

# S6A0070

80 SEG / 16 COM DRIVER & CONTROLLER FOR DOT MATRIX LCD

June. 2000.

Ver. 0.0

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## INTRODUCTION

The S6A0070 is a dot matrix LCD driver & controller LSI which is fabricated by low power CMOS technology. It is capable of displaying 1 or 2 lines with the 5 × 7 format or 1 line with the 5 × 10 dots format.

The mirror type of S6A0070: S6A1070

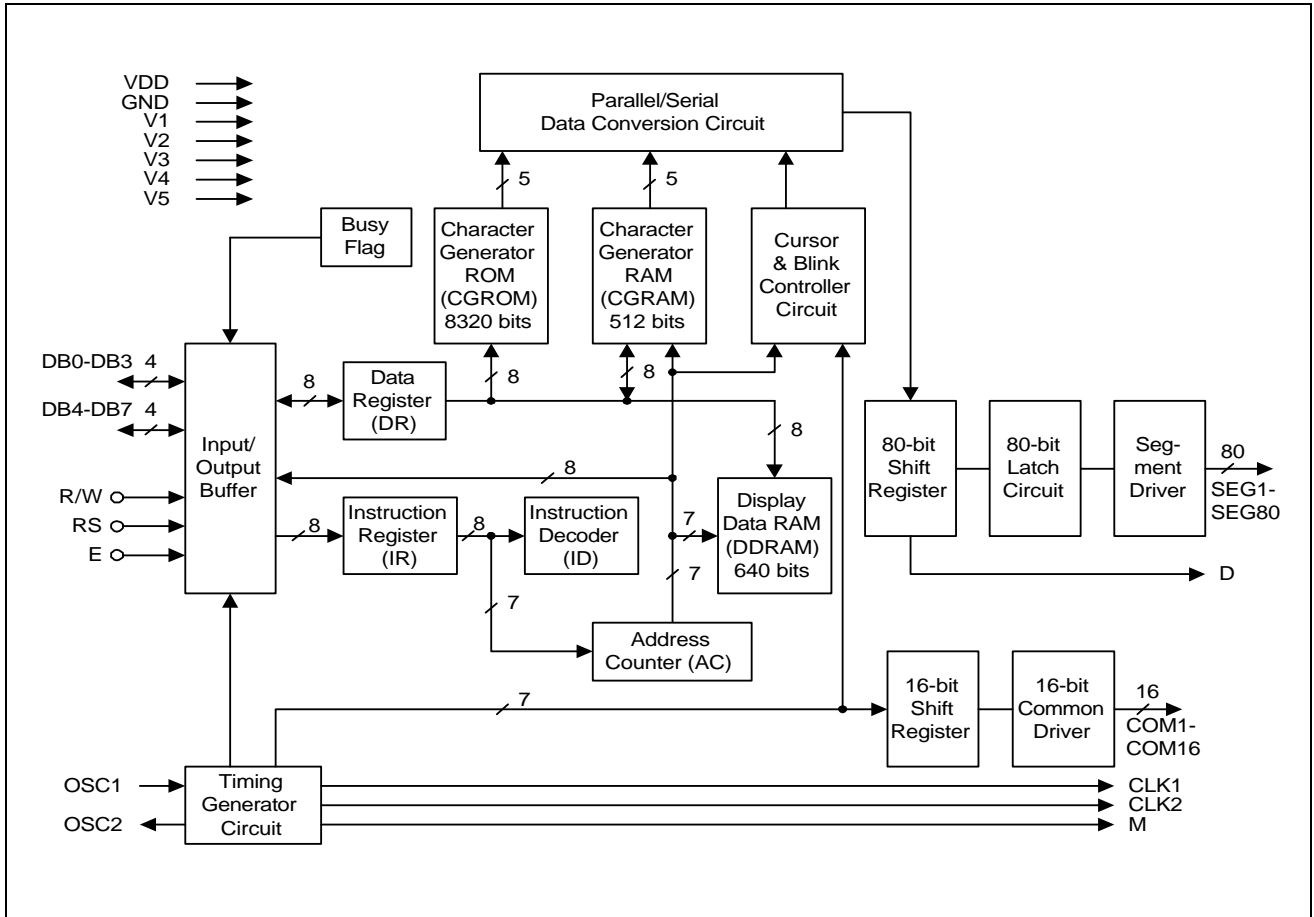
## FUNCTION

- Character type dot matrix LCD driver & controller
- Internal driver: 16 common and 80 segment signal output
- Easy Interface with a 4-bit or 8-bit MPU
- Display character pattern: 5 × 7 dots format (192 kinds), 5 × 10 dots format (32 kinds)
- The special character pattern is directly programmable by the Character Generator RAM.
- A customer character pattern is programmable by mask option.
- It can drive a maximum 80 characters by using the S6A0065 or S6A2067 externally.
- Various instruction functions
- Built-in automatic power on reset
- Driving method is A-type (line inversion)

