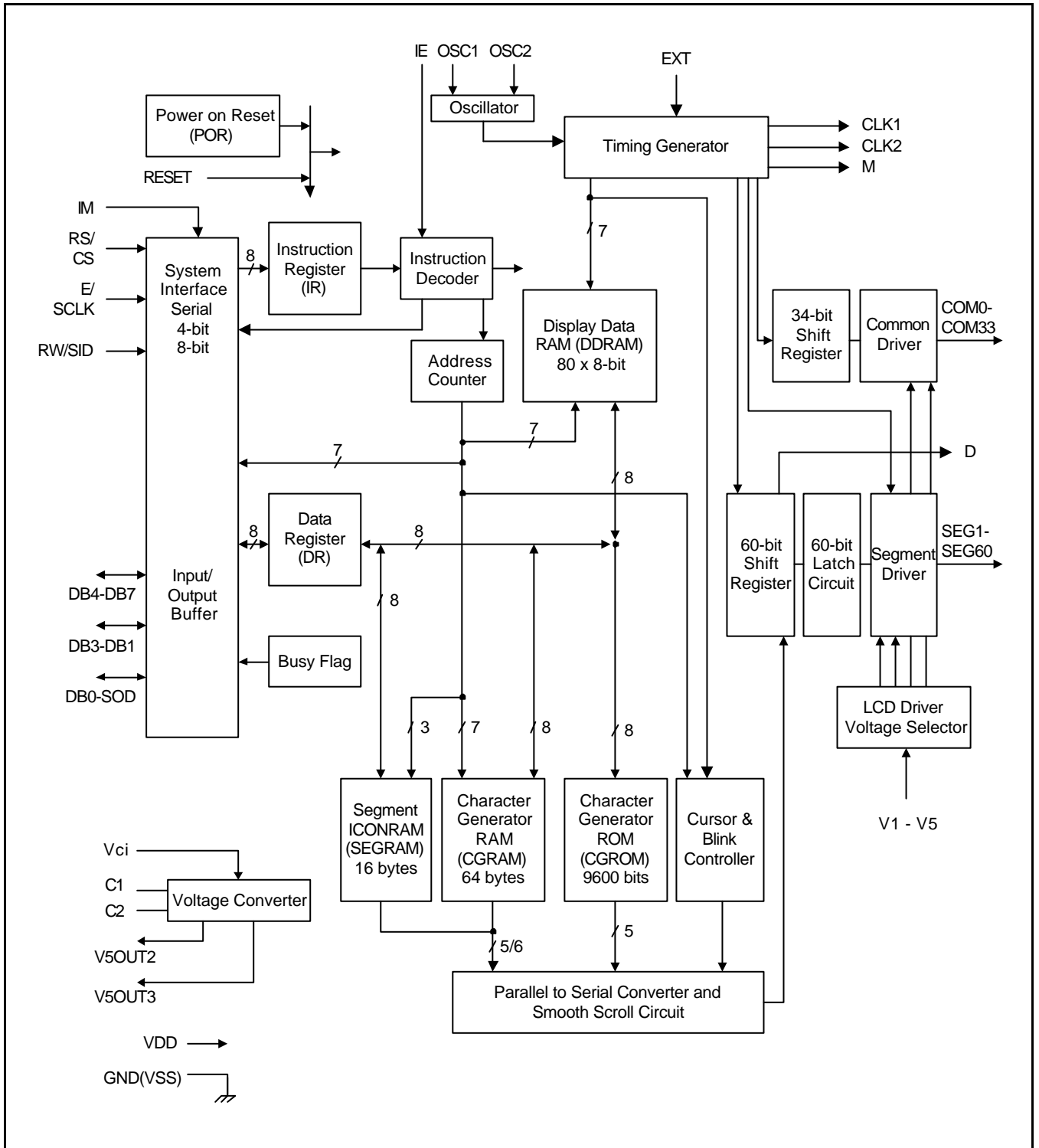
1) 5-dot Font Width

Display Line Numbers	Duty Ratio	Single-chip Operation		With Extension Driver	
		Displayable characters	Possible icons	Displayable characters	Possible icons
1	1/17	1 line of 24 characters	60	1 line of 52 characters	80
2	1/33	2 lines of 24 characters	60	2 lines of 32 characters	80
4	1/33	4 lines of 12 characters	60	4 lines of 20 characters	80

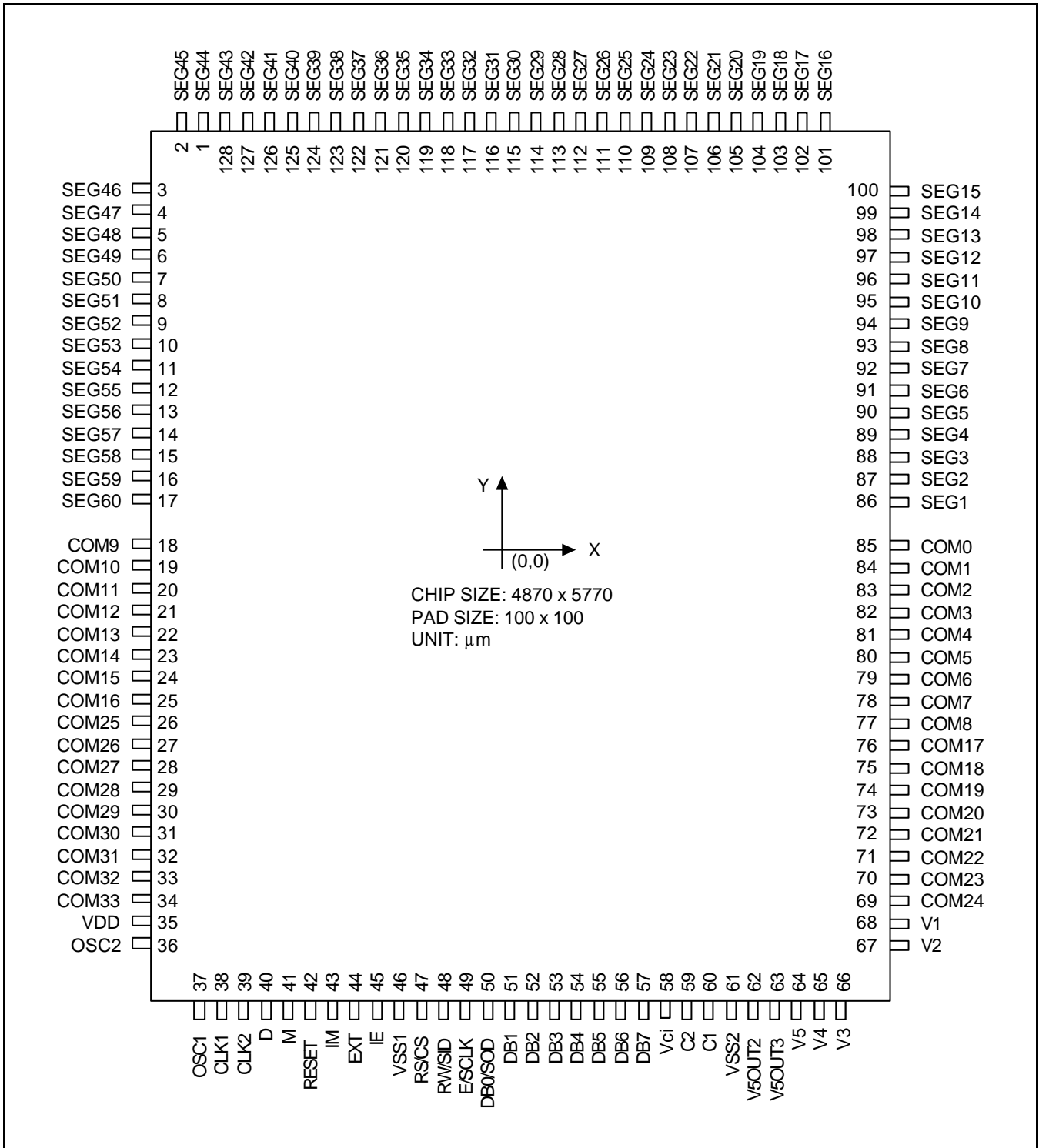
2) 6-dot Font Width

Display Line Numbers	Duty Ratio	Single-chip Operation		With Extension Driver	
		Displayable characters	Possible icons	Displayable characters	Possible icons
1	1/17	1 line of 20 characters	60	1 line of 50 characters	96
2	1/33	2 lines of 20 characters	60	2 lines of 30 characters	96
4	1/33	4 lines of 10 characters	60	4 lines of 20 characters	96

BLOCK DIAGRAM



PAD CONFIGURATION



PAD CENTER COORDINATES

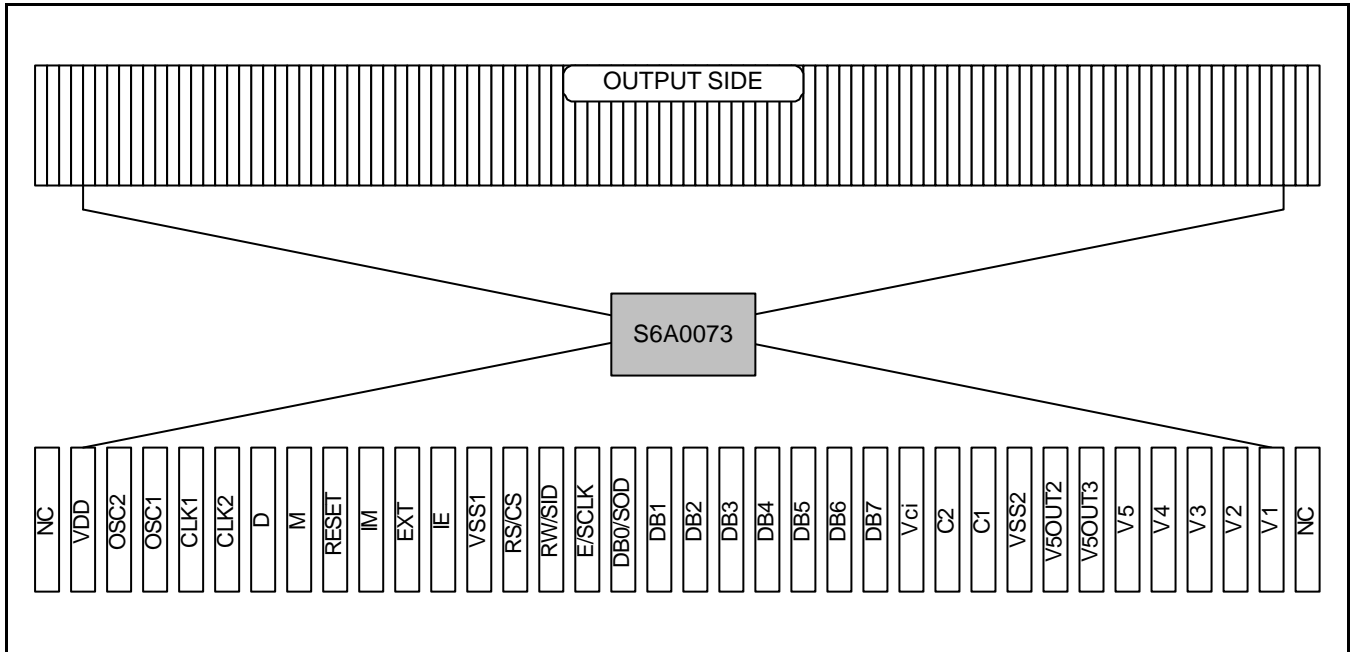
Pad Num.	Pad Name	Coordinate		Pad Num.	Pad Name	Coordinate		Pad Num.	Pad Name	Coordinate	
		X	Y			X	Y			X	Y
1	SEG44	-1687	2719	44	EXT	-986	-2719	87	SEG2	2269	497
2	SEG45	-1812	2719	45	IE	-861	-2719	88	SEG3	2269	622
3	SEG46	-2269	2122	46	VSS1	-736	-2719	89	SEG4	2269	747
4	SEG47	-2269	1997	47	RS/CS	-611	-2719	90	SEG5	2269	872
5	SEG48	-2269	1872	48	RW/SID	-486	-2719	91	SEG6	2269	997
6	SEG49	-2269	1747	49	E/SCLK	-361	-2719	92	SEG7	2269	1122
7	SEG50	-2269	1622	50	DB0/SOD	-236	-2719	93	SEG8	2269	1247
8	SEG51	-2269	1497	51	DB1	-111	-2719	94	SEG9	2269	1372
9	SEG52	-2269	1372	52	DB2	14	-2719	95	SEG10	2269	1497
10	SEG53	-2269	1247	53	DB3	139	-2719	96	SEG11	2269	1622
11	SEG54	-2269	1122	54	DB4	264	-2719	97	SEG12	2269	1747
12	SEG55	-2269	997	55	DB5	389	-2719	98	SEG13	2269	1872
13	SEG56	-2269	872	56	DB6	514	-2719	99	SEG14	2269	1997
14	SEG57	-2269	747	57	DB7	639	-2719	100	SEG15	2269	2122
15	SEG58	-2269	622	58	Vci	764	-2719	101	SEG16	1813	2719
16	SEG59	-2269	497	59	C2	889	-2719	102	SEG17	1688	2719
17	SEG60	-2269	372	60	C1	1014	-2719	103	SEG18	1563	2719
18	COM9	-2269	134	61	VSS2	1139	-2719	104	SEG19	1438	2719
19	COM10	-2269	9	62	V5OUT2	1264	-2719	105	SEG20	1313	2719
20	COM11	-2269	-116	63	V5OUR3	1389	-2719	106	SEG21	1188	2719
21	COM12	-2269	-241	64	V5	1514	-2719	107	SEG22	1063	2719
22	COM13	-2269	-366	65	V4	1639	-2719	108	SEG23	938	2719
23	COM14	-2269	-491	66	V3	1764	-2719	109	SEG24	813	2719
24	COM15	-2269	-616	67	V2	2269	-2116	110	SEG25	688	2719
25	COM16	-2269	-741	68	V1	2269	-1991	111	SEG26	563	2719
26	COM25	-2269	-866	69	COM24	2269	-1866	112	SEG27	438	2719
27	COM26	-2269	-991	70	COM23	2269	-1741	113	SEG28	313	2719
28	COM27	-2269	-1116	71	COM22	2269	-1616	114	SEG29	188	2719
29	COM28	-2269	-1241	72	COM21	2269	-1491	115	SEG30	63	2719
30	COM29	-2269	-1366	73	COM20	2269	-1366	116	SEG31	-62	2719
31	COM30	-2269	-1491	74	COM19	2269	-1241	117	SEG32	-187	2719
32	COM31	-2269	-1616	75	COM18	2269	-1116	118	SEG33	-312	2719

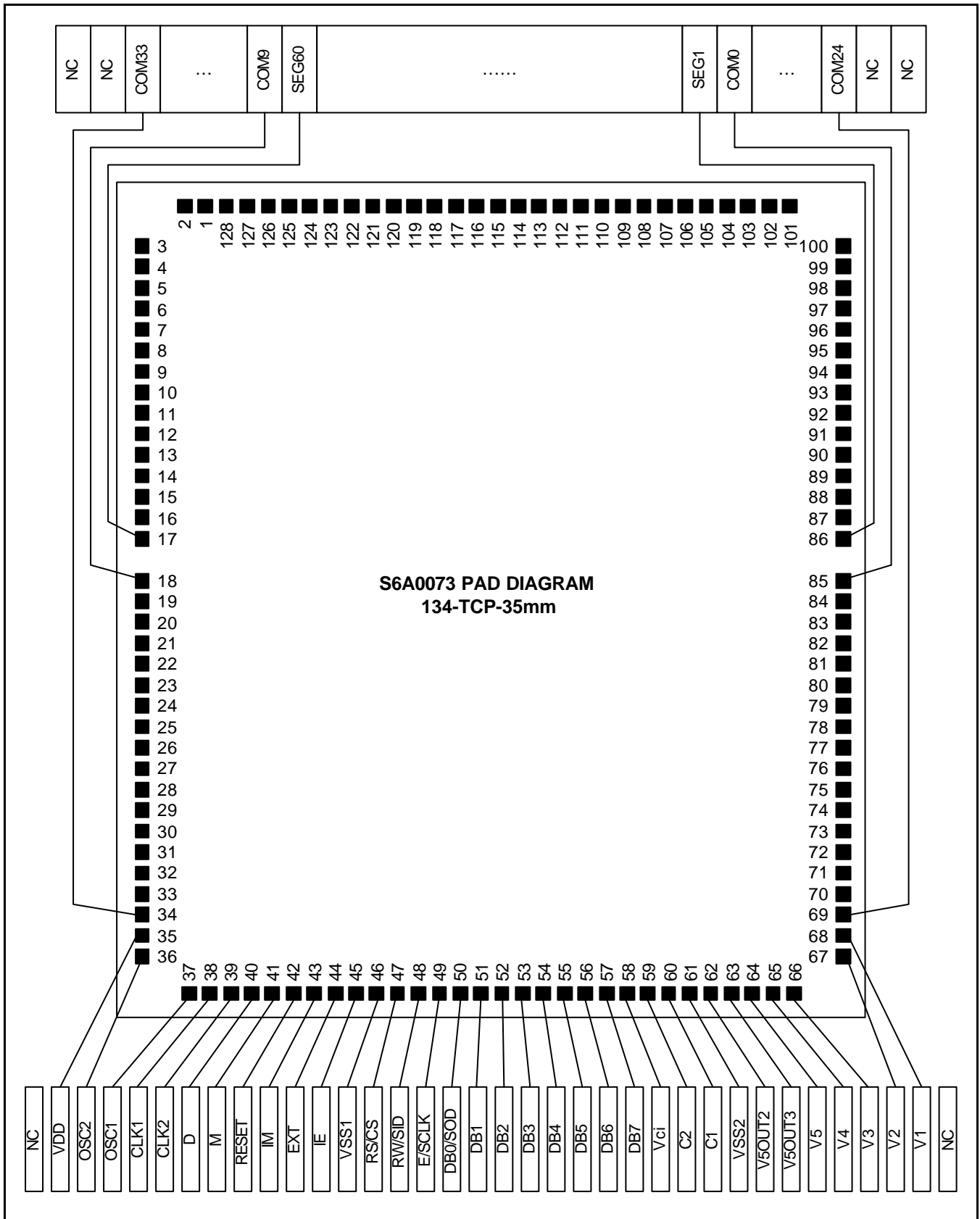
PAD CENTER COORDINATES (Continued)

Pad	Pad	Coordinate		Pad	Pad	Coordinate		Pad	Pad	Coordinate	
Num.	Name	X	Y	Num.	Name	X	Y	Num.	Name	X	Y
33	COM32	-2269	-1741	76	COM17	2269	-991	119	SEG34	-437	2719
34	COM33	-2269	-1866	77	COM8	2269	-866	120	SEG35	-562	2719
35	VDD	-2269	-1991	78	COM7	2269	-741	121	SEG36	-687	2719
36	OSC2	-2269	-2116	79	COM6	2269	-616	122	SEG37	-812	2719
37	OSC1	-1861	-2719	80	COM5	2269	-491	123	SEG38	-937	2719
38	CLK1	-1736	-2719	81	COM4	2269	-366	124	SEG39	-1062	2719
39	CLK2	-1611	-2719	82	COM3	2269	-241	125	SEG40	-1187	2719
40	D	-1486	-2719	83	COM2	2269	-116	126	SEG41	-1312	2719
41	M	-1361	-2719	84	COM1	2269	9	127	SEG42	-1437	2719
42	RESET	-1236	-2719	85	COM0	2269	134	128	SEG43	-1562	2719
43	IM	-1111	-2719	86	SEG1	2269	372				

PIN CONFIGURATION OF TCP

TCP OUTLINE





PIN DESCRIPTION

Pin (No)	I/O	Name	Description	Interface
V _{DD} (35)	-	Power supply	for logical circuit (+3V, +5V)	Power Supply
VSS1, VSS2 (46, 61)			0V (GND)	
V1-V5 (68 - 64)			Bias voltage level for LCD driving	
V _{ci} (58)	I		Input voltage to the voltage converter to generate LCD drive voltage (V _{ci} = 1.0 to 4.5V).	
SEG1 - SEG60 (86 -128, 1- 17)	O	Segment output	Segment signal output for LCD drive.	LCD
COM0 - COM33 (85 - 69, 18 - 34)	O	Common output	Common signal output for LCD drive	LCD
OSC1, OSC2 (37, 36)	I(OSC1), O(OSC2)	Oscillator	When using internal oscillator, connect external R _f resistor. If external clock is used, connect it to OSC1.	External resistor/oscillator (OSC1)
CLK1, CLK2 (38, 39)	O	Latch (CLK1)/ Shift (CLK2) clock	When EXT = "High", each outputs latch clock and shift clock for extension driver.	Extension driver
C1, C2 (60, 59)	I	External capacitance input	To use the voltage converter (2 times /3 times), these pins must be connected to the external capacitance.	External capacitance
M (41)	O	Alternated signal for LCD driver output	When EXT = "High", outputs the alternating signal to convert LCD driver waveform to AC for Extension driver.	Extension driver
D(40)	O	Display data interface	When EXT = "High", outputs extension driver data (the 61th dot's data)	Extension driver
EXT(44)	I	Extension driver control signal	When EXT = "High", makes extension driver control signal enable, When EXT = "Low", suppress extra current consumption and CLK1,CLK2,M,D should be open.	-
RESET (42)	I	Reset pin	Initialized to Low	-
IE (45)	I	Selection pin of instruction set.	When IE = "High", instruction set is selected as Table 6. When IE = "Low", instruction set is selected as Table 10.	-

PIN DESCRIPTION (continued)

Pin(No)	I/O	Name	Description	Interface
V5OUT2 (62)	O	Two times converter output	The value of Vci is converted two times. To use three times converter, the same capacitance as that of C1-C2 should be connected here.	V5/ capacitance
V5OUT3 (63)		Three times converter output	The value of Vci is converted three times.	V5
IM (43)	I	Interface mode selection	Select Interface mode with the MPU. When IM = "Low" : serial mode, When IM = "High" : 4-bit/8-bit bus mode.	—
RS/CS (47)	I	Register select /Chip select	When bus mode, used as register selection input. When RS/CS = "High", Data register is selected. When RS/CS = "Low", Instruction register is selected. In serial mode, used as chip selection input. When RS/CS = "Low", selected. When RS/CS = "High", not selected.(Low access enable)	MPU
RW/SID (48)	I	Read, write /Serial input data	In bus mode, used as read/write selection input. When RW/SID = "High", read operation When RW/SID = "Low", write operation. In serial mode, used for data input pin.	MPU
E/SCLK (49)	I	Read, write enable /Serial clock	When bus mode, used as read, write enable signal. When serial mode, used as serial clock input pin.	MPU
DB0/SOD (50)	I/O, O	Data bus 0 bit /Serial output data	In 8-bit bus mode, used as lowest bi-directional data bit. During 4-bit bus mode, Open this pin. In serial mode, used as serial data output pin. If not in read operation, open this pin.	MPU
DB1 - DB3 (51 - 53)	I/O	Data bus 1- 7	In 8-bit bus mode, used as low order bi-directional data bus. During 4-bit bus mode or serial mode, open these pins.	MPU
DB4 - DB7 (54 - 57)			In 8-bit bus mode, used as high order bi-directional data bus. In case of 4-bit bus mode, used as both high and low order. DB7 used for Busy Flag output. During serial mode, open these pins.	MPU

FUNCTION DESCRIPTION

System Interface

This chip has all three kinds of interface type with MPU : serial, 4-bit bus and 8-bit bus. Serial and bus(4-bit/8-bit) are selected by IM input, and 4-bit bus and 8-bit bus are selected by DL bit in the instruction register. During read or write operation, two 8-bit registers are used. one is data register (DR), the other is instruction register(IR). The data register(DR) is used as temporary data storage place for being written into or read from DDRAM/CGRAM/SEGRAM, target RAM is selected by RAM address setting instruction. Each internal operation, reading from or writing into RAM, is done automatically. Hence, after MPU reads DR data, the data in the next DDRAM/CGRAM/SEGRAM address is transferred into DR automatically. Also after MPU writes data to DR, the data in DR is transferred into DDRAM/CGRAM/SEGRAM automatically. The Instruction register(IR) is used only to store instruction code transferred from MPU. MPU cannot use it to read instruction data. To select register, use RS/CS input pin in 4-bit/8-bit bus mode(IM = "High") or RS bit in serial mode(IM = "Low").