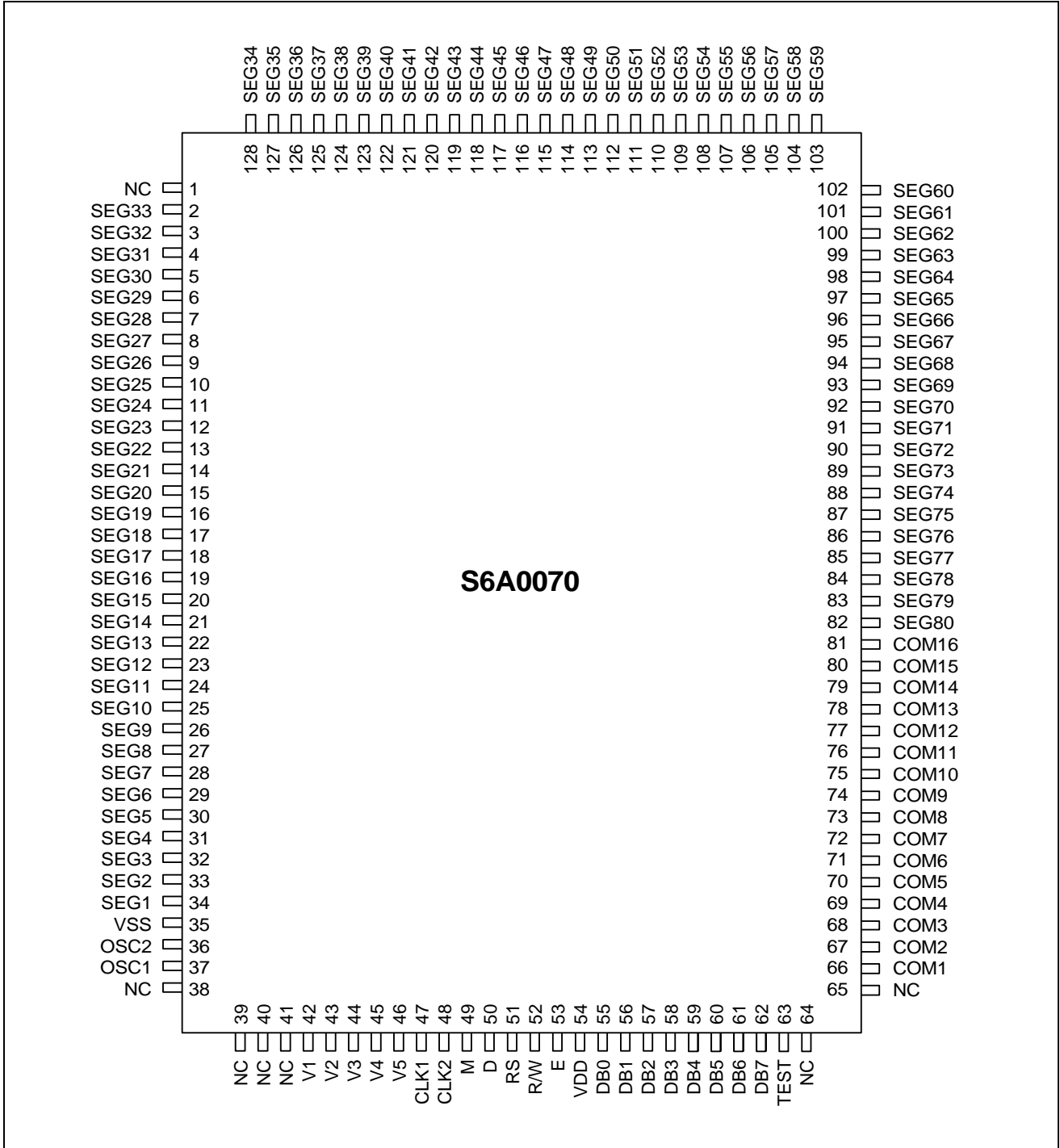
## FEATURES

- Internal Memory
  - Character Generator ROM: 8320bits (192 cha. X 5 x 7 dots) & (32 cha. X 5 x 10 dots)
  - Character Generator RAM: 64 x 8 bits (8 cha. X 5 x 7 dots)
  - Display Data RAM: 80 × 8 bits for 80 digits (80 characters max.)
- Power Supply Voltage: 2.7 to 5.5 V (VDD)
- LCD Driving Voltage: 3.0 to 10.0 V (VDD - V5)
- Supply Voltage for display: 0 to -5V (V5)
- Programmable duty cycle: 1/8 duty, 1/11 duty or 1/16
- Internal oscillator with an external resistor
- Bare die or bumped chip available

**BLOCK DIAGRAM**

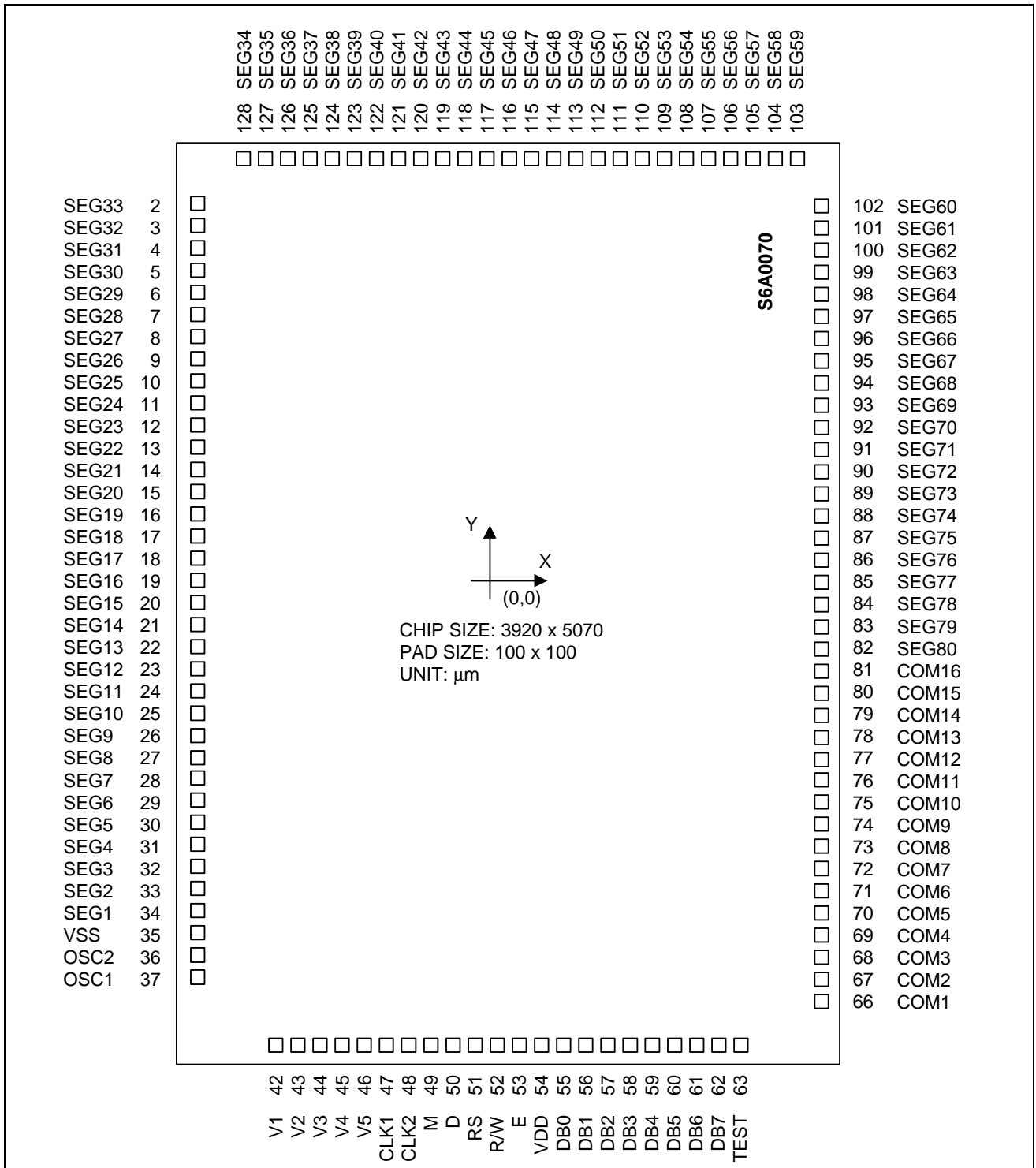


**PIN CONFIGURATION**

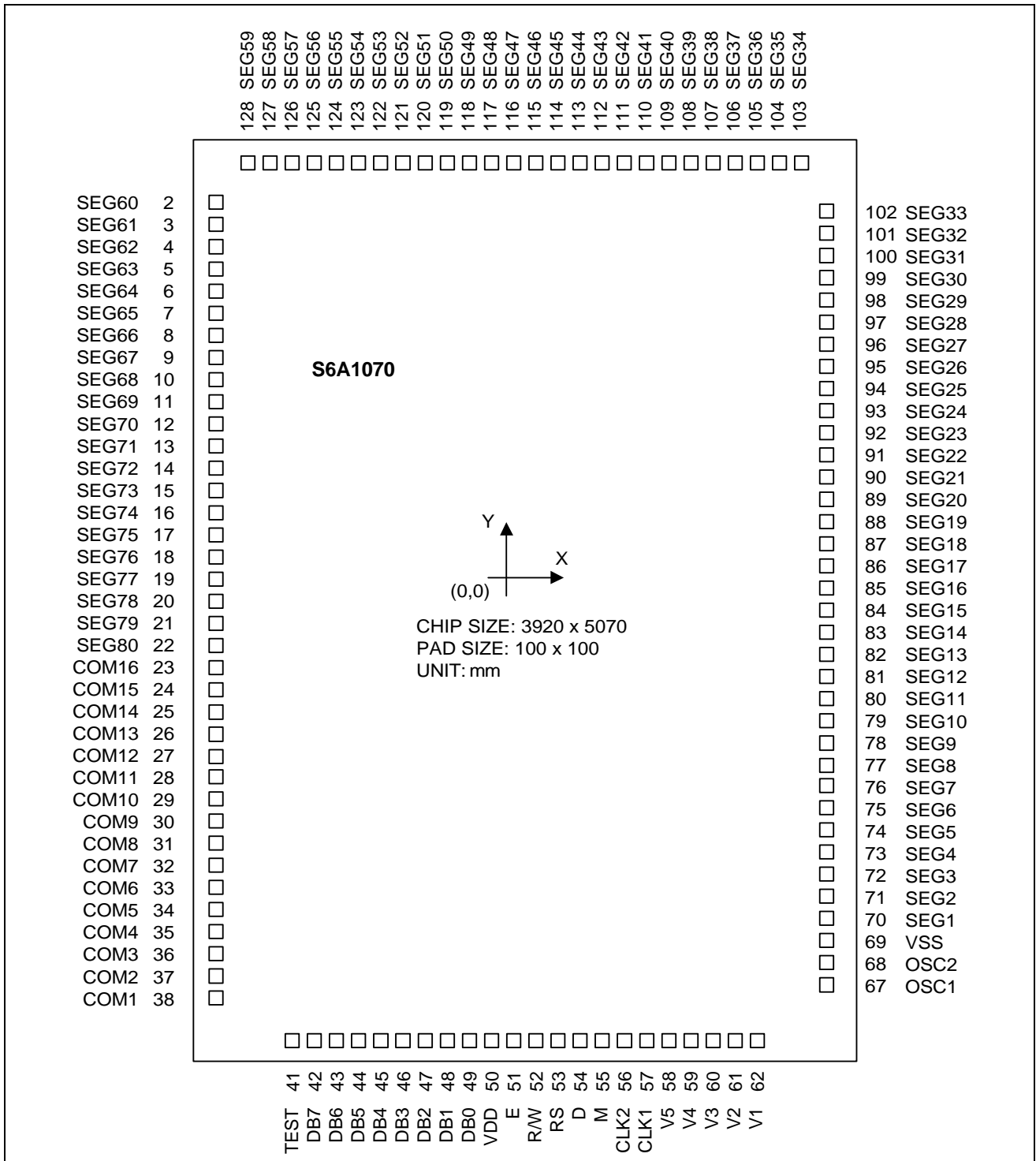


### PAD CONFIGURATION

#### 1) Normal Type PAD Configuration



2) Mirror Type PAD Configuration



## PAD CENTER COORDINATES

## 1) Normal Type PAD Coordinate (S6A0070)

PAD NUM.	PAD NAME	COORDINATE		PAD NUM.	PAD NAME	COORDINATE		PAD NUM.	PAD NAME	COORDINATE	
		X	Y			X	Y			X	Y
1	NC			44	V3	-905	-2369	87	SEG75	1794	294
2	SEG33	-1794	2169	45	V4	-780	-2369	88	SEG74	1794	419
3	SEG32	-1794	2044	46	V5	-655	-2369	89	SEG73	1794	544
4	SEG31	-1794	1919	47	CLK1	-530	-2369	90	SEG72	1794	669
5	SEG30	-1794	1794	48	CLK2	-405	-2369	91	SEG71	1794	794