Table 2. Various Kinds of Operations according to RS and R/W Bits

RS	R/W	Operation
L	L	Instruction Write operation (MPU writes Instruction code into IR)
L	H	Read Busy flag(DB7) and address counter (DB0 – DB6)
H	L	Data Write operation (MPU writes data into DR)
H	H	Data Read operation (MPU reads data from DR)

Busy Flag (BF)

When BF = "High", it indicates that the internal operation is being processed. So during this time the next instruction cannot be accepted. BF can be read, when RS = Low and R/W = High (Read Instruction Operation), through DB7. Before executing the next instruction, be sure that BF is not High.

Display Data RAM (DDRAM)

DDRAM stores display data of maximum 80×8 bits (80 characters). DDRAM address is set in the address counter (AC) as a hexadecimal number. (refer to Figure 1.)

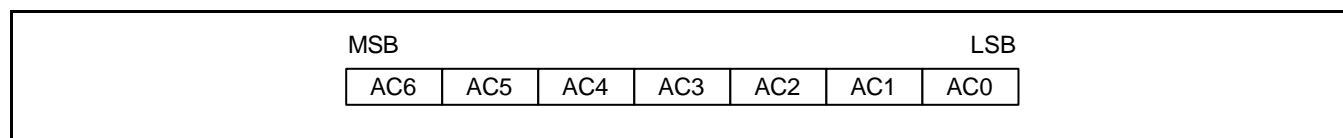


Figure 1. DDRAM Address

1) Display of 5-dot Font Width Character

(1) 5-dot 1-line Display

In case of 1 line display with 5-dot font, the address range of DDRAM is 00H - 4FH (refer to Figure 2). When EXT = "High", extension driver will be used. Figure 3 shows the example that 40 segment extension driver is added

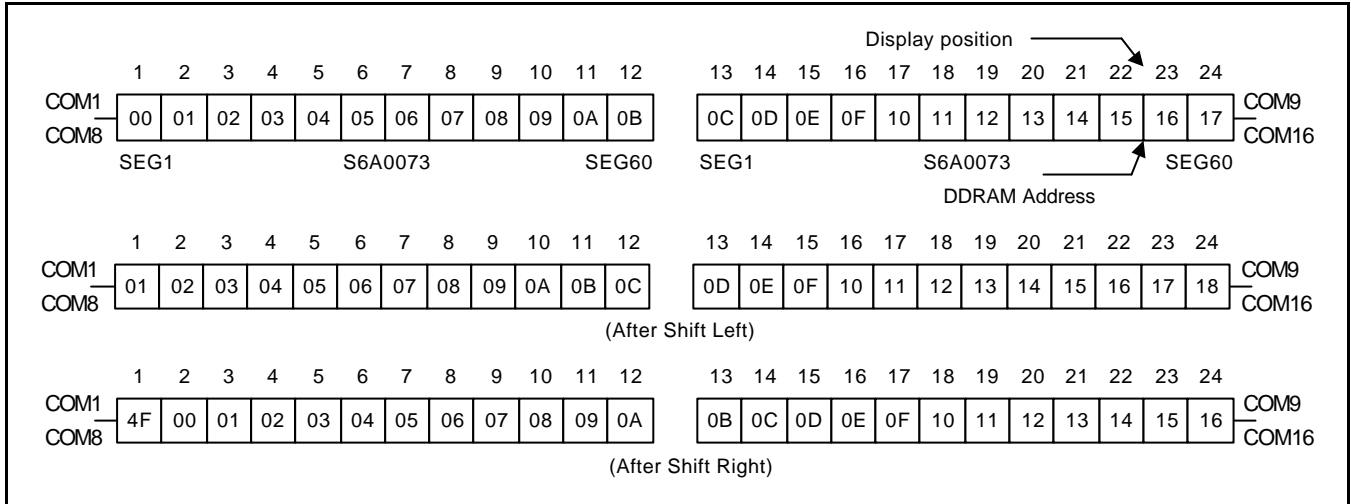


Figure 2. 1-line 24ch. Display (5-dot font width)

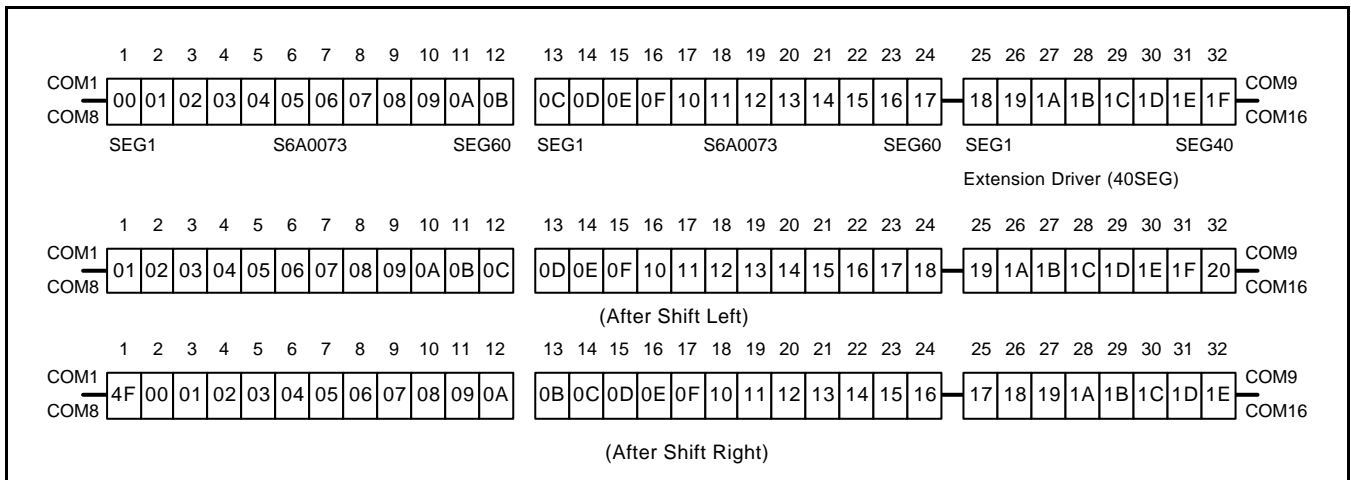


Figure 3. 1-line 32ch. Display with 40 SEG. extension driver (5-dot font width)

(2) 5-dot 2-line Display

In case of 2 line display with 5-dot font, the address range of DDRAM is 00H - 27H,40H - 67H (refer to Figure 4). When EXT = "High", extension driver will be used. Figure 5 shows the example that 40 segment extension driver is added.

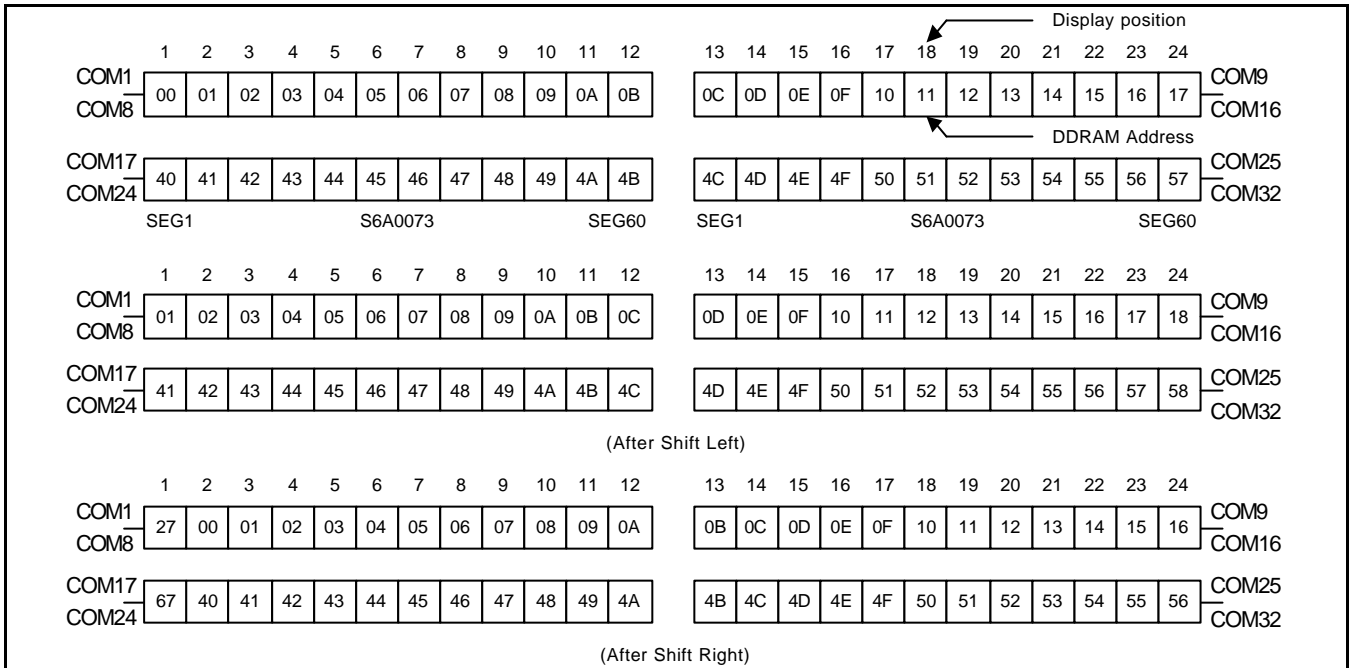


Figure 4. 2-line 24ch. Display (5-dot Font Width)

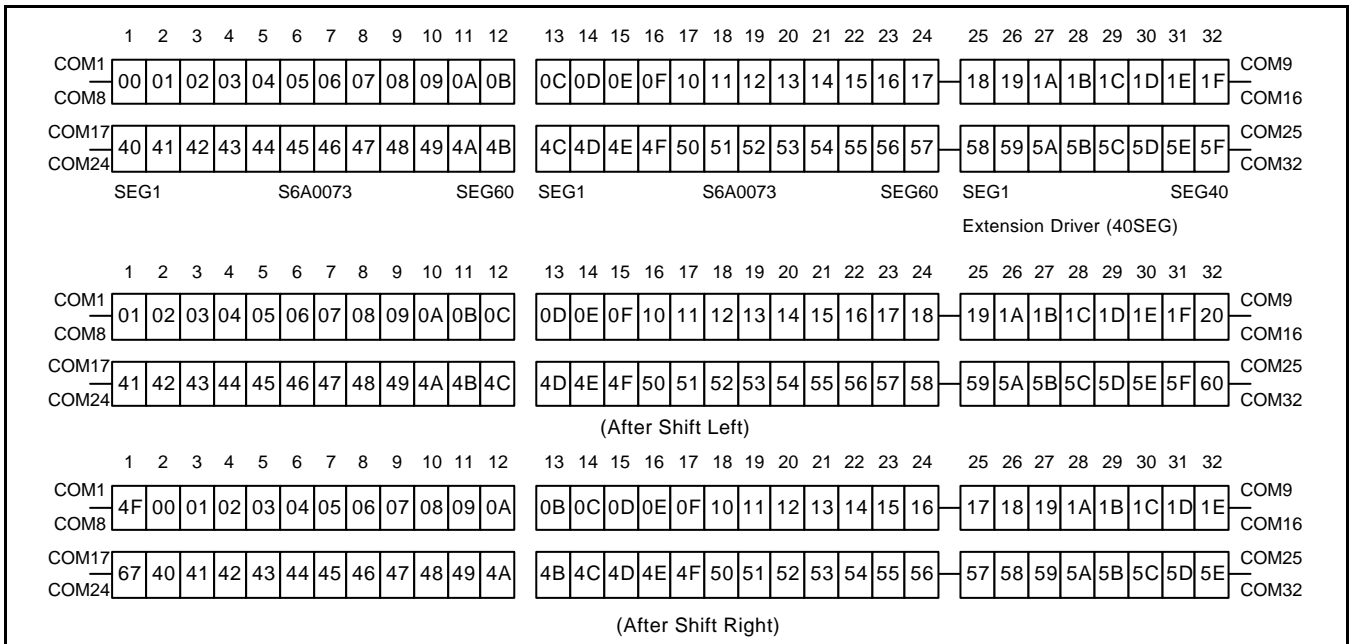


Figure 5. 2-line 32ch. Display with 40 SEG. Extension Driver (5-dot Font Width)



(3) 5-dot 4-line Display

In case of 4 line display with 5-dot font, the address range of DDARM is 00H - 13H, 20H - 33H, 40H - 53H, 60H - 73H (refer to Figure 6). When EXT = "High", extension driver will be used. Figure 7 shows the example that 40 segment extension driver is added.

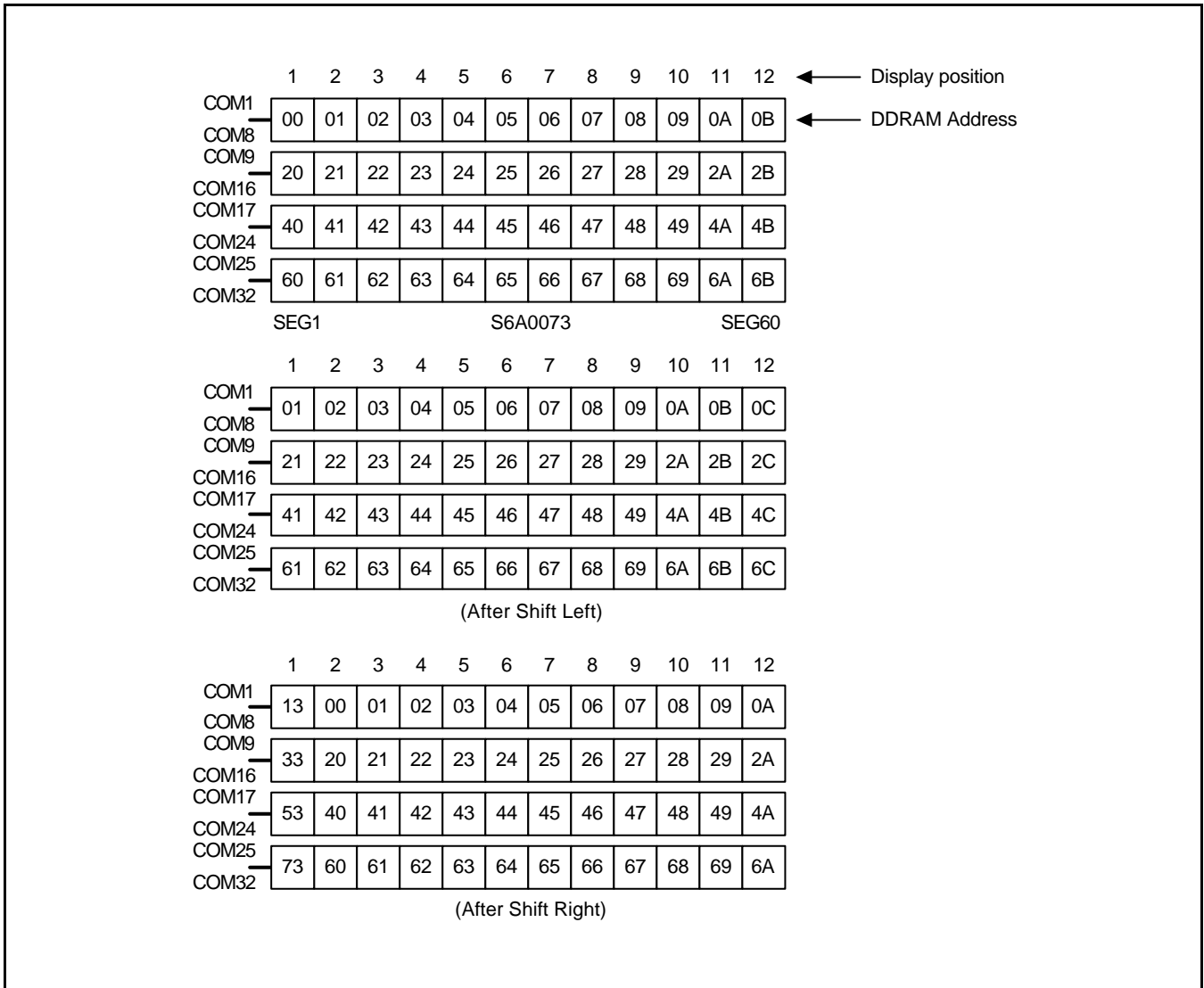


Figure 6. 4-line 12ch. Display (5-dot Font Width)

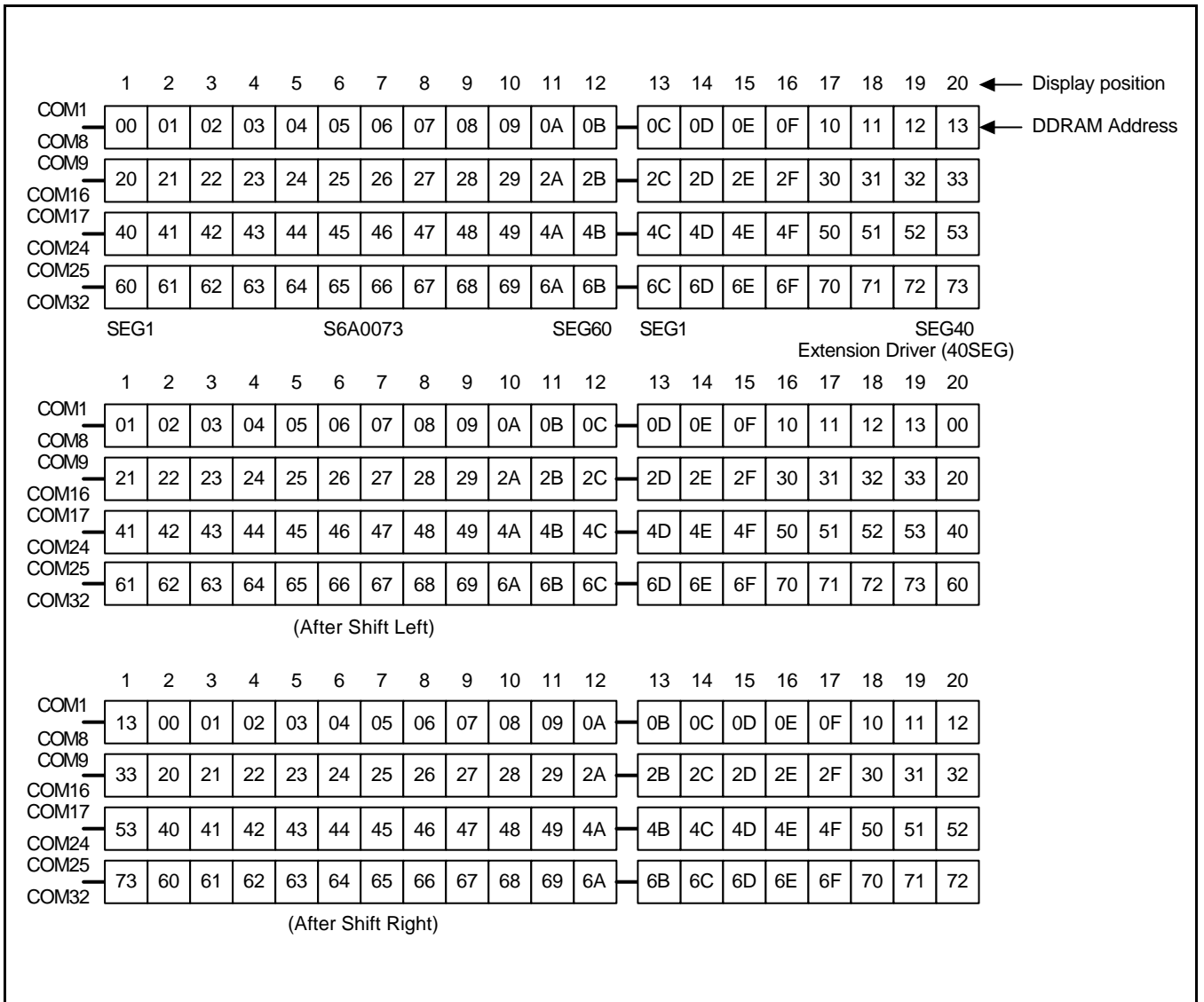


Figure 7. 4-line x 20ch. Display with 40 SEG. Extension Driver (5-dot Font Width)

2) Display of 6-dot Font Width Character

(1) 6-dot 1-line Display

In case of 1 line display with 6-dot font, the address range of DDRAM is 00H - 4FH (refer to Figure 8). When EXT = "High", extension driver will be used. Figure 9 shows the example that 40 segment extension driver is added.