6	SEG29	-1794	1669	49	M	-280	-2369	92	SEG70	1794	919
7	SEG28	-1794	1544	50	D	-155	-2369	93	SEG69	1794	1044
8	SEG27	-1794	1419	51	RS	-30	-2369	94	SEG68	1794	1169
9	SEG26	-1794	1294	52	R/W	95	-2369	95	SEG67	1794	1294
10	SEG25	-1794	1169	53	E	220	-2369	96	SEG66	1794	1419
11	SEG24	-1794	1044	54	VDD	345	-2369	97	SEG65	1794	1544
12	SEG23	-1794	919	55	DB0	470	-2369	98	SEG64	1794	1669
13	SEG22	-1794	794	56	DB1	595	-2369	99	SEG63	1794	1794
14	SEG21	-1794	669	57	DB2	720	-2369	100	SEG62	1794	1919
15	SEG20	-1794	544	58	DB3	845	-2369	101	SEG61	1794	2044
16	SEG19	-1794	419	59	DB4	970	-2369	102	SEG60	1794	2169
17	SEG18	-1794	294	60	DB5	1095	-2369	103	SEG59	1563	2369
18	SEG17	-1794	169	61	DB6	1220	-2369	104	SEG58	1438	2369
19	SEG16	-1794	44	62	DB7	1345	-2369	105	SEG57	1313	2369
20	SEG15	-1794	-81	63	TEST	1470	-2369	106	SEG56	1188	2369
21	SEG14	-1794	-206	64	NC			107	SEG55	1063	2369
22	SEG13	-1794	-331	65	NC			108	SEG54	938	2369
23	SEG12	-1794	-456	66	COM1	1794	-2331	109	SEG53	813	2369
24	SEG11	-1794	-581	67	COM2	1794	-2206	110	SEG52	688	2369
25	SEG10	-1794	-706	68	COM3	1794	-2081	111	SEG51	563	2369
26	SEG9	-1794	-831	69	COM4	1794	-1956	112	SEG50	438	2369
27	SEG8	-1794	-956	70	COM5	1794	-1831	113	SEG49	313	2369
28	SEG7	-1794	-1081	71	COM6	1794	-1706	114	SEG48	188	2369
29	SEG6	-1794	-1206	72	COM7	1794	-1581	115	SEG47	63	2369
30	SEG5	-1794	-1331	73	COM8	1794	-1456	116	SEG46	-62	2369