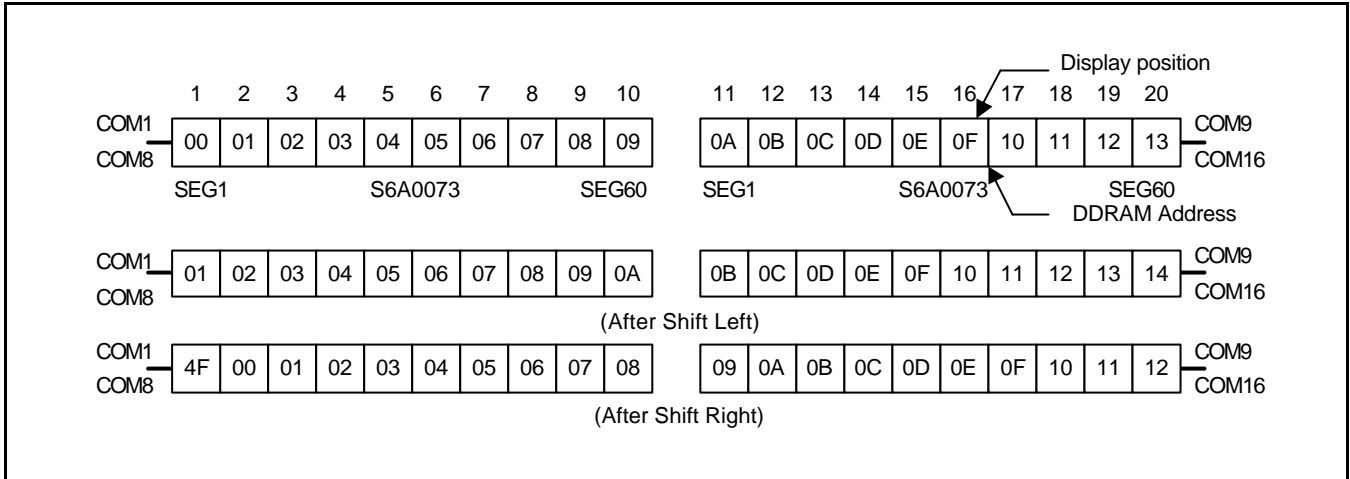


Figure 8. 1-line 20ch. Display (6-dot Font Width)

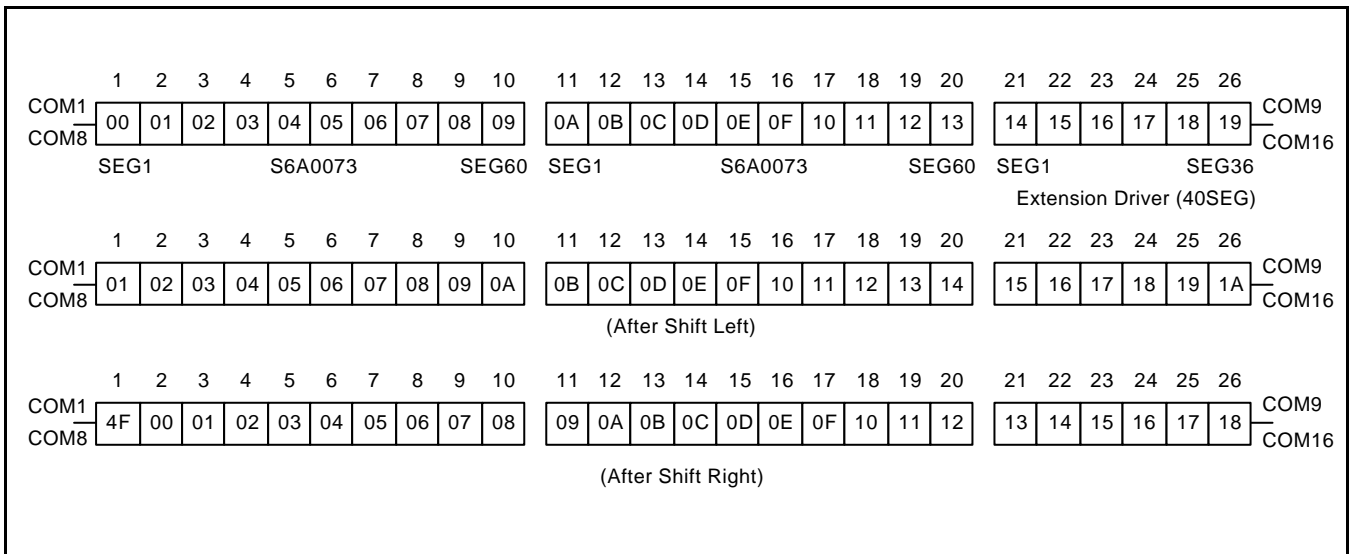


Figure 9. 1-line 26ch. Display with 40 SEG. Extension Driver (6-dot Font Width)

(2) 6-dot 2-line Display

In case of 2 line display with 6-dot font, the address range of DDRAM is 00H - 27H, 40H - 67H. (refer to Figure 10)
 When EXT = "High", extension driver will be used. Figure 11 shows the example that 40 segment extension driver is added.

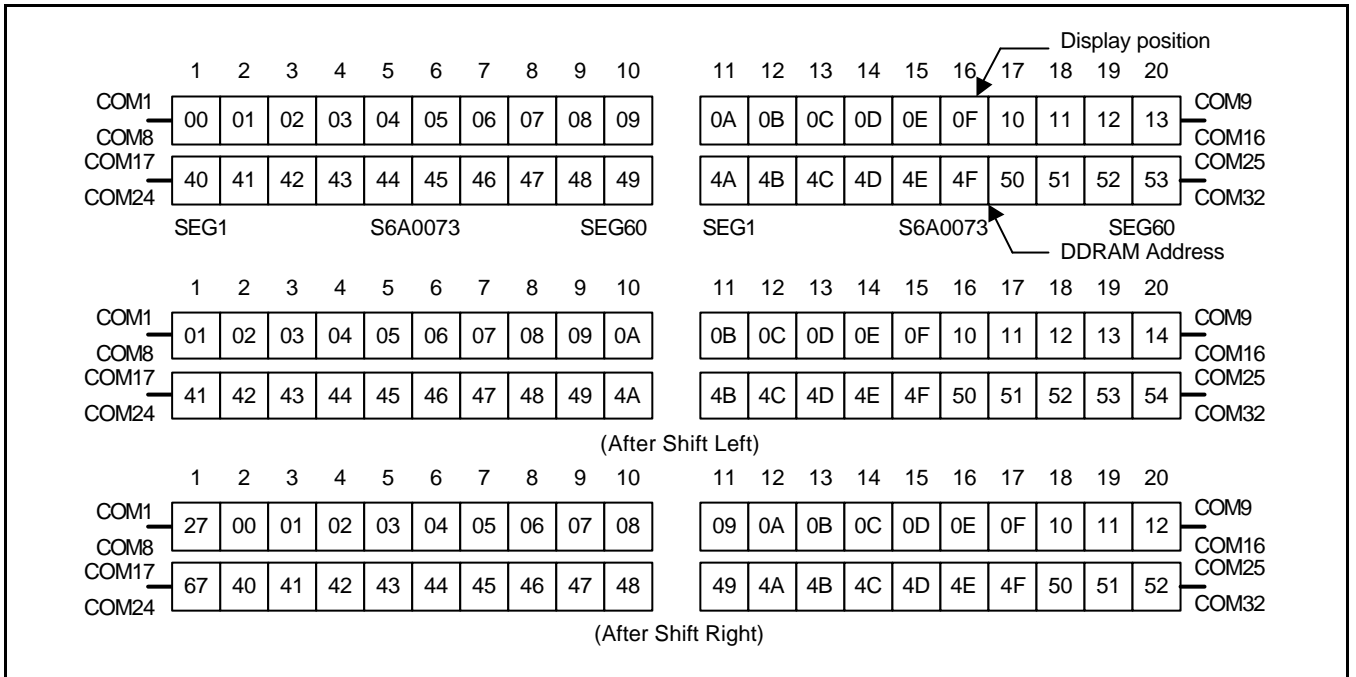


Figure 10. 2-line 20ch. Display (6-dot Font Width)

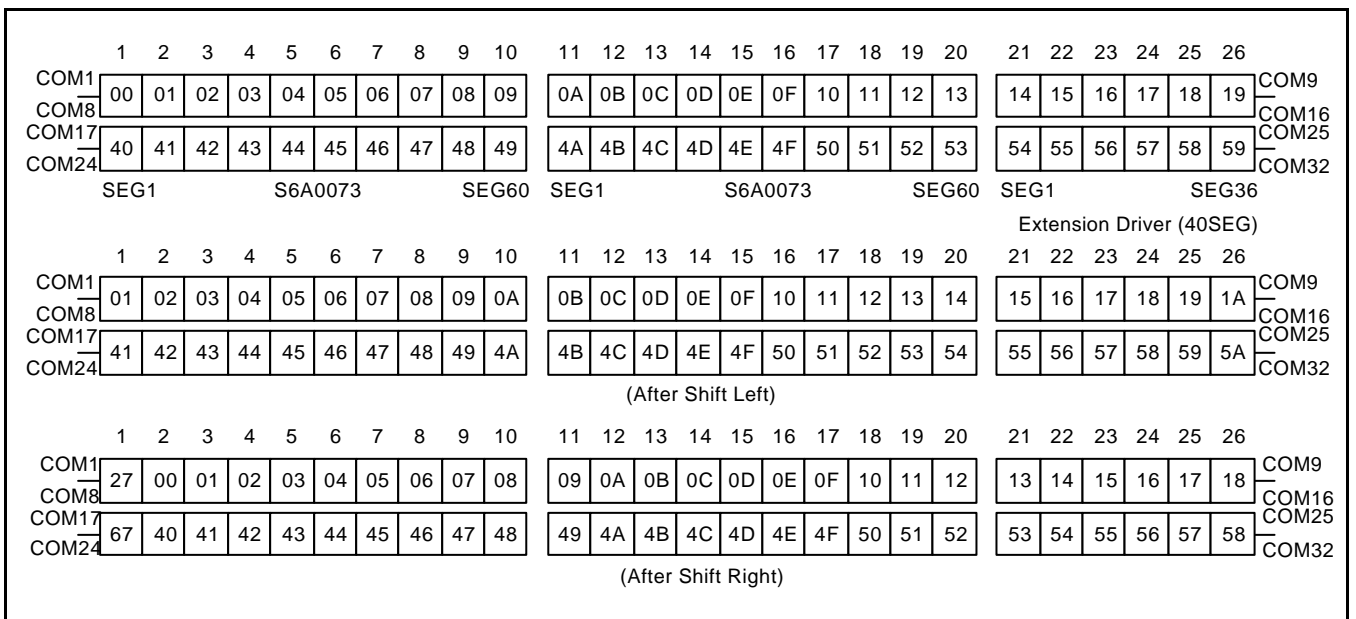


Figure 11. 2-line 26ch. Display with 40 SEG. Extension Driver (6-dot Font Width)



(3) 6-dot 4-line Display

In case of 4 line display with 6-dot font, the address range of DDARM is 00H-13H, 20H-33H, 40H-53H, 60H-73H (refer to Figure 12). When EXT = "High", extension driver will be used. Figure 13 shows the example that 40 segment extension driver is added.

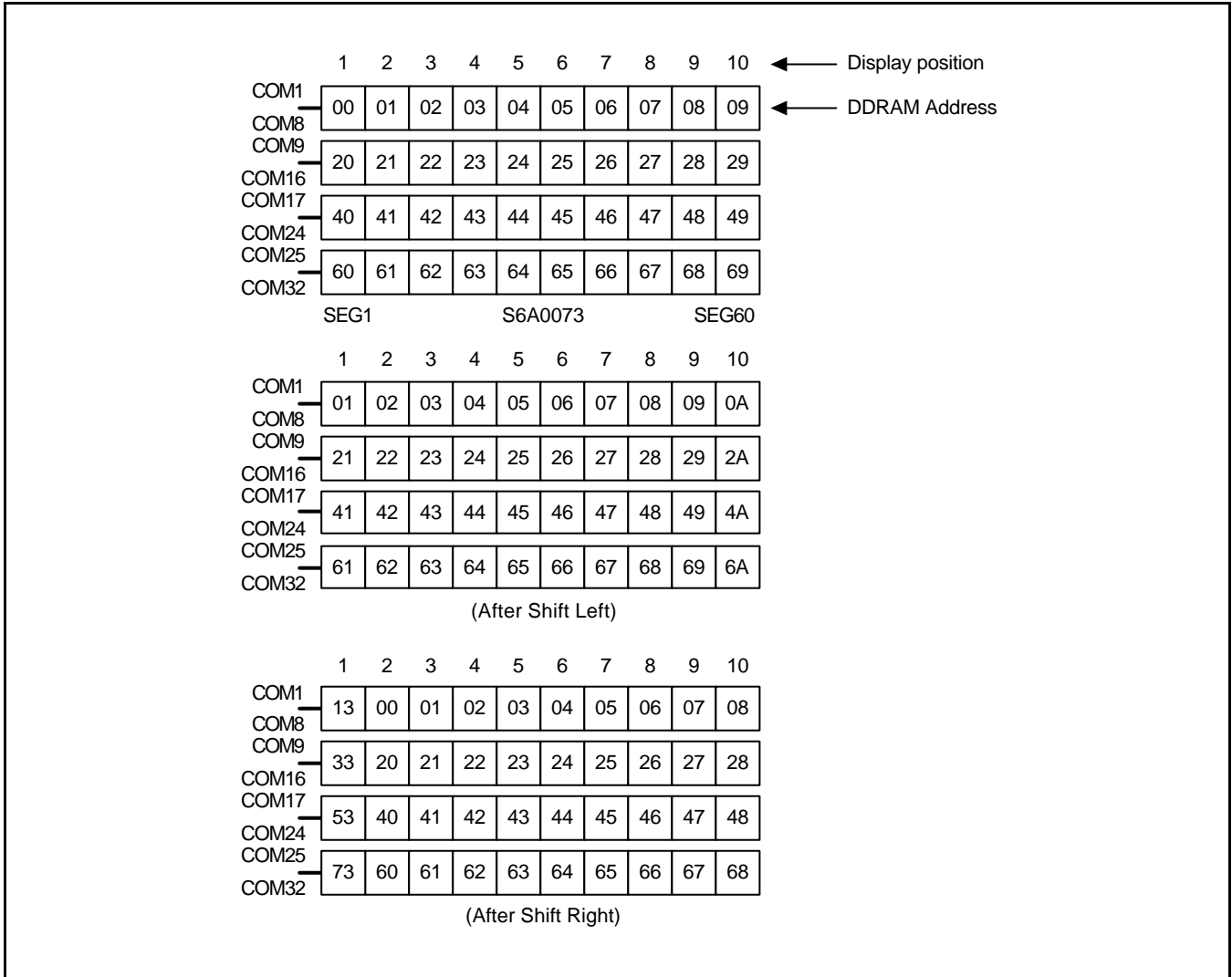


Figure 12. 4-line 10 ch. Display (6-dot Font Width)

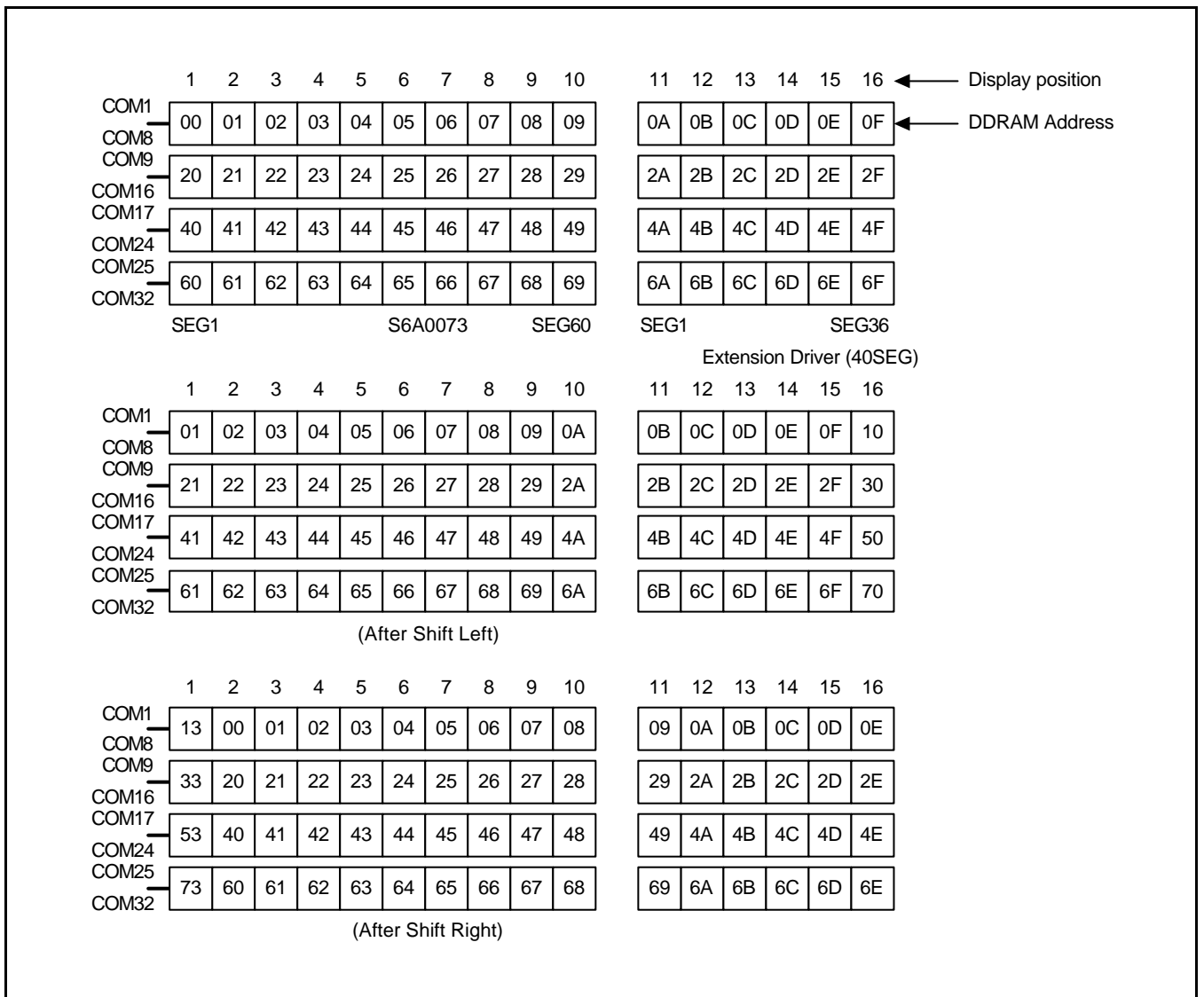


Figure 13. 4-line x 16ch. Display with 40 SEG. Driver (6-dot Font Width)

Timing Generation Circuit

Timing generation circuit generates clock signals for the internal operations.

Address Counter (AC)

Address Counter(AC) stores DDRAM/CGRAM/SEGRAM address, transferred from IR. After writing into (reading from) DDRAM/CGRAM/SEGRAM, AC is automatically increased (decreased) by 1. When RS = "Low" and R/W = "High", AC can be read through DB0-DB6 ports.

Cursor/Blink Control Circuit

It controls cursor/blink ON/OFF and black/white inversion at cursor position.

LCD Driver Circuit

LCD Driver circuit has 34 common and 60 segment signals for LCD driving. Data from SEGRAM/CGRAM/CGROM is transferred to 60-bit segment latch serially, which is then stored to a 60-bit shift latch. When each com is selected by 34-bit common register, segment data also output through segment driver from 100-bit segment latch. In case of 1-line display mode, COM0 - COM17 have a 1/17 duty ratio, and in 2-line or 4-line mode, COM0-COM33 have a 1/33 duty ratio.

CGROM (Character Generator ROM)

CGROM has 5 × 8-dot 240 character pattern.

CGRAM (Character Generator RAM)

CGRAM has up to 5 × 8-dot 8 characters. By writing font data to CGRAM, user defined character can be used (refer to Table 4).

Table 4. Relationship between Character Code (DDRAM) and Character Pattern (CGRAM)

— 5 × 8 dots Character Pattern

Character Code (DDRAM data)								CGRAM Address				CGRAM Data								Pattern Number		
D7	D6	D5	D4	D3	D2	D1	D0	A5	A4	A3	A2	A1	A0	P7	P6	P5	P4	P3	P2		P1	P0
0	0	0	0	x	0	0	0	0	0	0	0	0	0	B1	B0	x	0	1	1	1	0	Pattern 1
											0	0	1				1	0	0	0	1	
											0	1	0				1	0	0	0	1	
				⋮						⋮	0	1	1			⋮	1	1	1	1	1	
				⋮						⋮	1	0	0			⋮	1	0	0	0	1	
				⋮						⋮	1	0	1			⋮	1	0	0	0	1	
				⋮						⋮	1	1	0			⋮	1	0	0	0	1	
											1	1	1				0	0	0	0	0	
				⋮						⋮												
0	0	0	0	x	1	1	1	1	1	1	0	0	0	B1	B0	x	1	0	0	0	1	Pattern 8
											0	0	1				1	0	0	0	1	
											0	1	0				1	0	0	0	1	
				⋮						⋮	0	1	1			⋮	1	1	1	1	1	
				⋮						⋮	1	0	0			⋮	1	0	0	0	1	
				⋮						⋮	1	0	1			⋮	1	0	0	0	1	
				⋮						⋮	1	1	0			⋮	1	0	0	0	1	
											1	1	1				0	0	0	0	0	

— 6-dot Character Pattern

Character Code (DDRAM data)								CGRAM Address						CGRAM Data								Pattern Number
D7	D6	D5	D4	D3	D2	D1	D0	A5	A4	A3	A2	A1	A0	P7	P6	P5	P4	P3	P2	P1	P0	
0	0	0	0	x	0	0	0	0	0	0	0	0	0	B1	B0	0	0	1	1	1	0	Pattern 1
											0	0	1			0	1	0	0	0	1	
											0	1	0			0	1	0	0	0	1	
				.						.	0	1	1	.		0	1	1	1	1	1	
				.						.	1	0	0	.		0	1	0	0	0	1	
				.						.	1	0	1	.		0	1	0	0	0	1	
				.						.	1	1	0	.		0	1	0	0	0	1	
				.						.	1	1	1	.		0	0	0	0	0	0	
				
0	0	0	0	x	1	1	1	1	1	1	0	0	0	B1	B0	0	1	0	0	0	1	Pattern 8
											0	0	1			0	1	0	0	0	1	
											0	1	0			0	1	0	0	0	1	
				.						.	0	1	1	.		0	1	1	1	1	1	
				.						.	1	0	0	.		0	1	0	0	0	1	
				.						.	1	0	1	.		0	1	0	0	0	1	
				.						.	1	1	0	.		0	1	0	0	0	1	
				.						.	1	1	1	.		0	0	0	0	0	0	

NOTES:

- When Be(Blink Enable bit) = "High", blink is controlled by B1 and B0 bit. In case of 5-dot font width, when B1 = "1", enabled dots of P0 - P4 will blink, and when B1 = "0" and B0 = "1", enabled dots in P4 will blink, when B1 = "0" and B0 = "0", blink will not happen.
In case of 6-dot font width, when B1 = "1", enabled dots of P0-P5 will blink, and when B1 = "0" and B0 = "1", enabled dots of P5 will blink, when B1 = "0" and B0 = "0", blink will not happen.
- "X" is don't care.

SEGRAM (Segment Icon RAM)

SEGRAM has segment control data and segment pattern data. During 1-line display mode, COM0(COM17) makes the data of SEGRAM enable to display icons. When used in 2/4-line display mode COM0(COM33) does that. Its higher 2-bits are blinking control data, and lower 6-bits are pattern data (refer to Table 5 and Figure 14).

Table 5. Relationship between SEGRAM Address and Display Pattern

SEGRAM Address				SEGRAM Data Display Pattern															
				5-dot Font Width								6-dot Font Width							
A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	B1	B0	X	S1	S2	S3	S4	S5	B1	B0	S1	S2	S3	S4	S5	S6
0	0	0	1	B1	B0	X	S6	S7	S8	S9	S10	B1	B0	S7	S8	S9	S10	S11	S12
0	0	1	0	B1	B0	X	S11	S12	S13	S14	S15	B1	B0	S13	S14	S15	S16	S17	S18
0	0	1	1	B1	B0	X	S16	S17	S18	S19	S20	B1	B0	S19	S20	S21	S22	S23	S24
0	1	0	0	B1	B0	X	S21	S22	S23	S24	S25	B1	B0	S25	S26	S27	S28	S29	S30
0	1	0	1	B1	B0	X	S26	S27	S28	S29	S30	B1	B0	S31	S32	S33	S34	S35	S36
0	1	1	0	B1	B0	X	S31	S32	S33	S34	S35	B1	B0	S37	S38	S39	S40	S41	S42
0	1	1	1	B1	B0	X	S36	S37	S38	S39	S40	B1	B0	S43	S44	S45	S46	S47	S48
1	0	0	0	B1	B0	X	S41	S42	S43	S44	S45	B1	B0	S49	S50	S51	S52	S53	S54
1	0	0	1	B1	B0	X	S46	S47	S48	S49	S50	B1	B0	S55	S56	S57	S58	S59	S60
1	0	1	0	B1	B0	X	S51	S52	S53	S54	S55	B1	B0	S61	S62	S63	S64	S65	S66
1	0	1	1	B1	B0	X	S56	S57	S58	S59	S60	B1	B0	S67	S68	S69	S70	S71	S72
1	1	0	0	B1	B0	X	S61	S62	S63	S64	S65	B1	B0	S73	S74	S75	S76	S77	S78
1	1	0	1	B1	B0	X	S66	S67	S68	S69	S70	B1	B0	S79	S80	S81	S82	S83	S84
1	1	1	0	B1	B0	X	S71	S72	S73	S74	S75	B1	B0	S85	S86	S87	S88	S89	S90
1	1	1	1	B1	B0	X	S76	S77	S78	S79	S80	B1	B0	S91	S92	S93	S94	S95	S96

NOTES:

1. B1, B0 : Blinking control bit

Control Bit			Blinking Port	
BE	B1	B0	5-dot font width	6-dot font width
0	X	X	No blink	No blink
1	0	0	No blink	No blink
1	0	1	D4	D5
1	1	X	D4 - D0	D5 - D0

2. S1 - S80 : Icon pattern ON/OFF in 5-dot font width
S1 - S96 : Icon pattern ON/OFF in 6-dot font width
3. "X" : don't care

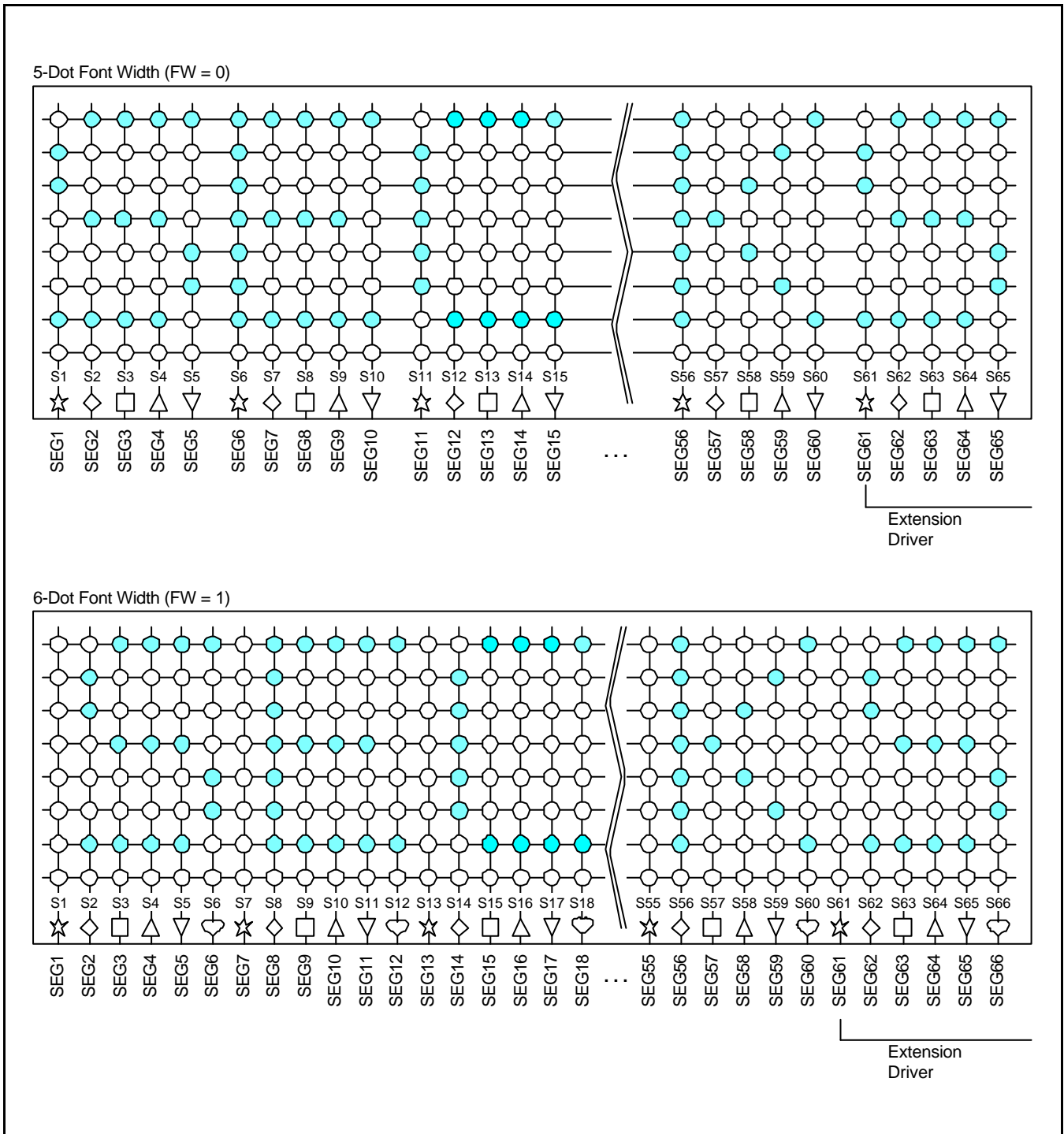


Figure 14. Relationship between SEGRAM and Segment Display

INSTRUCTION DESCRIPTION

OUTLINE

To overcome the speed difference between internal clock of S6A0073 and MPU clock, S6A0073 performs internal operation by storing control information to IR or DR. The internal operation is determined according to the signal from MPU, composed of read/write and data bus. Instruction can be divided largely four kinds,

- (1) S6A0073 function set instructions (set display methods, set data length, etc.)
- (2) address set instructions to internal RAM
- (3) data transfer instructions with internal RAM
- (4) others .

The address of internal RAM is automatically increased or decreased by 1.

When IE = "High", S6A0073 is operated according to Instruction Set 1 (Table 6) and when IE = "Low", S6A0073 is operated according to Instruction Set 2 (Table 10).

NOTE

During internal operation, Busy Flag (DB7) is read High. Busy Flag check must be preceded the next instruction. When an MPU program with Busy Flag (DB7) checking is made, $1/2 f_{OSC}$ is necessary for executing the next instruction by the falling edge of the 'E' signal after the Busy Flag (DB7) goes to "LOW".

INSTRUCTION DESCRIPTION 1 (IE = "HIGH")

Table 6. Instruction Set 1

Instruction	Instruction Code											Description	Execution time (f _{OSC} =70kHz)	
	RE	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0			
Clear display	X	0	0	0	0	0	0	0	0	0	1	Write "20" to DDRAM, and set DDRAM address to "00H" from AC.	1.53ms	
Return home	0	0	0	0	0	0	0	0	0	0	1	x	Set DDRAM address to "00H" from AC and return cursor to its original position if shifted. The contents of DDRAM are not changed.	1.53ms
Power down mode	1	0	0	0	0	0	0	0	0	0	1	PD	Set power down mode bit. (PD = "1" : power down mode set, PD = "0" : power down mode disable)	39μs
Entry mode set	0	0	0	0	0	0	0	0	0	1	I/D	S	Assign cursor moving direction, (I/D = "1": increment, I/D = "0": decrement, and display shift enable bit. (S = "1": make display shift of the enabled lines by the DS4-DS1 bits in the shift Enable instruction S = "0": display shift disable)	39μs
	1	0	0	0	0	0	0	0	0	1	1	B/D	Segment bidirectional function. (BID = "1": Seg60 →Seg1 BID = "0": Seg1 →Seg60)	
Display ON/OFF Control	0	0	0	0	0	0	0	0	1	D	C	B	Set display/cursor/blink on/off D = "1" : display on, D = "0" : display off, C = "1" : cursor on, C = "0" : cursor off, B = "1" : blink on, B = "0" : blink off.	39μs
Extended function set	1	0	0	0	0	0	0	0	1	FW	B/W	NW	Assign font width, black/white inverting of cursor, and 4-line display mode control bit. FW = "1" : 6-dot font width, FW = "0" : 5-dot font width, B/W = "1" : black/white inverting of cursor enable, B/W = "0" : black/white inverting of cursor disable. NW = "1" : 4-line display mode, NW = "0" : 1-line or 2-line display mode.	39μs

Table 6. Instruction Set 1 Continued

Instruction	Instruction Code											Description	Execution time (fosc=70kHz)
	RE	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Cursor or Display Shift	0	0	0	0	0	0	1	S/C	R/L	X	X	Cursor or display shift. S/C = "1" : display shift, S/C = "0" : cursor shift, R/L = "1" : shift to right, R/L = "0" : shift to left.	39μs
Shift Enable	1	0	0	0	0	0	1	DS4	DS3	DS2	DS1	(when DH = "1") Determine the line for display shift . DS1 = "1/0": 1st line display shift enable/disable DS2 = "1/0": 2nd line display shift enable/disable DS3 = "1/0": 3rd line display shift enable/disable DS4 = "1/0": 4th line display shift enable/disable.	39μs
Scroll Enable	1	0	0	0	0	0	1	HS4	HS3	HS2	SH1	(when DH = "0") Determine the line for horizontal smooth scroll. HS1 = "1/0" : 1st line dot scroll enable/disable HS2 = "1/0" : 2nd line dot scroll enable/disable HS3 = "1/0" : 3rd line dot scroll enable/disable HS4 = "1/0" : 4th line dot scroll enable/disable.	39μs
Function Set	0	0	0	0	0	1	DL	N	RE (0)	DH	REV	Set interface data length (DL = "1" : 8-bit, DL = "0" : 4-bit), numbers of display line when NW = "0", (N = "1" : 2-line, N = "0" : 1-line), extension register, RE("0"), shift/scroll enable DH = "1" : display shift enable DH = "0" : dot scroll enable. And reverse bit REV = "1" : reverse display, REV = "0" : normal display.	39μs
	1	0	0	0	0	1	DL	N	RE (1)	BE	LP	Set DL, N, RE("1") and CGRAM/SEGRAM blink enable (BE) BE = " 1/0" : CGRAM/SEGRAM blink enable/disable LP = "1" : low power mode LP = "0" : normal operation mode	39μs

Table 6. Instruction Set 1 continued

Instruction	Instruction Code											Description	Execution time ($f_{osc}=270kHz$)
	RE	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Set CGRAM Address	0	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM address in address counter.	39 μ s
Set SEGRAM Address	1	0	0	0	1	X	X	AC3	AC2	AC1	AC0	Set SEGRAM address in address counter.	39 μ s
Set DDRAM Address	0	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address counter.	39 μ s
Set Scroll Quantity	1	0	0	1	X	SQ5	SQ4	SQ3	SQ2	SQ1	SQ0	Set the quantity of horizontal dot scroll.	39 μ s
Read Busy flag and Address	x	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Can be known whether during internal operation or not by reading BF. The contents of address counter can also be read. BF = "1" : busy state, BF = "0" : ready state.	0 μ s
Write Data	X	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM/SEGRAM).	43 μ s
Read Data	X	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM (DDRAM/CGRAM/SEGRAM).	43 μ s

NOTE: When an MPU program with Busy Flag (DB7) checking is mode, $1/2 f_{OSC}$ is necessary for executing the next instruction by the falling edge of the "E" signal after the Busy Flag (DB7) goes to "low". "X" is don't care.

Display Clear

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

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

Return Home (RE = 0)

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

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

Power Down Mode Set (RE = 1)

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

Power down mode enable bit set instruction. When PD = "High", it makes S6A0073 suppress current consumption except the current needed for data storage by executing next three functions.

- Make the output value of all the COM/SEG ports V_{DD}
- Make the COM/SEG output value of extension driver V_{DD} by setting D output to "High" and M output to "Low"
- Disable voltage converter to remove the current through the divide resistor of power supply.
This instruction can be used power sleep mode. When PD = "Low", power down mode becomes disabled.

Entry Mode Set (RE = 0)

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

Set the moving direction of cursor and display.

I/D : Increment/decrement of DDRAM address (cursor or blink)

When I/D = "High", cursor/blink moves to right and DDRAM address is increased by 1.

When I/D = "Low", cursor/blink moves to left and DDRAM address is decreased by 1.

* CGRAM/SEGRAM operates the same as DDRAM, when read from or write to CGRAM/SEGRAM.

When S = "High", after DDRAM write, the display of enabled line by DS1 - DS4 bits in the Shift Enable instruction is shifted to the right (I/D = "0") or to the left (I/D = "1"). But it will seem as if the cursor does not move.

When S = "Low", or DDRAM read, or CGRAM/SEGRAM read/write operation, shift of display as the above function is not performed.

Entry Mode Set (RE = 1)

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

Set the data shift direction of segment in the application set.

BID : Data Shift Direction of Segment

When BID = "Low", segment data shift direction is set to normal order from SEG1 to SEG100.

When BID = "High", segment data shift direction is set to reversely from SEG100 to SEG1.

By using this instruction, the efficiency of application board area can be raised.

* The BID setting instruction is recommended to be set at the same time level of function set instruction.

* DB1 bit must be set to "1".

Display ON/OFF Control (RE = 0)

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

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

D : Display ON/OFF control bit

When D = "High", entire display is turned on.

When D = "Low", display is turned off, but display data is remained in DDRAM.

C : Cursor ON/OFF control bit

When C = "High", cursor is turned on.

When C = "Low", cursor is disappeared in current display, but I/D register remains its data.

B : Cursor Blink ON/OFF control bit

When B = "High", cursor blink is on, that performs alternate between all the high data and display character at the cursor position. If fosc has frequency of 270kHz, blinking has 370 ms interval.

When B = "Low", blink is off.

Extended Function Set (RE = 1)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	1	F/W	B/W	NW

FW : Font Width control

When FW = "High", display character font width is assigned to 6-dot and execution time becomes 6/5 times than that of 5-dot font width. The user font, specified in CGRAM, is displayed into 6-dot font width, bit-5 to bit-0, including the left most space bit of CGRAM.(refer to Figure 15)

When FW = "Low", 5-dot font width is set.

B/W : Black/White Inversion enable bit

When B/W = "High", black/white inversion at the cursor position is set. In this case C/B bit of display ON/OFF control instruction becomes don't care condition. If fosc has frequency of 270kHz, inversion has 370 ms intervals.

NW : 4 Line mode enable bit

When NW = "High", 4 line display mode is set. In this case N bit of function set instruction becomes don't care condition.

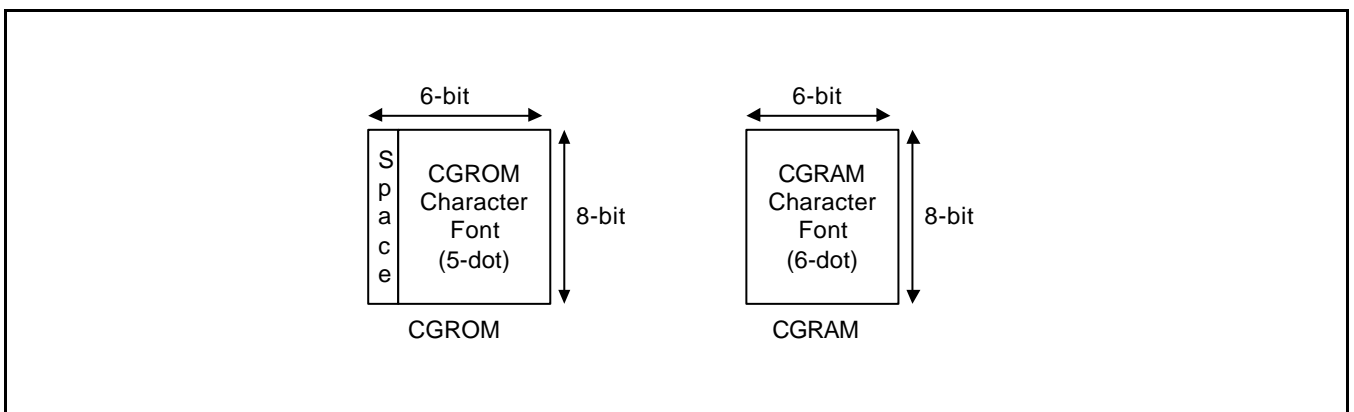


Figure 15. 6-dot Font Width CGROM/CGRAM

Cursor or Display Shift (RE = 0)

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

Shift right/left cursor position or display without writing or reading of display data. This instruction is used to correct or search display data (refer to Table 7). During 2-line mode display, cursor moves to the 2nd line after 40th digit of 1st line. In 4-line mode, cursor moves to the next line, only after every 20th digit of the current line.

Note that display shift is performed simultaneously in all the line enabled by DS1 - DS4 in the Shift Enable instruction. When displayed data is shifted repeatedly, each line shifted individually. When display shift is performed, the contents of address counter are not changed. During low power consumption mode, display shift may not be performed normally.

Table 7. Shift Patterns according to S/C and R/L Bits

S/C	R/L	Operation
0	0	Shift cursor to the left, ADDRESS COUNTER is decreased by 1
0	1	Shift cursor to the right, ADDRESS COUNTER is increased by 1
1	0	Shift all the display to the left, cursor moves according to the display
1	1	Shift all the display to the right, cursor moves according to the display

Shift/Scroll Enable (RE = 1)**DH = 0**

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	1	HS4	HS3	HS2	HS1

HS : Horizontal Scroll per Line Enable. This instruction makes valid dot shift by a display line unit.

HS1, HS2, HS3 and HS4 indicate each line to be dot scrolled, and each scroll is performed individually in each line. If you want to scroll the line in 1-line display mode or the 1st line in 2-line display mode, set HS1 and HS2 to "High". If the 2nd line scroll is needed in 2-line mode, set HS3 and HS4 to "High". (refer to Table 8)

DH = 1

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	1	DS4	DS3	DS2	DS1

DS : Display Shift per Line Enable. This instruction selects shifting line to be shifted according to each line mode in display shift right/left instruction. DS1, DS2, DS3 and DS4 indicate each line to be shifted, and each shift is performed individually in each line. If you set DS1 and DS2 to "High" (enable) in 2 line mode, only the 1st line is shifted and the 2nd line is not shifted. When only DS1 = "High", only the half of the 1st line is shifted. If all the DS bits (DS1 to DS4) are set to "Low" (disable), no display is shifted.

Table 8. Relationship between DS and COM signal

Enable bit	Enabled common signal during shift	Description
HS1/DS1	COM1 - COM8	The part of display line that corresponds to enabled common signal can be shifted.
HS2/DS2	COM9 - COM16	
HS3/DS3	COM17 - COM24	
HS4/DS4	COM25 - COM32	

Function Set (RE = 0)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	DL	N	RE(0)	DH	REV

DL : Interface data length control bit

When DL = "High", it means 8-bit bus mode with MPU.

When DL = "Low", it means 4-bit bus mode with MPU. So to speak, DL is a signal to select 8-bit or 4-bit bus mode. In 4-bit bus mode, it needs to transfer 4-bit data by two times.

N : Display line number control bit

It is variable only when NW bit of extended function set instruction is Low.

When N = "Low", 1-line display mode is set.

When N = "High", 2-line display mode is set.

When NW = "High", N bit is invalid, it means 4-line mode independent of N bit.

RE : Extended function registers enable bit

At this instruction, RE must be "Low".

DH : Display shift enable selection bit.

When DH = "High", enables display shift per line.

When DH = "Low", enables smooth dot scroll.

This bit can be accessed only when IE pin input is "High".

REV : Reverse enable bit

When REV = "High", all the display data are reversed. i.e., all the white dots become black and black dots become white. When REV = "Low", the display mode set normal display.

Function Set (RE = 1)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	DL	N	RE(0)	DH	REV

DL : Interface data length control bit

When DL = "High", it means 8-bit bus mode with MPU.

When DL = "Low", it means 4-bit bus mode with MPU. Hence, DL is a signal to select 8-bit or 4-bit bus mode. When 4-bit bus mode, it is required to transfer 4-bit data by two times.

N : Display line number control bit

It is variable only when NW bit of extended function set instruction is Low.

When N = "Low", 1-line display mode is set.

When N = "High", 2-line display mode is set.

When NW = "High", N bit is invalid, it means 4-line mode independent of N bit.

RE : Extended function registers enable bit

When RE = "High", extended function set registers, SEGRAM address set registers, BID bit, HS/DS bits of shift/scroll enable instruction and BE bits of function set register can be accessed.

BE : CGRAM/SEGRAM data blink enable bit

BE = "High", makes user font of CGRAM and segment of SEGRAM blinking. The quantity of blink is assigned the highest 2 bit of CGRAM/SEGRAM.

LP : Low power consumption mode enable bit

When EXT input is "Low"(without extension driver) and LP bit is set to "High", S6A0073 operates in low power consumption mode.

During 1-line mode S6A0073 operates on a 4-division clock, and in 2-line or 4-line mode it operates on a 2-division clock. According to this instruction, execution time becomes 4 or 2 times longer.

Note not to use display shift instruction, as it may result incorrect operation.

And the frame frequency is lower to 5/6 times lower than that of normal operation.

Set CGRAM Address (RE = 0)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0

Set CGRAM address to AC.

This instruction makes CGRAM data available from MPU.

Set SEGRAM Address (RE = 1)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	1	X	X	AC3	AC2	AC1	AC0

Set SEGRAM address to AC.

This instruction makes SEGRAM data available from MPU.

Set DDRAM Address (RE = 0)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0

Set DDRAM address to AC.

This instruction makes DDRAM data available from MPU.

In 1-line display mode (N = 0, NW = 0), DDRAM address is from "00H" to "4FH".

In 2-line display mode (N = 1, NW = 0), DDRAM address in the 1st line is from "00H" to "27H", and DDRAM address in the 2nd line is from "40H" to "67H".

In 4-line display mode (NW = 1), DDRAM address is from "00H" to "13H" in the 1st line, from "20H" to "33H" in the 2nd line, from "40H" to "53H" in the 3rd line and from "60H" to "73H" in the 4th line.

Set Scroll Quantity (RE = 1)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	1	X	SQ5	SQ4	SQ3	SQ2	SQ1	SQ0

As set SQ5 to SQ0, horizontal scroll quantity can be controlled in dot units. (refer to Table 9).