## Normal Type Pad Coordinate (Continued)

PAD NUM.	PAD NAME	COORDINATE		PAD NUM.	PAD NAME	COORDINATE		PAD NUM.	PAD NAME	COORDINATE	
		X	Y			X	Y			X	Y
31	SEG4	-1794	-1456	74	COM9	1794	-1331	117	SEG45	-187	2369
32	SEG3	-1794	-1581	75	COM10	1794	-1206	118	SEG44	-312	2369
33	SEG2	-1794	-1706	76	COM11	1794	-1081	119	SEG43	-437	2369
34	SEG1	-1794	-1831	77	COM12	1794	-956	120	SEG42	-562	2369
35	VSS	-1794	-1956	78	COM13	1794	-831	121	SEG41	-687	2369
36	OSC2	-1794	-2106	79	COM14	1794	-706	122	SEG40	-812	2369
37	OSC1	-1794	-2231	80	COM15	1794	-581	123	SEG39	-937	2369
38	NC			81	COM16	1794	-456	124	SEG38	-1062	2369
39	NC			82	SEG80	1794	-331	125	SEG37	-1187	2369
40	NC			83	SEG79	1794	-206	126	SEG36	-1312	2369
41	NC			84	SEG78	1794	-81	127	SEG35	-1437	2369
42	V1	-1155	-2369	85	SEG77	1794	44	128	SEG34	-1562	2369
43	V2	-1030	-2369	86	SEG76	1794	169				

\* "S6A0070" Marking: easy to find the PAD No. 98.



## 2) Mirror Type PAD Coordinate (S6A1070)

PAD NUM.	PAD NAME	COORDINATE		PAD NUM.	PAD NAME	COORDINATE		PAD NUM.	PAD NAME	COORDINATE	
		X	Y			X	Y			X	Y
1		NC		44	DB5	-1095	-2369	87	SEG18	1794	294
2	SEG60	-1794	2169	45	DB4	-970	-2369	88	SEG19	1794	419
3	SEG61	-1794	2044	46	DB3	-845	-2369	89	SEG20	1794	544
4	SEG62	-1794	1919	47	DB2	-720	-2369	90	SEG21	1794	669
5	SEG63	-1794	1794	48	DB1	-595	-2369	91	SEG22	1794	794
6	SEG64	-1794	1669	49	DB0	-470	-2369	92	SEG23	1794	919
7	SEG65	-1794	1544	50	VDD	-345	-2369	93	SEG24	1794	1044
8	SEG66	-1794	1419	51	E	-220	-2369	94	SEG25	1794	1169
9	SEG67	-1794	1294	52	RW	-95	-2369	95	SEG26	1794	1294
10	SEG68	-1794	1169	53	RS	30	-2369	96	SEG27	1794	1419
11	SEG69	-1794	1044	54	D	155	-2369	97	SEG28	1794	1544
12	SEG70	-1794	919	55	M	280	-2369	98	SEG29	1794	1669
13	SEG71	-1794	794	56	CLK2	405	-2369	99	SEG30	1794	1794
14	SEG72	-1794	669	57	CLK1	530	-2369	100	SEG31	1794	1919
15	SEG73	-1794	544	58	V5	655	-2369	101	SEG32	1794	2044
16	SEG74	-1794	419	59	V4	780	-2369	102	SEG33	1794	2169
17	SEG75	-1794	294	60	V3	905	-2369	103	SEG34	1562	2369
18	SEG76	-1794	169	61	V2	1030	-2369	104	SEG35	1437	2369
19	SEG77	-1794	44	62	V1	1155	-2369	105	SEG36	1312	2369
20	SEG78	-1794	-81	63	NC			106	SEG37	1187	2369
21	SEG79	-1794	-206	64	NC			107	SEG38	1062	2369
22	SEG80	-1794	-331	65	NC			108	SEG39	937	2369
23	C16	-1794	-456	66	NC			109	SEG40	812	2369
24	C15	-1794	-581	67	OSC1	1794	-2231	110	SEG41	687	2369
25	C14	-1794	-706	68	PSC2	1794	-2106	111	SEG42	562	2369
26	C13	-1794	-831	69	VSS	1794	-1956	112	SEG43	437	2369
27	C12	-1794	-956	70	SEG1	1794	-1831	113	SEG44	312	2369
28	C11	-1794	-1081	71	SEG2	1794	-1706	114	SEG45	187	2369
29	C10	-1794	-1206	72	SEG3	1794	-1581	115	SEG46	62	2369
30	C9	-1794	-1331	73	SEG4	1794	-1456	116	SEG47	-63	2369
31	C8	-1794	-1456	74	SEG5	1794	-1331	117	SEG48	-188	2369
32	C7	-1794	-1581	75	SEG6	1794	-1206	118	SEG49	-313	2369
33	C6	-1794	-1706	76	SEG7	1794	-1081	119	SEG50	-438	2369