In this case S6A0073 can show hidden areas of DDRAM by executing smooth scroll from 1 to 48 dots.

Table 9. Scroll Quantity According to HDS bits

SQ5	SQ4	SQ3	SQ2	SQ1	SQ0	Function
0	0	0	0	0	0	No shift
0	0	0	0	0	1	shift left by 1-dot
0	0	0	0	1	0	shift left by 2-dot
0	0	0	0	1	1	shift left by 3-dot
:	:	:	:	:	:	:
1	0	1	1	1	1	shift left by 47-dot
1	1	X	X	X	X	shift left by 48-dot

Read Busy Flag & Address

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0

This instruction shows whether S6A0073 is in internal operation or not. If the resultant BF is High, the internal operation is in progress and should wait until BF to be Low, which by then the next instruction can be performed. In this instruction the value of address can also be read.

Write Data to RAM

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	0	D7	D6	D5	D4	D3	D2	D1	D0

Write binary 8-bit data to DDRAM/CGRAM/SEGRAM.

The selection of RAM from DDRAM, CGRAM, or SEGRAM, is set by the previous address set instruction : DDRAM address set, CGRAM address set, SEGRAM address set.

RAM set instruction can also determines the AC direction to RAM.

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

Read Data from RAM

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	1	D7	D6	D5	D4	D3	D2	D1	D0

Read binary 8-bit data from DDRAM/CGRAM/SEGRAM.

The selection of RAM is set by the previous address set instruction. If address set instruction of RAM is not performed before this instruction, the data that read first is invalid, as the direction of AC is not determined.

If RAM data read several times without RAM address set instruction before read operation, the correct RAM data can be obtained from the second, but the first data would be incorrect, as there is no time margin to transfer RAM data.

In case of DDRAM read operation, cursor shift instruction plays the same role as DDRAM address set instruction : it also transfer RAM data to output data register.

After read operation address counter is automatically increased/decreased by 1 according to the entry mode. After CGRAM/SEGRAM read operation, display shift may not be executed correctly.

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

INSTRUCTION DESCRIPTION 2 (IE = "LOW")

Table 10. Instruction Set 2

Instruction	RE	Instruction Code										Description	Execution time (f _{OSC} =270kHz)	
		RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0			
Clear Display	X	0	0	0	0	0	0	0	0	0	0	1	Write "20H" to DDRAM. and set DRAM address to "00H" from AC.	1.53ms
Return Home	X	0	0	0	0	0	0	0	0	0	1	X	Set DDRAM address to "00H" from AC and return cursor to its original position if shifted. The contents of DDRAM are not changed.	1.53ms
Entry Mode Set	X	0	0	0	0	0	0	0	0	1	I/D	S	Assign cursor moving direction. I/D = "1" : increment, I/D = "0" : decrement. and display shift enable bit. S = "1" :make entire display shift of all lines during DDRAM write, S = "0":display shift disable	39μs
Display ON/OFF Control	0	0	0	0	0	0	0	0	1	D	C	B	Set display/cursor/blink on/off D = "1" : display on, D = "0" : display off, C = "1" : cursor on, C = "0" : cursor off, B = "1" : blink on, B = "0" : blink off.	39μs
Extended function set	1	0	0	0	0	0	0	0	1	FW	BW	NW	Assign font width, black/white inverting of cursor, and 4-line display mode control bit. FW = "1" : 6-dot font width, FW = "0" : 5-dot font width, B/W = "1" : black/white inverting of cursor enable, B/W = "0" : black/white inverting of cursor disable NW = "1" : 4-line display mode, NW = "0" : 1-line or 2-line display mode	39μs
Cursor or Display Shift	0	0	0	0	0	0	0	1	S/C	R/L	X	X	Cursor or display shift. S/C = "1" : display shift, S/C = "0" : cursor shift, R/L = "1" : shift to right, R/L = "0" : shift to left	39μs

Table 10. Instruction Set 2 (continued)

Instruction	RE	Instruction Code										Description	Execution time (f _{OSC} =270kHz)
		RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Scroll Enable	1	0	0	0	0	0	1	HS4	HS3	HS2	HS1	Determine the line for horizontal smooth scroll. HS1 = "1/0" : 1st line dot scroll enable/disable HS2 = "1/0" : 2nd line dot scroll enable/disable HS3 = "1/0" : 3rd line dot scroll enable/disable HS4 = "1/0" : 4th line dot scroll enable/disable	39μs
Function Set	0	0	0	0	0	1	DL	N	RE (0)	X	X	Set interface data length DL = "1" : 8-bit, DL = "0" : 4-bit numbers of display line when NW = "0", N = "1" : 2-line, N = "0" : 1-line extension register, RE("0"),	39μs
	1	0	0	0	0	1	DL	N	RE (1)	BE	LP	Set DL, N, RE("1") and CGRAM/SEGRAM blink enable (BE) BE = "1/0" : CGRAM/SEGRAM blink enable/disable LP = "1" : low power mode LP = "0" : normal operation mode	39μs
Set CGRAM Address	0	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM address in address counter.	39μs
Set SEGRAM Address	1	0	0	0	1	X	X	AC3	AC2	AC1	AC0	Set SEGRAM address in address counter.	39μs
Set DDRAM Address	0	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address counter.	39μs
Set Scroll Quantity	1	0	0	1	X	SQ5	SQ4	SQ3	SQ2	SQ1	SQ1	Set the quantity of horizontal dot scroll.	39μs
Read Busy flag and Address	X	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Can be known whether during internal operation or not by reading BF. The contents of address counter can also be read. BF = "1" : busy state, BF = "0" : ready state.	0μs
Write Data	X	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM/SEGRAM).	43μs
Read Data	X	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM (DDRAM/CGRAM/SEGRAM).	43μs

NOTE: When an MPU program with Busy Flag (DB7) checking is made, 1/2 f_{OSC} (is necessary) for executing the next instruction by the falling edge of the 'E' signal after the Busy Flag (DB7) goes to "low".

Display Clear

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

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

Return Home

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

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

Entry Mode Set

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

Set the moving direction of cursor and display.

I/D : Increment/decrement of DDRAM address (cursor or blink)

When I/D = "High", cursor/blink moves to right and DDRAM address is increased by 1.

When I/D = "Low", cursor/blink moves to left and DDRAM address is decreased by 1.

* CGRAM/SEGRAM operates the same as DDRAM, when read from or write to CGRAM/SEGRAM.

When S = "High", after DDRAM write, the entire display of all lines is shifted to the right (I/D = "low") or to the left (I/D = "high"). But it will seem as if the cursor is not moving. When S = "Low", or DDRAM read, or CGRAM/SEGRAM read/write operation, shift of entire display is not performed.

Display ON/OFF Control (RE = 0)

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

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

D : Display ON/OFF control bit

When D = "High", entire display is turned on.

When D = "Low", display is turned off, but display data is remained in DDRAM.

C : Cursor ON/OFF control bit

When C = "High", cursor is turned on.

When C = "Low", cursor is disappeared in current display, but I/D register preserves its data.

B : Cursor Blink ON/OFF control bit

When B = "High", cursor blink is on, that performs alternate between all the high data and display character at the cursor position. If fosc has 270kHz frequency, blinking has 370ms interval.

When B = "Low", blink is off.

Extended Function Set (RE = 1)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	1	FW	BW	NW

FW : Font Width control

When FW = "High", display character font width is assigned to 6-dot and execution time becomes 6/5 times than that of 5-dot font width. The user font, specified in CGRAM, is displayed into 6-dot font width, bit-5 to bit-0, including the leftmost space bit of CGRAM.(refer to Figure 16). When FW = "Low", 5-dot font width is set.

B/W : Black/White Inversion enable bit

When B/W = "High", black/white inversion at the cursor position is set. In this case C/B bit of display ON/OFF control instruction becomes don't care condition. If fosc has frequency of 270kHz, inversion has 370ms intervals.

NW : 4 Line mode enable bit

When NW = "High", 4 line display mode is set. In this case N bit of function set instruction becomes don't care condition.

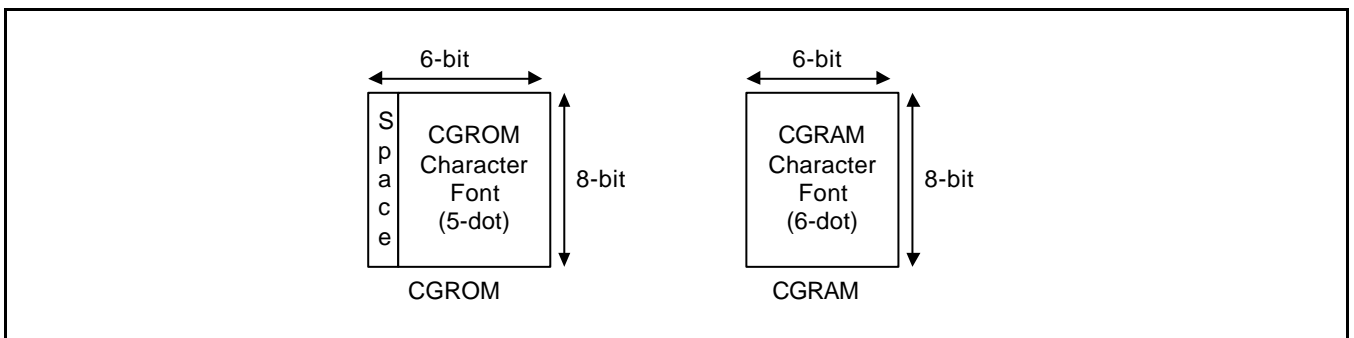


Figure 16. 6-dot Font Width CGROM/CGRAM

Cursor or Display Shift (RE = 0)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	1	SC	R/L	-	-

Shift right/left cursor position or display without writing or reading of display data. This instruction is used to correct or search display data (refer to Table 11). During 2-line mode display, cursor moves to the 2nd line after 40th digit of 1st line. In 4-line mode, cursor moves to the next line, only after every 20th digit of the current line. Note that display shift is performed simultaneously in all the line. When displayed data is shifted repeatedly, each line shifted individually. When display shift is performed, the contents of address counter are not changed.

Table 11. Shift Patterns According to S/C and R/L bits

S/C	R/L	Operation
0	0	Shift cursor to the left, ADDRESS COUNTER is decreased by 1
0	1	Shift cursor to the right, ADDRESS COUNTER is increased by 1
1	0	Shift all the display to the left, cursor moves according to the display
1	1	Shift all the display to the right, cursor moves according to the display

Scroll Enable (RE = 1)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	1	HS4	HS3	HS2	HS1

HS : Horizontal Scroll per Line Enable

This instruction makes valid dot shift by a display line unit.

HS1, HS2, HS3 and HS4 indicate each line to be dot scrolled, and each scroll is performed individually in each line. If the line in 1-line display mode or the 1st line in 2-line display mode is to be scrolled, set HS1 and HS2 to "high". If the 2nd line scroll is needed in 2-line mode, set HS3 and HS4 to "high". (Refer to table 8)

Function Set (RE = 0)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	DL	N	RE(0)	-	-

DL : Interface data length control bit

When DL = "High", it means 8-bit bus mode with MPU.

When DL = "Low", it means 4-bit bus mode with MPU. Hence, DL is a signal to select 8-bit or 4-bit bus mode. When 4-bit bus mode, it is required to transfer 4-bit data twice.

N : Display line number control bit

It is variable only when NW bit of extended function set instruction is Low.

When N = "Low", 1-line display mode is set.

When N = "High", 2-line display mode is set.

When NW = "High", N bit is invalid, it means 4-line mode independent of N bit.

RE : Extended function registers enable bit

At this instruction, RE must be "Low".

Function Set (RE = 1)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	DL	N	RE(1)	RE	LP

DL : Interface data length control bit

When DL = "High", it means 8-bit bus mode with MPU.

When DL = "Low", it means 4-bit bus mode with MPU. So to speak, DL is a signal to select 8-bit or 4-bit bus mode.

When 4-bit bus mode, it is required to transfer 4-bit data twice.

N : Display line number control bit

It is variable only when NW bit of extended function set instruction is Low.

When N = "Low", 1-line display mode is set.

When N = "High", 2-line display mode is set.

When NW = "High", N bit is invalid, it means 4-line mode independent of N bit.

RE : Extended function registers enable bit

When RE = "High", extended function set registers, SEGRAM address set registers, HS bits of scroll enable instruction and BE bits of function set register can be accessed.

BE : CGRAM/SEGRAM data blink enable bit

BE = "High", makes user font of CGRAM and segment of SEGRAM blinking. The quantity of blink is assigned the highest 2 bit of CGRAM/SEGRAM.

LP : Low power consumption mode enable bit

When EXT port input is "Low"(without extension driver) and LP bit is set to "High", S6A0073 operates in low power consumption mode.

During 1-line mode S6A0073 operates on a 4-division clock, and in 2-line or 4-line mode it operates on a 2-division clock. According to this instruction, execution time becomes 4 or 2 times longer.

Note not to use display shift instruction, it may happen wrong operation.

And the frame frequency is lower to 5/6 than that of normal operation.

Set CGRAM Address (RE = 0)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0

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

Set SEGRAM Address (RE = 1)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	1	X	X	AC3	AC2	AC1	AC0

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

Set DDRAM Address (RE = 0)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0

Set DDRAM address to AC.
This instruction makes DDRAM data available from MPU.
In 1-line display mode (N = 0, NW = 0), DDRAM address is from "00H" to "4FH".
In 2-line display mode (N = 1, NW = 0), DDRAM address in the 1st line is from "00H" to "27H", and DDRAM address in the 2nd line is from "40H" to "67H".
In 4-line display mode (NW = 1), DDRAM address is from "00H" to "13H" in the 1st line, from "20H" to "33H" in the 2nd line, from "40H" to "53H" in the 3rd line and from "60H" to "73H" in the 4th line.

Set Scroll Quantity (RE = 1)

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	1	X	SQ5	SQ4	SQ3	SQ2	SQ1	SQ0

Setting SQ5 to SQ0, horizontal scroll quantity can be controlled in dot units. (refer to Table 12). In this case S6A0073 execute dot smooth scroll from 1 to 48 dots.

Table 12. Scroll Quantity According to HDS bits

SQ5	SQ4	SQ3	SQ2	SQ1	SQ0	Function
0	0	0	0	0	0	No shift
0	0	0	0	0	1	shift left by 1-dot
0	0	0	0	1	0	shift left by 2-dot
0	0	0	0	1	1	shift left by 3-dot
:	:	:	:	:	:	:
1	0	1	1	1	1	shift left by 47-dot
1	1	X	X	X	X	shift left by 48-dot

Read Busy Flag & Address

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0

This instruction shows whether S6A0073 is in internal operation or not. If the resultant BF is High, the internal operation is in progress and should wait until BF becomes "LOW", which by then the next instruction can be performed. In this instruction value of address counter can also be read.

Write data to RAM

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	0	D7	D6	D5	D4	D3	D2	D1	D0

Write binary 8-bit data to DDRAM/CGRAM/SEGRAM.

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

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

Read data from RAM

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	1	D7	D6	D5	D4	D3	D2	D1	D0

Read binary 8-bit data from DDRAM/CGRAM/SEGRAM.

The selection of RAM is set by the previous address set instruction. If address set instruction of RAM is not performed before this instruction, the data that read first is invalid, because the direction of AC is not determined. If the RAM data several is read times without RAM address set instruction before read operation, the correct RAM data from the second, but the first data would be incorrect, as there is no time margin to transfer RAM data. In case of DDRAM read operation, cursor shift instruction plays the same role as DDRAM address set instruction : it also transfer RAM data to output data register.

After read operation address counter is automatically increased/decreased by 1 according to the entry mode. After CGRAM/SEGRAM read operation, display shift may not be executed correctly.

NOTE: In case of RAM write operation, after this AC is increased/decreased by 1 as in read operation after this. In this time, AC indicates the next address position, but the previous data can only be read by read instruction.

INTERFACE WITH MPU

S6A0073 can transfer data in bus mode (4-bit or 8-bit) or serial mode with MPU. Hence, both types 4 or 8-bit MPU can be used. In case of 4-bit bus mode, data transfer is performed by two times to transfer 1 byte data.

1. When interfacing data length are 4-bit, only 4 ports, from DB4 to DB7, are used as data bus.
At first higher 4-bit (in case of 8-bit bus mode, the contents of DB4 - DB7) are transferred, and then lower 4-bit (in case of 8-bit bus mode, the contents of DB0 - DB3) are transferred. So transfer is performed by two times.
Busy Flag outputs "High" after the second transfer are ended.
2. When interfacing data length are 8-bit, transfer is performed at a time through 8 ports, from DB0 to DB7.
3. If IM is set to "Low", serial transfer mode is set.

INTERFACE WITH MPU IN BUS MODE

Interface with 8-bits MPU

If 8-bits MPU is used, S6A0073 can connect directly with that. In this case, port E, RS, R/W and DB0 to DB7 need to interface each other. Example of timing sequence is shown below.

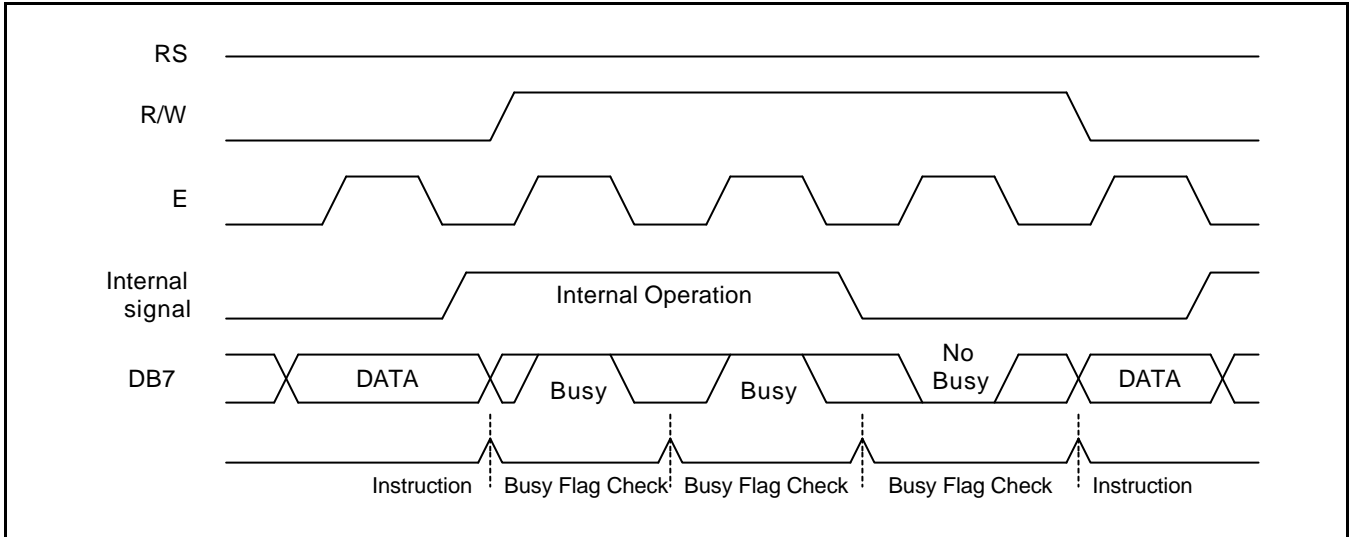


Figure 17. Example of 8-bit Bus Mode Timing Sequence

Interface with 4-bits MPU

If 4-bits MPU is used, S6A0073 can connect directly with this. In this case, E, RS, R/W and DB4 to DB7 need to interface each other. The transfer is performed by twice. Example of timing sequence is shown below.

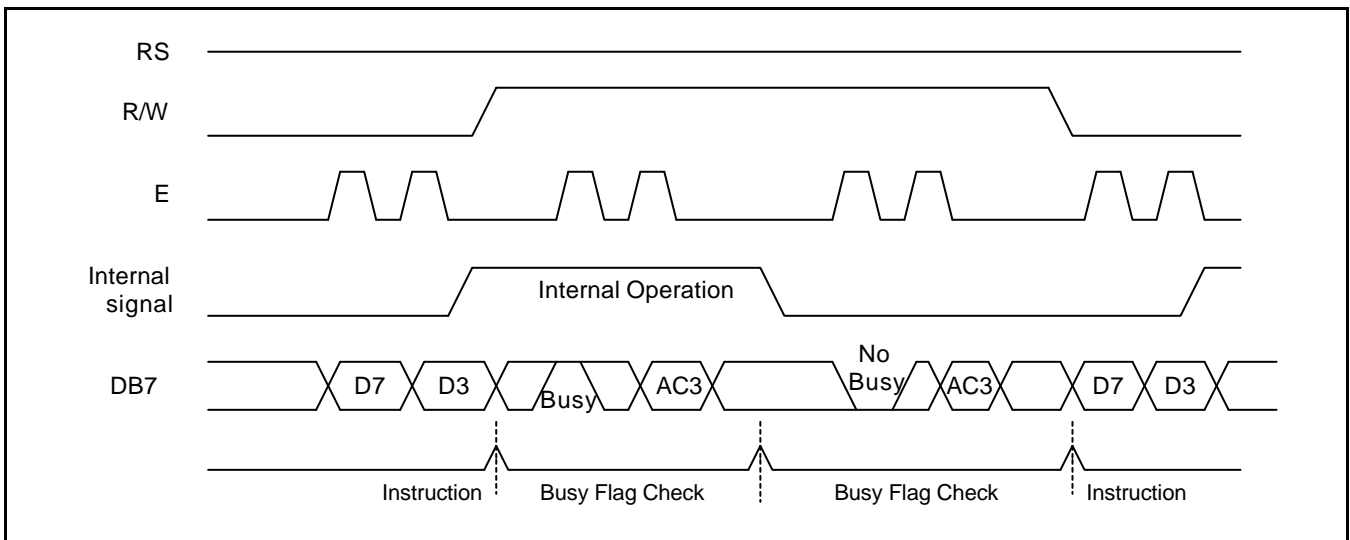


Fig 18. Example of 4-bit Bus Mode Timing Sequence

Interface with MPU in Serial Mode

When IM input is "Low", serial interface mode is started. At this time, all three ports, SCLK (synchronizing transfer clock), SID (serial input data), and SOD (serial output data), are used. If S6A0073 is to be used with other chips, chip select port (CS) can be used. By setting CS to "Low", S6A0073 can receive SCLK input. If CS is set to "High", S6A0073 reset the internal transfer counter.

Before transfer real data, start byte has to be transferred. It is composed of succeeding 5 "High" bits, register read write control bit (R/W), register selection bit (RS) and end bit that indicates the end of start byte. Whenever succeeding 5 "High" bits are detected by S6A0073, it resets the serial transfer counter and prepares to receive next information. The next input data is the register selection bit which determines which register will be used, and read write control bit that determine the direction of data. Then end bit is transferred, which must have "Low" value to show the end of start byte. (refer to Figure 19, Figure 20)

(1) Write Operation (R/W = 0)

After start byte is transferred from MPU to S6A0073, 8-bit data is transferred which is divided into 2 bytes, each byte has 4 bit's real data and 4 bit's partition token data. For example, if real data is "10110001" (D0 - D7), then serially transferred data becomes "1011 0000 0001 0000" where 2nd and 4th 4 bits must be "0000" for safe transfer. To transfer several bytes continuously without changing RS bit and RW bit, start byte transfer is needed only at first starting time, i. e, after first start byte is transferred, real data succeeding can be transferred.

(2) Read Operation (R/W = 1)

After start byte is transferred to S6A0073, MPU can receive 8-bit data through the SOD at a time from the LSB. Waiting time is needed to insert between start byte and data reading, as internal reading from RAM requires some delay. Continuous data reading is possible such as serial write operation. It also needs only one start bytes, only if some delay between reading operations of each byte is inserted. During the reading operation, S6A0073 observes succeeding 5 "High" from MPU. If it is detected, S6A0073 restarts serial operation at once and prepares to receive RS bit. So in continuous reading operation, SID port must be "low".

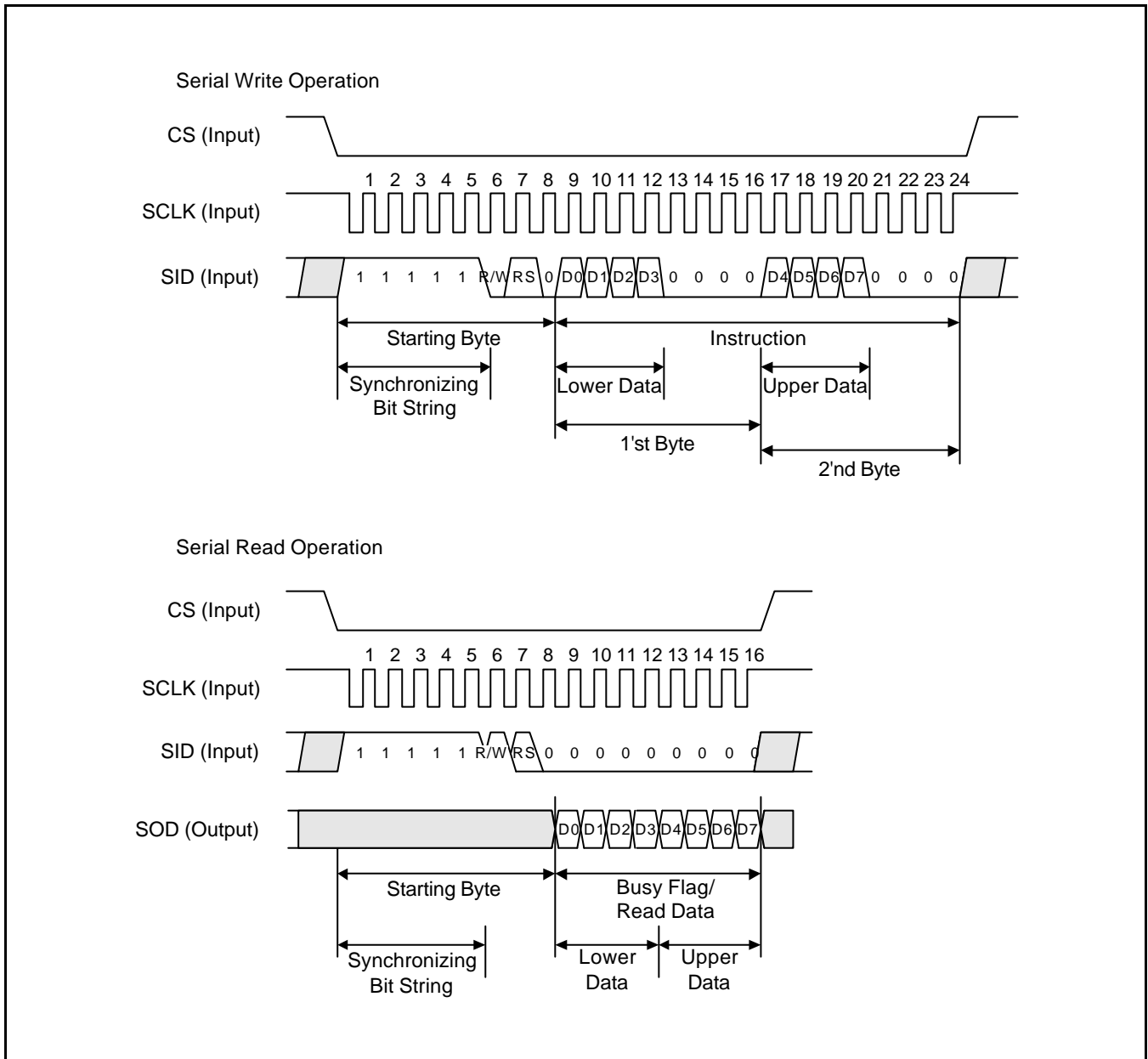


Figure 19. Timing Diagram of Serial Data Transfer

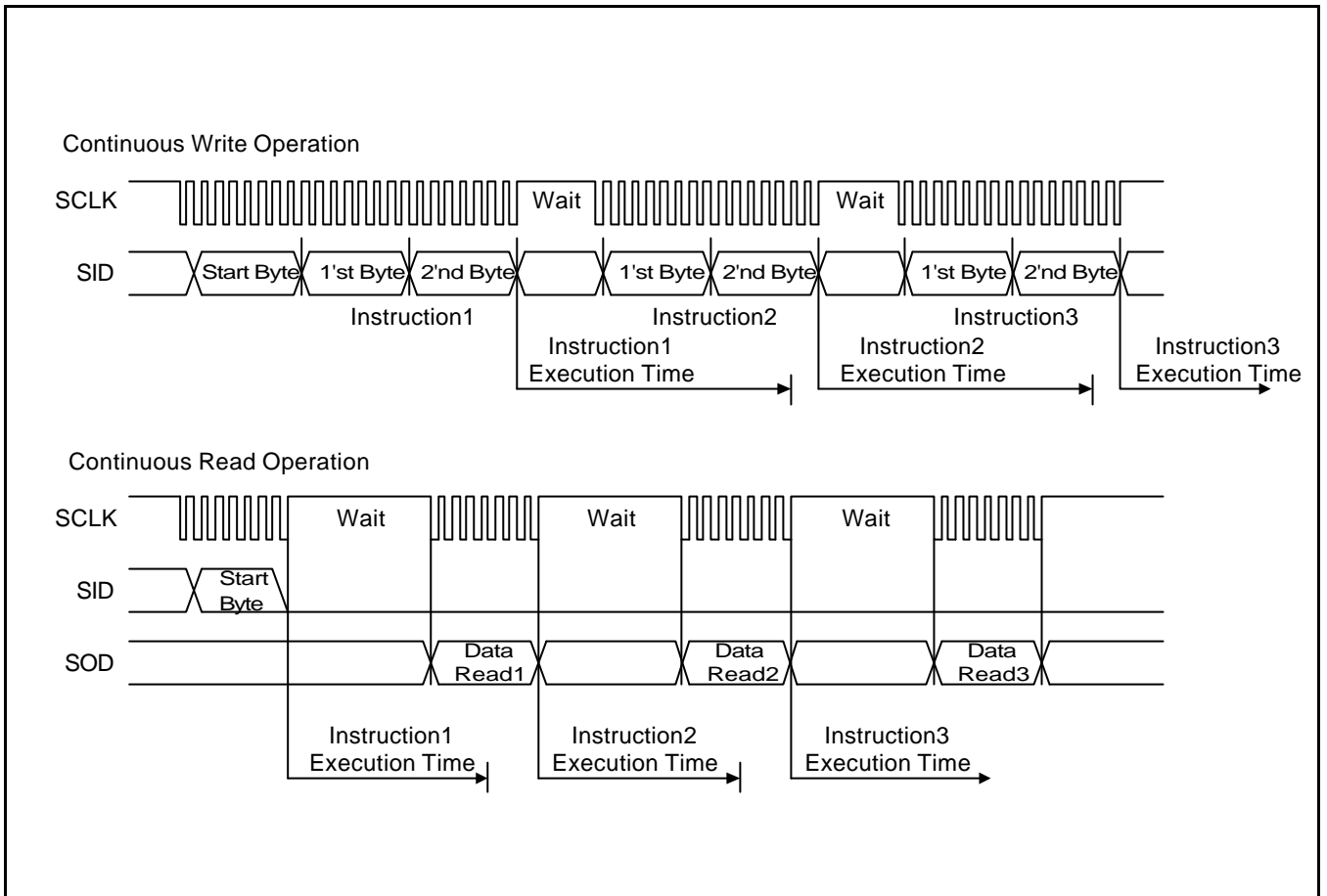
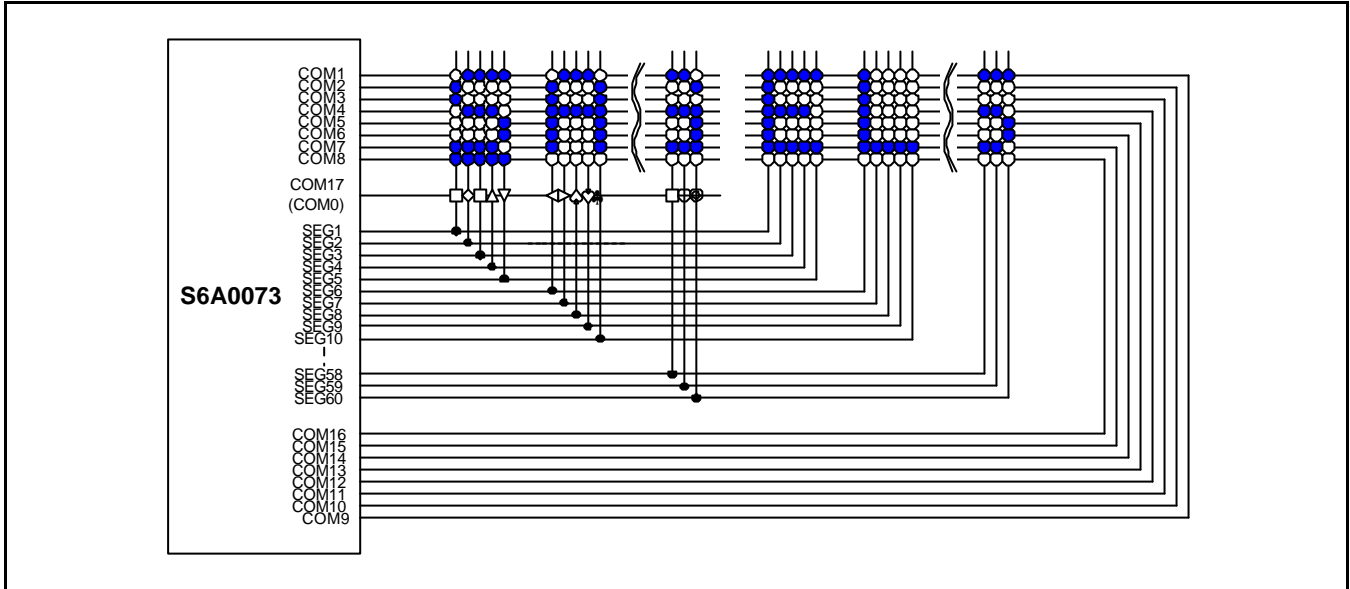


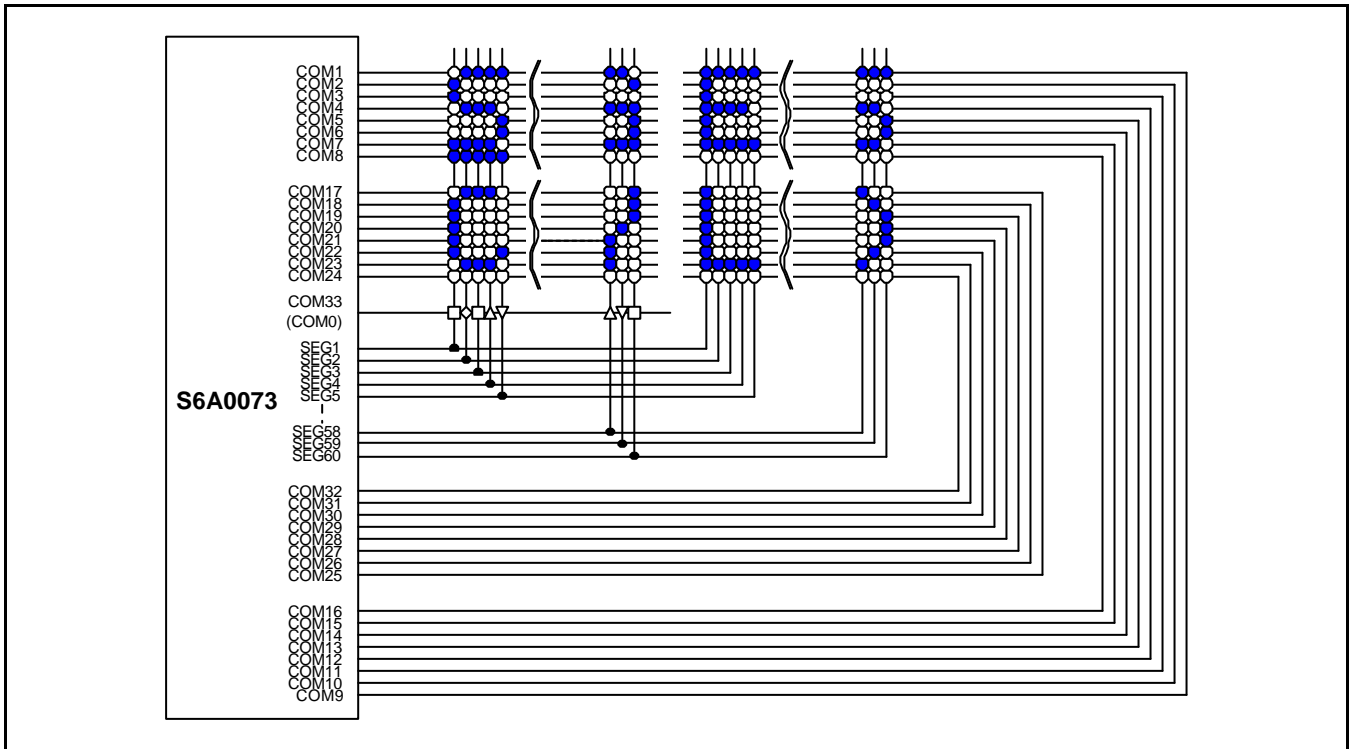
Fig 20. Timing Diagram of Continuous Data Transfer

APPLICATION INFORMATION ACCORDING TO LCD PANEL

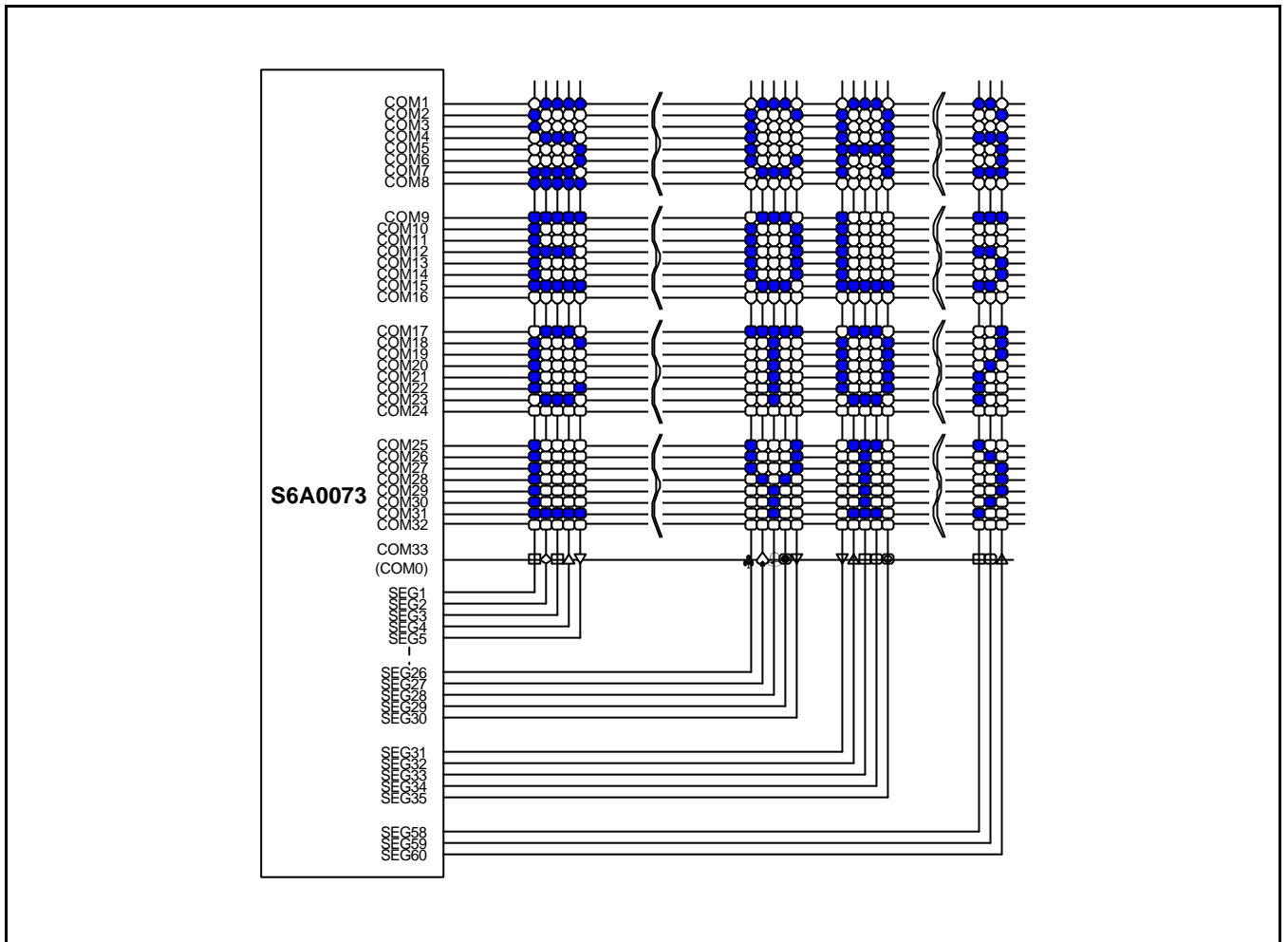
LCD Panel: 24 Character x 1-line Format (5-dot Font, 1/17 Duty)



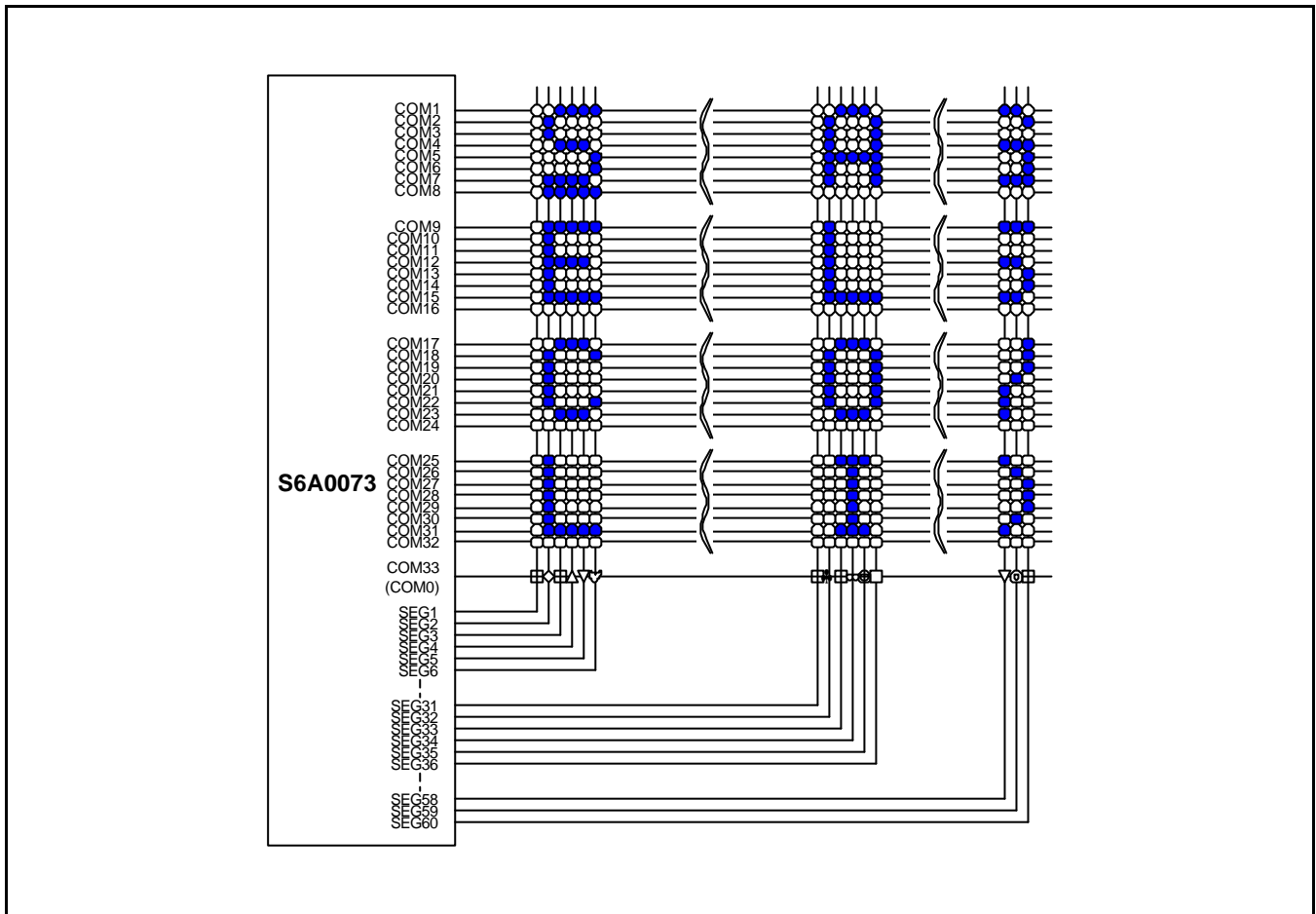
LCD Panel: 24 Character x 2-line Format (5-dot Font, 1/33 Duty)



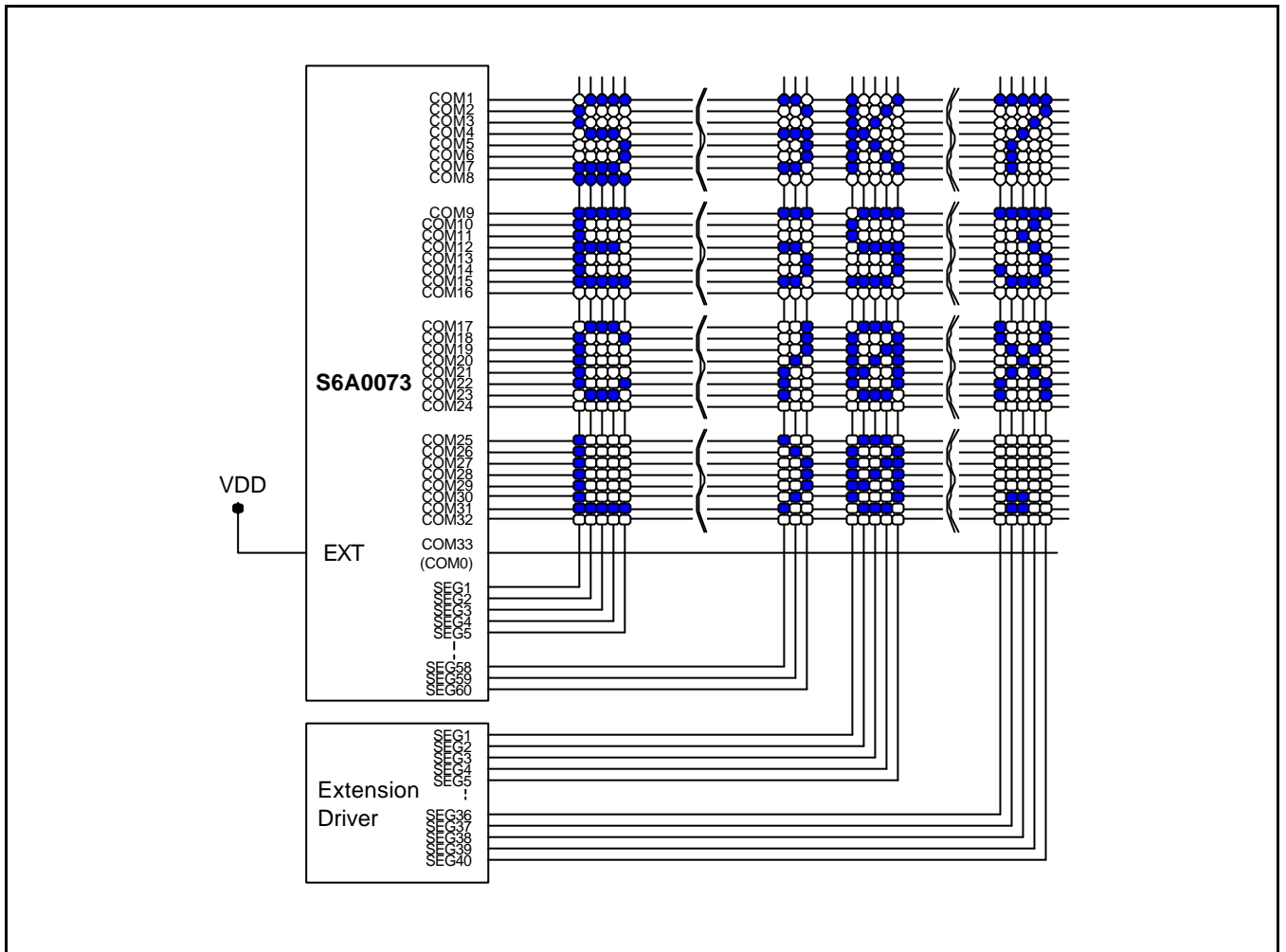
LCD Panel: 12 Character x 4-line Format (5-dot Font, 1/33 Duty)



LCD Panel: 10 Character 4-line Format (6-dot Font, 1/33 Duty)



LCD Panel: 20 Character x 4-line Format (5-dot Font, 1/33 Duty)



INITIALIZING

Initializing by Internal Reset Circuit

When the power is turned on, S6A0073 is initialized automatically by power on reset circuit. During the initialization, the following instructions are executed, and BF(Busy Flag) is kept "High"(busy state) to the end of initialization.

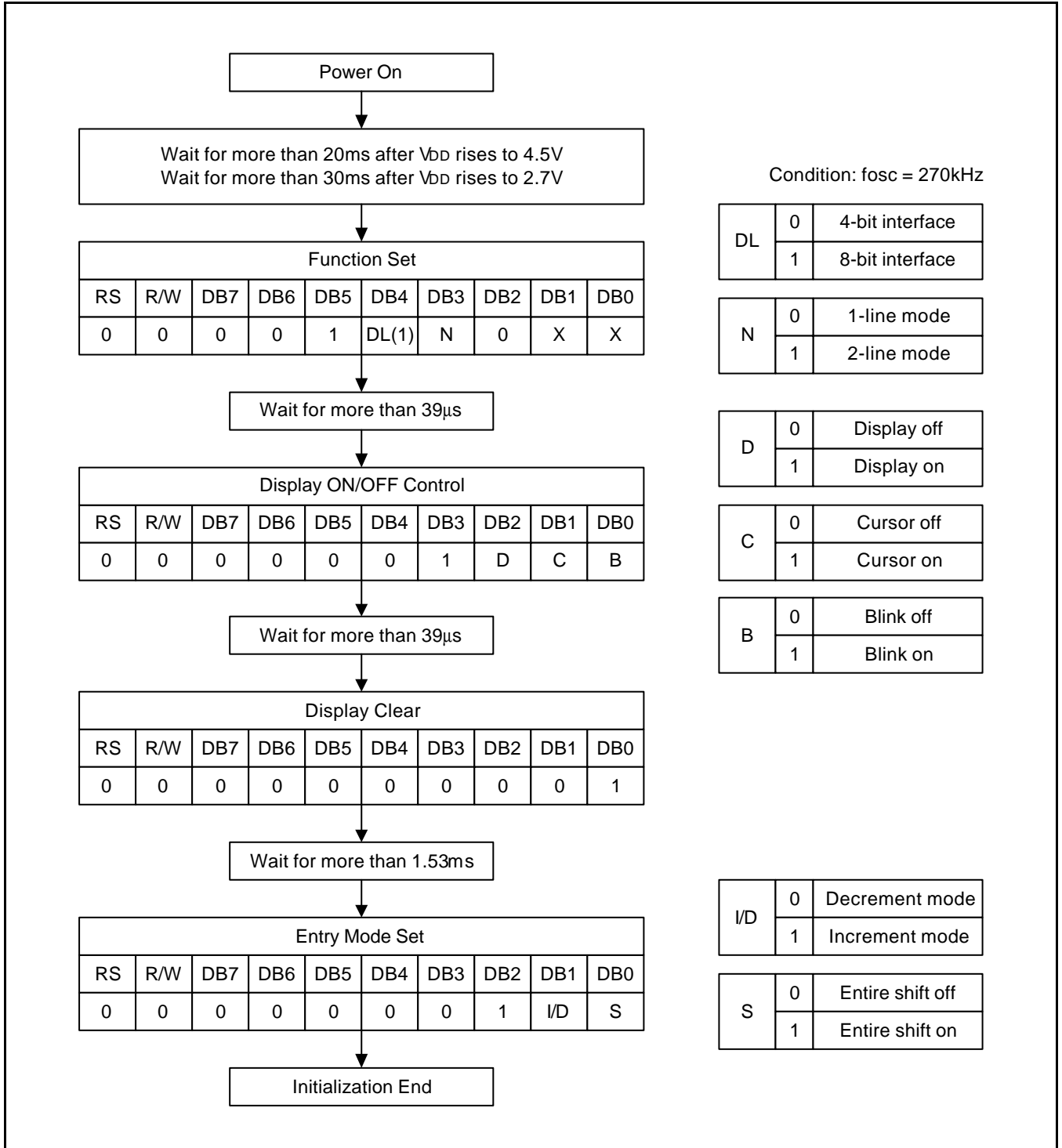
- (1) Display Clear instruction
Write "20H" to all DDRAM
- (2) Set Functions instruction
DL = 1 : 8-bit bus mode
N = 1 : 2-line display mode
RE = 0 : Extension register disable
BE = 0 : CGRAM/SEGRAM blink OFF
LP = 0 : Operate in normal mode (Not in Low Power Mode)
DH = 0 : Horizontal scroll enable
REV = 0 : Normal display mode (Not reversed display)
- (3) Control Display ON/OFF instruction
D = 0 : Display OFF
C = 0 : Cursor OFF
B = 0 : Blink OFF
- (4) Set Entry Mode instruction
I/D = 1 : Increment by 1
S = 0 : No entire display shift
BID = 0 : Normal direction segment port
- (5) Set Extension Function instruction
FW = 0 : 5-dot font width character display
B/W = 0 : Normal cursor (8th line)
NW = 0 : Not 4-line display mode, 2-line mode is set because of N("1")
- (6) Enable Scroll/Shift instruction
HS = 0000 : Scroll per line disable
DS = 0000 : Shift per line disable
- (7) Set scroll Quantity instruction
SQ = 000000 : Not scroll

Initializing by Hardware RESET input

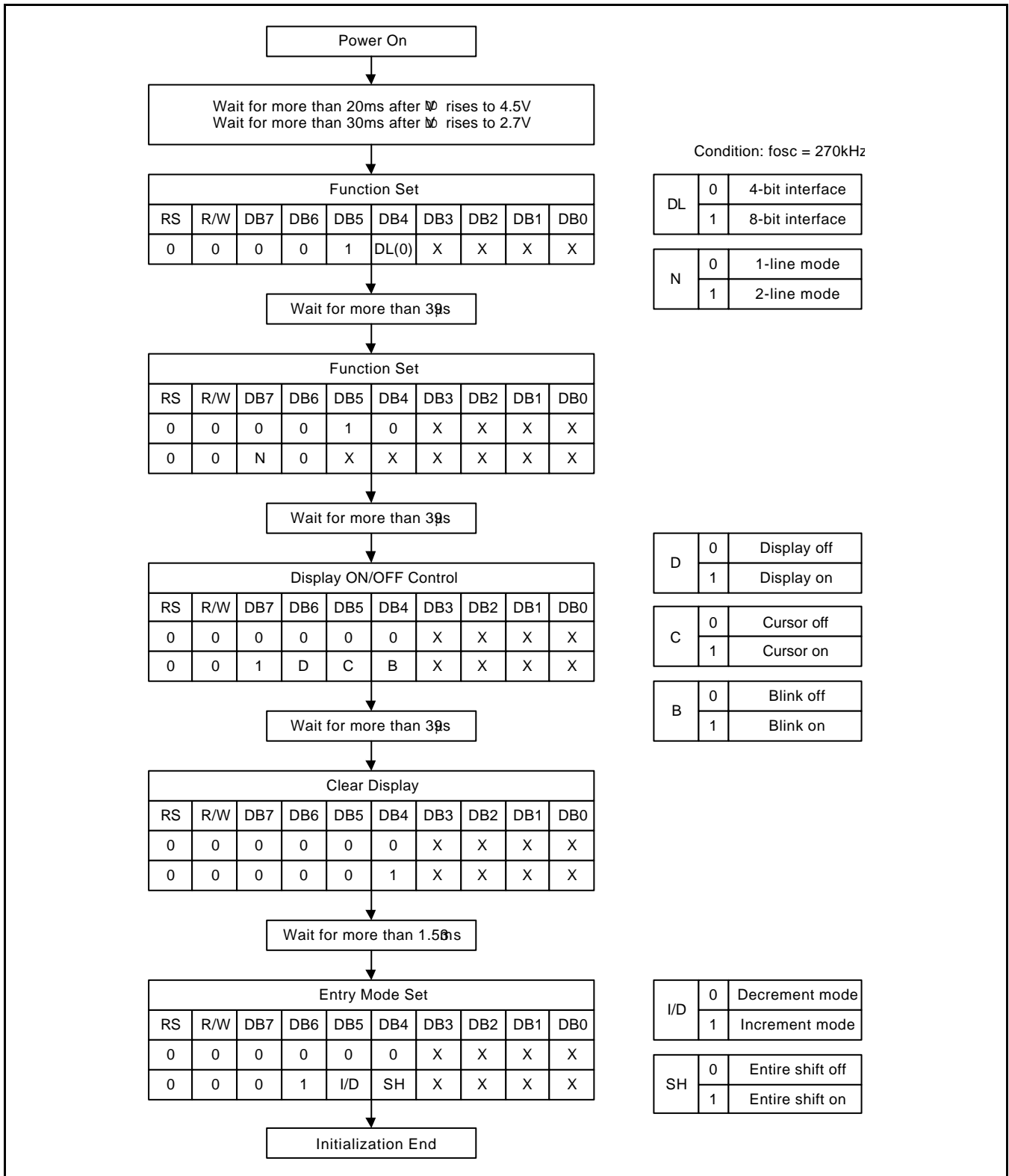
When RESET pin = "Low", S6A0073 can be initialized like the case of power on reset. During the power on reset operation, this pin is ignored.

INITIALIZING BY INSTRUCTION

8-bit Interface Mode



4-bit Interface Mode



EXAMPLE OF INSTRUCTION AND DISPLAY CORRESPONDENCE

IE = "Low"

										LCD DISPLAY
1. Power supply on: Initialized by the internal power on reset circuit										[]
RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
2. Function Set: 8-bit, 1-line, RE (0)										[]
RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
0	0	0	0	1	1	0	0	X	X	
3. Display ON/OFF Control: Display/Cursor on										[_]
RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
0	0	0	0	0	0	1	1	1	0	
4. Entry Mode Set: Increment										[_]
RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
0	0	0	0	0	0	0	1	1	0	
5. Write Data to DDRAM: Write S										[S_]
RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
1	0	0	1	0	1	0	0	1	1	
6. Write Data to DDRAM: Write A										[SA_]
RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
1	0	0	1	0	0	0	0	0	1	
7. Write Data to DDRAM: Write M										[SAM_]
RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
1	0	0	1	0	0	1	1	0	1	
8. Write Data to DDRAM: Write S										[SAMS_]
RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
1	0	0	1	0	1	0	0	1	1	



9. Write Data to DDRAM: Write U

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

LCD DISPLAY

SAMSU_

10. Write Data to DDRAM: Write N

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

SAMSUN_

11. Write Data to DDRAM: Write G

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

SAMSUNG_

12. Cursor or Display Shift: Cursor shift to right

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

SAMSUNG_

13. Entry Mode Set: Entire Display Shift Enable

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

SAMSUNG_

14. Write Data to DDRAM: Write S

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

AMSUNG S_

15. Write Data to DDRAM: Write 6

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

MSUNG S6_

16. Write Data to DDRAM: Write A

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

SUNG S6A_

17. Write Data to DDRAM: Write 0

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

LCD DISPLAY

UNG S6A00_

18. Write Data to DDRAM: Write 7

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

NG S6A007_

19. Write Data to DDRAM: Write 3

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

G S6A0073_

20. Cursor or Display Shift: Cursor shift left

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

G S6A007 3

21. Write Data to DDRAM: Write 3

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

S6A0073_

22. Return Home

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

SAMSUNG S6A0073

23. Clear Display

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

_



IE = "High"

1. Power Supply on: Initialized by the internal power on reset circuit

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

2. Function Set: 8-bit, RE(1)

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

3. Extended Function Set: 5-font, 4-line

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

4. Function Set: RE(0)

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

5. Display ON/OFF Control: Display/Cursor on

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

6. Write Data to DDRAM: Write S

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

7. Write Data to DDRAM: Write A

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

SAMSUNG
SA_

⋮

12. Write Data to DDRAM: Write G

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

SAMSUNG
S_

13. Set DDRAM Address 20H

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

SAMSUNG
_

14. Write Data to DDRAM: Write S

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

SAMSUNG
S_

⋮

19. Write Data to DDRAM: Write 3

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

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20. Set DDRAM Address 40H

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

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_



21. Write Data to DDRAM: Write L

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

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S6A0073
L_

30. Write Data to DDRAM: Write R

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

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LCD DRIVER_

31. Set DDRAM Address 60H

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

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LCD DRIVER
_

43. Write Data to DDRAM: Write R

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

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LCD DRIVER
& CONTROLLER_

44. Function Set: RE("0"), DH("1")

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

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LCD DRIVER
& CONTROLLER_

45. Function Set: RE("1")

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

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& CONTROLLER_

46. Shift/Scroll Enable: DS4("1"), DS3/2/1("0")

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

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47. Function Set: RE("0")

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

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LCD DRIVER
& CONTROLLER_

48. Cursor or Display Shift: Display shift to left

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

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LCD DRIVER
CONTROLLER_

49. Cursor or Display Shift: Display shift to left

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

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LCD DRIVER
CONTROLLER_

50. Cursor or Display Shift: Display shift to left

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

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LCD DRIVER
ONTROLLER_

51. Cursor or Display Shift: Display shift to left

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

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S6A0073
LCD DRIVER
NTROLLER_

52. Return Home

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

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LCD DRIVER
& CONTROLLER

53. Function Set: RE("0"), REV("1")

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

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LCD DRIVER
& CONTROLLER

54. Cursor or Display Shift: Display shift to right

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

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& CONTROLLER

55. Cursor or Display Shift: Display shift to right

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

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LCD DRIVER
& CONTROLLER

56. Return Home

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

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& CONTROLLER

57. Function Set: RE("0"), REV("0")

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

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& CONTROLLER

58. Function Set: RE("1")

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

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59. Entry Mode Set: BID("1")

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

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& CONTROLLER

60. Write Data to DDRAM: Write B

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

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& CONTROLLER

61. Write Data to DDRAM: Write I

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

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& CONTROLLER

62. Write Data to DDRAM: Write D

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

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LCD DRIVER
& CONTROLLER

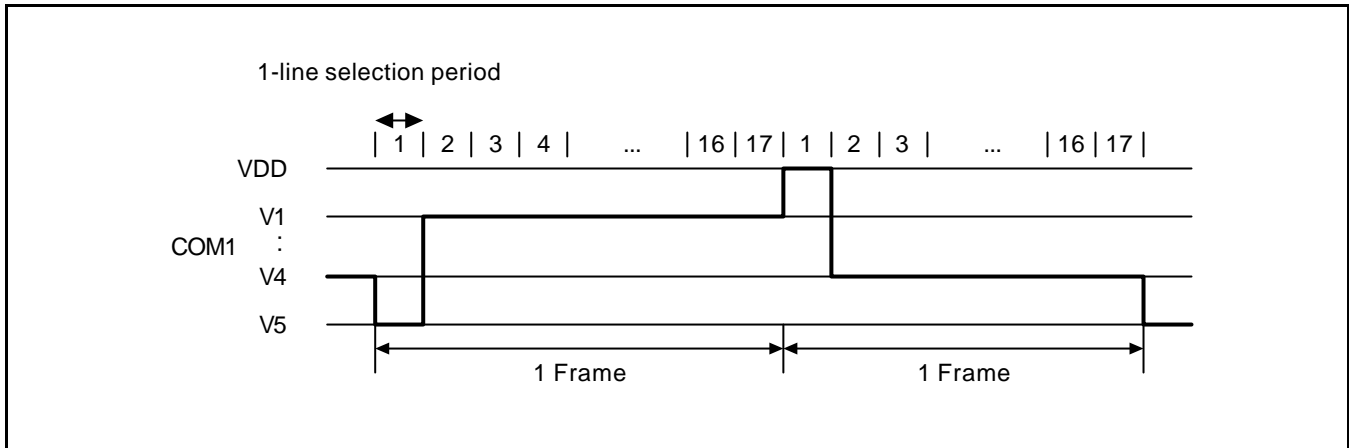
63. Clear Display

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

-

FRAME FREQUENCY

1/17 Duty Cycle

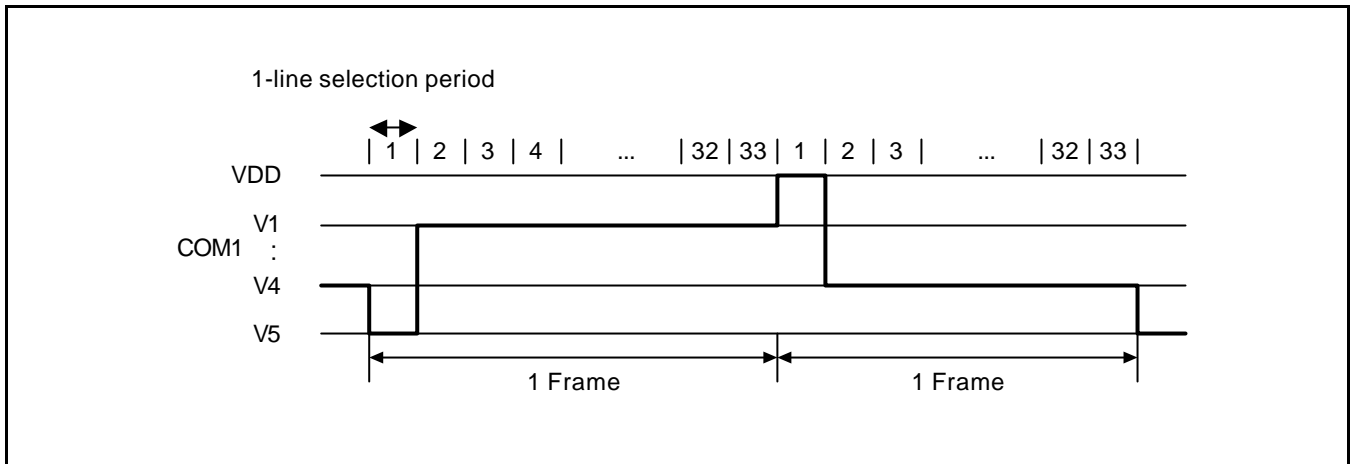


Item	Normal Display Mode (LP = 0)	
	5-dot font width	6-dot font width
1-line selection period	200 clocks	240 clocks
Frame frequency	79.4Hz	66.2Hz

Item	Low Power Mode (LP = 1)	
	5-dot font width	6-dot font width
1-line selection period	60 clocks	72 clocks
Frame frequency	66.2Hz	55.1Hz

NOTE: $f_{OSC} = 270\text{kHz}$ (1 clock = $3.7\mu\text{s}$)

1/33 Duty Cycle



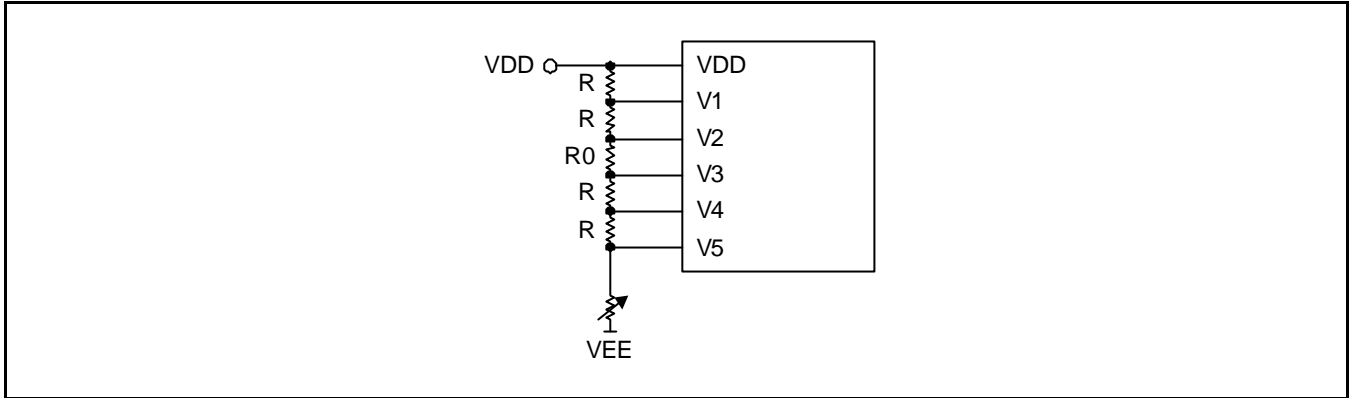
Item	Normal Display Mode (LP = 0)	
	5-dot font width	6-dot font width
1-line selection period	100 clocks	120 clocks
Frame frequency	81.8Hz	68.2Hz

Item	Normal Display Mode (LP = 1)	
	5-dot font width	6-dot font width
1-line selection period	60 clocks	72 clocks
Frame frequency	68.2Hz	56.8Hz

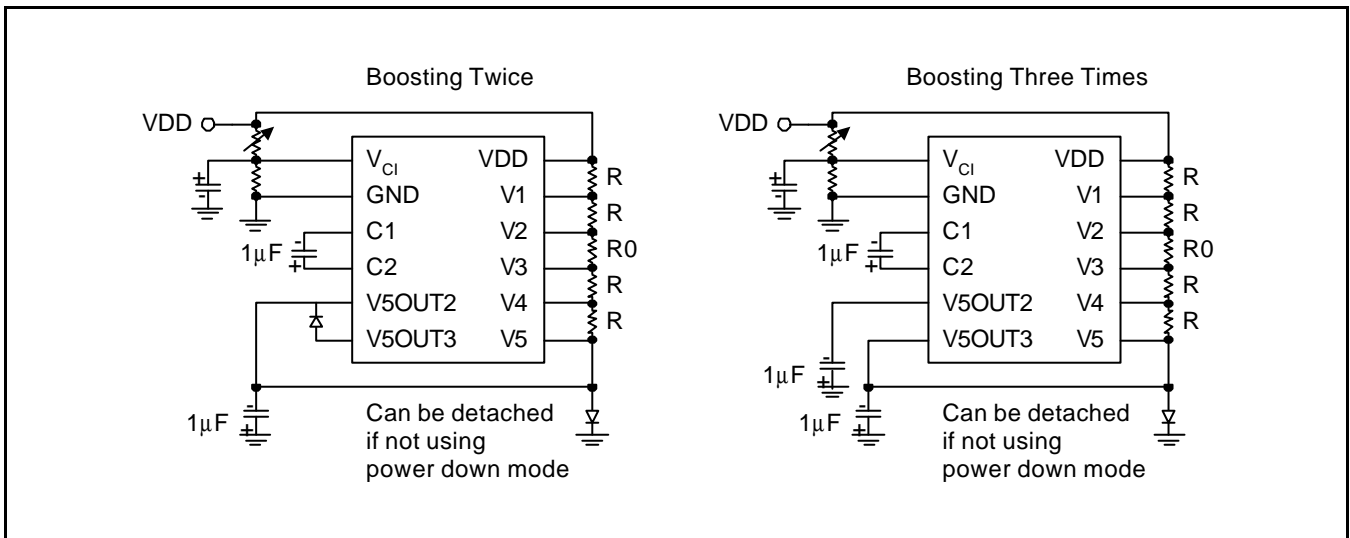
NOTE: $f_{OSC} = 270kHz$ (1 clock = $3.7\mu s$)

POWER SUPPLY FOR DRIVING LCD PANEL

When an external power supply is used



When an internal booster is used



NOTES:

1. Boosted output voltage should not exceed the maximum value (13 V) of the LCD driving voltage. Especially, a voltage of over 4.3V should not be input to the reference voltage(Vci) when boosting three times.
2. A voltage of over 5.5V should not be input to the reference voltage (Vci) when boosting twice.
3. The value of resistance, according to the number of lines, duty ratio and the bias, is shown below. (Refer to Table 13)

Table 13. Duty Ratio and Power Supply for LCD Driving

Item		Data	
Number of lines		1	2 or 4
Duty ratio		1/17	1/33
Bias		1/5	1/6.7
Divided resistance	R	R	R
	R0	R	2.7R

MAXIMUM ABSOLUTE RATE

Characteristic	Symbol	Value	UNIT
Power Supply Voltage (1)	V_{DD}	-0.3 to +7.0	V
Power Supply Voltage (2)	V_{LCD}	$V_{DD} - 15.0$ to $V_{DD} + 0.3$	V
Input Voltage	V_{IN}	-0.3 to $V_{DD} + 0.3$	V
Operating Temperature	T_{OPR}	-30 to +80	°C
Storage Temperature	T_{STG}	-55 to +125	°C

NOTE: Voltage greater than above may damage to the circuit ($V_{DD} \geq V1 \geq V2 \geq V3 \geq V4 \geq V5$)

ELECTRICAL CHARACTERISTICS

DC Characteristics

($V_{DD} = 2.7V$ to $5.5V$, $T_A = -30$ to $+85^\circ C$)

Characteristic	Symbol	Condition	Min	Typ	Max	Unit	
Operating Voltage	V_{DD}	–	2.7	–	5.5	V	
Supply Current	I_{DD}	Internal oscillation or external clock. ($V_{DD}=3.0V$, $f_{OSC} = 270kHz$)	–	0.15	0.3	mA	
Input Voltage (1) (except OSC1)	V_{IH1}	–	$0.7V_{DD}$	–	V_{DD}	V	
	V_{IL1}	$V_{DD} = 2.7$ to 3.0	-0.3	–	$0.2V_{DD}$		
		$V_{DD} = 3.0$ to 5.5	-0.3	–	0.6		
Input Voltage (2) (OSC1)	V_{IH2}	–	$0.7V_{DD}$	–	V_{DD}	V	
	V_{IL2}	–	–	–	$0.2V_{DD}$		
Output Voltage (1) (DB0 to DB7)	V_{OH1}	$I_{OH} = -0.1mA$	$0.75V_{DD}$	–	–	V	
	V_{OL1}	$I_{OL} = 0.1mA$	–	–	$0.2V_{DD}$		
Output Voltage (2) (expect DB0 to DB7)	V_{OH2}	$I_O = -40\mu A$	$0.8V_{DD}$	–	–	V	
	V_{OL2}	$I_O = 40\mu A$	–	–	$0.2V_{DD}$		
Voltage Drop	V_{dCOM}	$I_O = \pm 0.1mA$	–	–	1	V	
	v_{dSEG}		–	–	1		
Input Leakage Current	I_{IL}	$V_{IN} = 0V$ to V_{DD}	-1	–	1	μA	
Low Input Current	I_{IN}	$V_{IN} = 0V$, $V_{DD} = 3V$ (pull up)	-10	-50	-120		
Internal Clock (external R_f)	f_{OSC}	$R_f = 91k\Omega \pm 2\%$ ($V_{DD} = 5V$)	190	270	350	kHz	
External Clock	f_{EC}	–	125	270	410	kHz	
	Duty		45	50	55	%	
	t_R , t_F		–	–	0.2	μs	
Voltage Converter Out2 ($V_{ci} = 4.5V$)	V_{OUT2}	$T_A = 25^\circ C$, $C = 1\mu F$, $I_{OUT} = 0.25mA$, $f_{OSC} = 270kHz$	-3.0	-4.2	–	V	
Voltage Converter Out3 ($V_{ci} = 2.7V$)	V_{OUT3}		-4.3	-5.1	–		
Voltage Converter Input LCD Driving Voltage	V_{ci}	–	2.5	–	4.5	V	
	V_{LCD}	$V_{DD}-V_5$	1/5 bias	3.0	–		13.0
			1/6.7 bias	3.0	–		13.0

AC Characteristics $(V_{DD} = 4.5 \text{ to } 5.5\text{V}, T_A = -30 \text{ to } +85^\circ\text{C})$

Mode	Item	Symbol	Min	Typ	Max	Unit
(1) Write Mode (refer to Figure 21)	E Cycle Time	t_C	500	–	–	ns
	E Rise/Fall Time	t_R, t_F	–	–	20	
	E Pulse Width (High, Low)	t_W	230	–	–	
	R/W and RS Setup Time	t_{SU1}	40	–	–	
	R/W and RS Hold Time	t_{H1}	10	–	–	
	Data Setup Time	t_{SU2}	60	–	–	
	Data Hold Time	t_{H2}	10	–	–	
(2) Read Mode (refer to Figure 22)	E Cycle Time	t_C	500	–	–	ns
	E Rise/Fall Time	t_R, t_F	–	–	20	
	E Pulse Width (High, Low)	t_W	230	–	–	
	R/W and RS Setup Time	t_{SU}	40	–	–	
	R/W and RS Hold Time	t_H	10	–	–	
	Data Output Delay Time	t_D	–	–	160	
	Data Hold Time	t_{DH}	5	–	–	
(3) Serial Interface Mode (refer to Figure 23)	Serial Clock Cycle Time	t_C	0.5	–	20	μs
	Serial Clock Rise/Fall Time	t_R, t_F	–	–	50	ns
	Serial Clock Width (High, Low)	t_W	200	–	–	
	Chip Select Setup Time	t_{SU1}	60	–	–	
	Chip Select Hold Time	t_{H1}	20	–	–	
	Serial Input Data Setup Time	t_{SU2}	100	–	–	
	Serial Input Data Hold Time	t_{H2}	100	–	–	
	Serial Output Data Delay Time	t_D	–	–	160	
	Serial Output Data Hold Time	t_{DH}	5	–	–	

AC Characteristics (Continued) $(V_{DD} = 2.7 \text{ to } 4.5\text{V}, T_A = -30 \text{ to } +85^\circ\text{C})$

Mode	Item	Symbol	Min	Typ	Max	Unit
(4) Write Mode (refer to Figure 21)	E Cycle Time	t_C	1000	–	–	ns
	E Rise/Fall Time	t_R, t_F	–	–	25	
	E Pulse Width (High, Low)	t_W	450	–	–	
	R/W and RS Setup Time	t_{SU1}	60	–	–	
	R/W and RS Hold Time	t_{H1}	20	–	–	
	Data Setup Time	t_{SU2}	195	–	–	
	Data Hold Time	t_{H2}	10	–	–	
(5) Read Mode (refer to Figure 22)	E Cycle Time	t_C	1000	–	–	ns
	E Rise/Fall Time	t_R, t_F	–	–	25	
	E Pulse Width (High, Low)	t_W	450	–	–	
	R/W and RS Setup Time	t_{SU}	60	–	–	
	R/W and RS Hold Time	t_H	20	–	–	
	Data Output Delay Time	t_D	–	–	360	
	Data Hold Time	t_{DH}	5	–	–	
(6) Serial Interface Mode (refer to Figure 23)	Serial Clock Cycle Time	t_C	1	–	20	μs
	Serial Clock Rise/Fall Time	t_R, t_F	–	–	50	ns
	Serial Clock Width (High, Low)	t_W	400	–	–	
	Chip Select Setup Time	t_{SU1}	60	–	–	
	Chip Select Hold Time	t_{H1}	20	–	–	
	Serial Input Data Setup Time	t_{SU2}	200	–	–	
	Serial Input Data Hold Time	t_{H2}	200	–	–	
	Serial Output Data Delay Time	t_D	–	–	360	
	Serial Output Data Hold Time	t_{DH}	5	–	–	

AC Characteristics (Continued)

($V_{DD} = 2.7$ to $5.5V$, $T_A = -30$ to $+85^\circ C$)

Mode	Item	Symbol	Min	Typ	Max	Unit
(7) Interface Mode with Extension Driver (refer to Figure 24)	Clock Pulse Width (High, Low)	t_W	800	-	-	ns
	Clock Rise/Fall Time	t_R, t_F	-	-	100	
	Clock Setup Time	t_{SU1}	500	-	-	
	Data Setup Time	t_{SU2}	300	-	-	
	Data Hold Time	t_{DH}	300	-	-	
	M Delay Time	t_{DM}	-1000	-	1000	

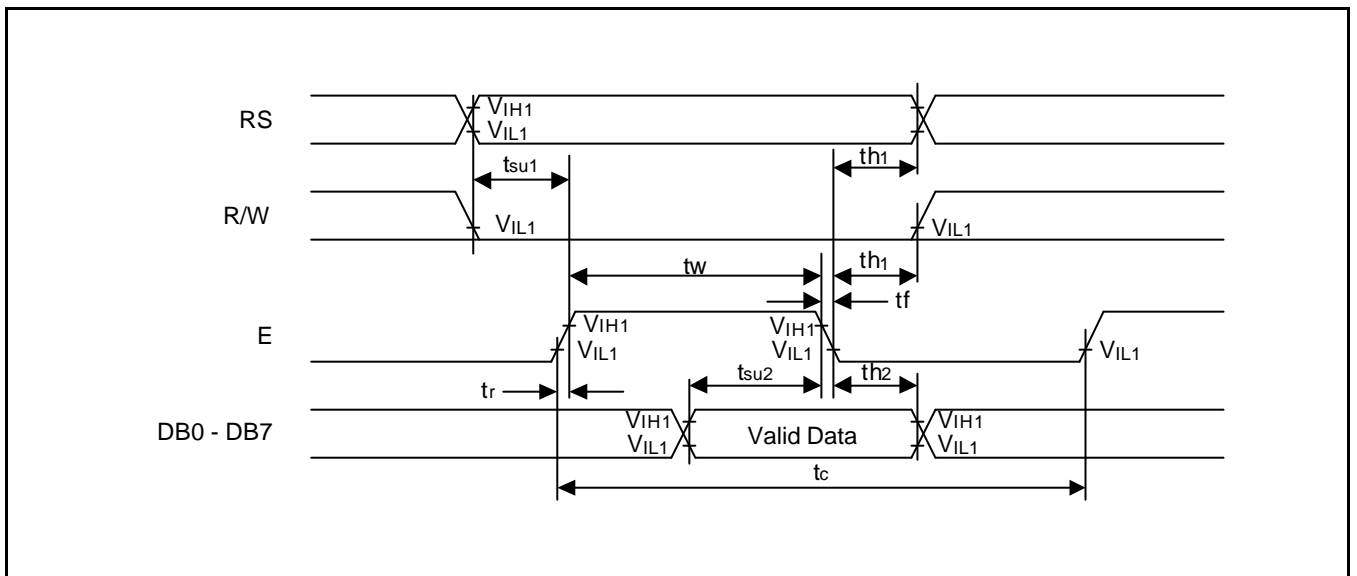


Figure 21. Write Mode

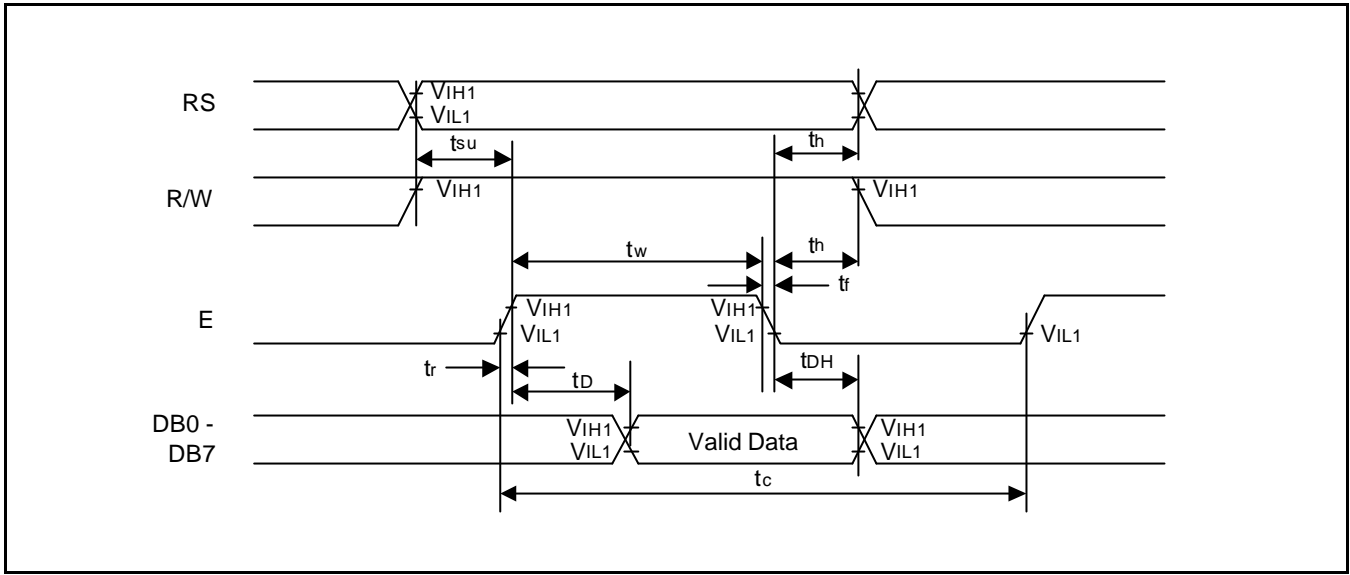


Figure 22. Read Mode

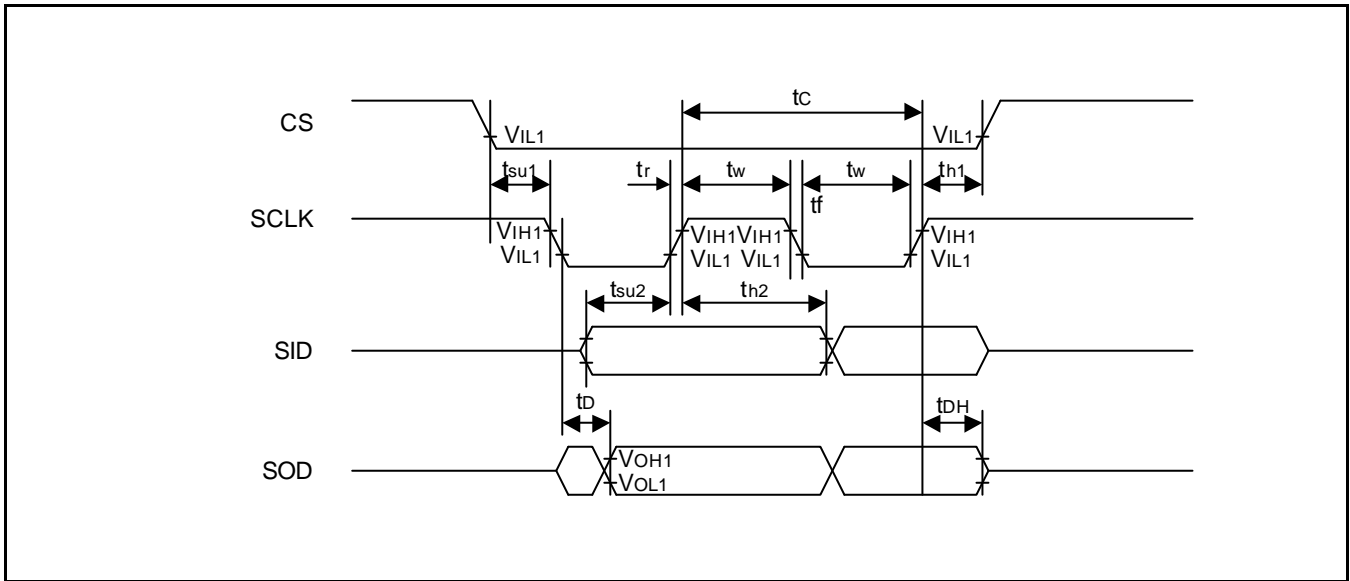


Figure 23. Serial Interface Mode

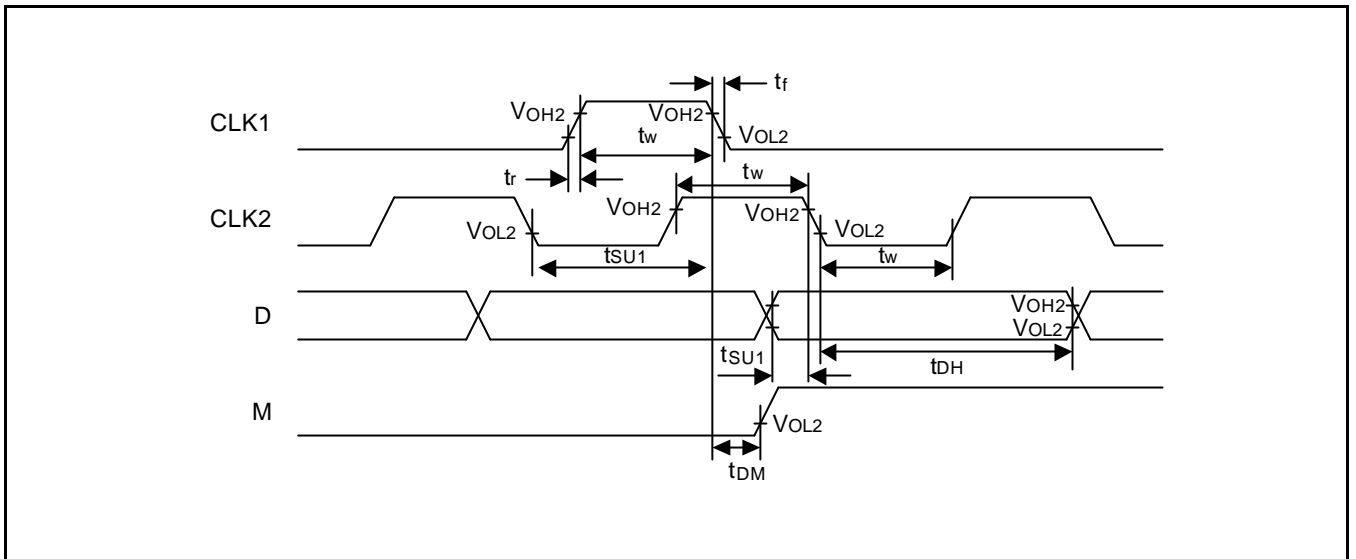


Figure 24. Interface Mode with Extension Driver

RESET TIMING

($V_{DD} = 2.7$ to $5.5V$, $T_A = -30$ to $+85^\circ C$)

Time	Symbol	Min	Typ	Max	Unit
Reset low level width (refer to Figure 24)	t_{RES}	10	-	-	ms

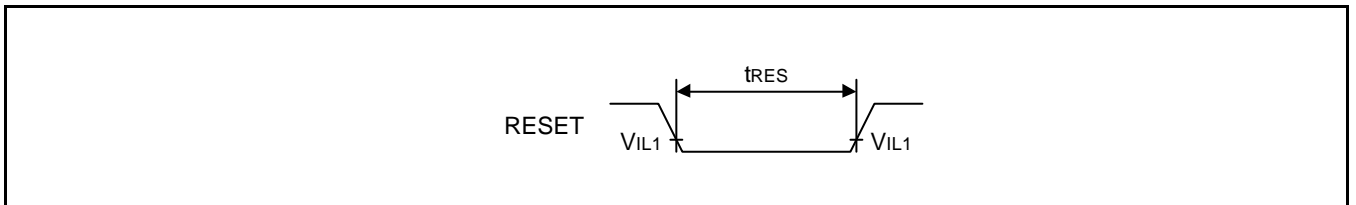


Figure 25. Reset Timing Diagram

NOTES