## Mirror Type Pad Coordinate (Continued)

PAD NUM.	PAD NAME	COORDINATE		PAD NUM.	PAD NAME	COORDINATE		PAD NUM.	PAD NAME	COORDINATE	
		X	Y			X	Y			X	Y
34	COM5	-1794	-1831	77	SEG8	1794	-956	120	SEG51	-563	2369
35	COM4	-1794	-1956	78	SEG9	1794	-831	121	SEG52	-688	2369
36	COM3	-1794	-2081	79	SEG10	1794	-706	122	SEG53	-813	2369
37	COM2	-1794	-2206	80	SEG11	1794	-581	123	SEG54	-938	2369
38	COM1	-1794	-2331	81	SEG12	1794	-456	124	SEG55	-1063	2369
39	NC			82	SEG13	1794	-331	125	SEG56	-1188	2369
40	NC			83	SEG14	1794	-206	126	SEG57	-1313	2369
41	TEST	-1470	-2369	84	SEG15	1794	-81	127	SEG58	-1438	2369
42	DB7	-1345	-2369	85	SEG16	1794	44	128	SEG59	-1563	2369
43	DB6	-1220	-2369	86	SEG17	1794	169				

\* "S6A1070" Marking: easy to find the PAD No. 12.

## PIN DESCRIPTION

Pad (No) (normal/mirror)	I/O	Name	Description	Interface
V <sub>DD</sub> (54/50)	-	Power supply	for logical circuit (+3V, +5V)	Power supply
V <sub>SS</sub> (35, 69)			0V (GND)	
V1-V5 (42-46/62-58)		Power supply	Bias voltage level for LCD driving	
SEG1-SEG80 (34-2, 128-82/ 70-128, 2-28)	Output	Segment output	Segment signal output for LCD driving	LCD
COM1-COM16 (66-81/38-23)	Output	Common output	Common signal output for LCD driving	LCD
OSC1, OSC2 (37, 36/67, 68)	Input (OSC1) Output (OSC2)	Oscillator	When using internal oscillator, connect external R <sub>f</sub> resistor. If external clock is used, connect it to OSC1.	Extension register/ oscillator (OSC1)
CLK1, CLK2 (47, 48/57, 56)	Output	Extension driver latch (CLK1)/Shift (CLK2) clock	Each outputs extension driver latch clock and extension driver shift clock	Extension driver
M (49/55)	Output	Alternated signal for LCD driver output	Outputs the alternating signal to convert LCD driver waveform to AC.	Extension driver
D (50/54)	Output	Display data interface	Output extension driver data (the 41st dot's data)	Extension driver
RS (51/53)	Input	Register select	Used s register selection input. When RS = 1, Data register is selected. When RS = 0, Instruction register is selected	MPU
RW (52/52)	Input	Read/Write	Used as read/write selection input. When RW = 1, read operation. When RW = 0, write operation.	MPU
E (53/51)	Input	Read/Write Enable	Used as read. Write enable signal.	MPU
DB0-DB3 (55-58/49-46)	Input/ Output	Data bus 0-3	When 8-bit bus mode, used as low order bidirectional data bus. During 4-bit bus mode open these pins.	MPU
DB4-DB7 (59-62/45-42)	Input/ Output	Data bus 4-7	When 8-bit bus mode, used as high order bidirectional data bus. In case of 4-bit bus mode, used as both high and low order. DB7 used for Busy Flag output.	MPU
TEST(63/41)	Input	Test pin	This pin must be fixed to VDD or open.	-

## FUNCTION DESCRIPTION

### System Interface

This chip has both kinds of interface type with MPU: 4-bit bus and 8-bits bus. 4-bit bus and 8-bit bus are selected by the DL bit in the instruction register.

During read or write operation, two 8-bit registers are used. One is the data register (DR), and the other is the instruction register (IR).

The data register (DR) is used as a temporary data storage place for being written into or read from DRAM/CGRAM . Target RAM is selected by RAM address setting instruction. Each internal operation, reading from or writing into RAM, is done automatically. After MPU reads DR data, the data in the next DDRAM/CGRAM address is transferred into DR automatically. Also, after MPU writes data to DR, the data in DR is transferred into DDRAM/CGRAM automatically.

The instruction register (IR) is used only to store instruction codes transferred from MPU. MPU cannot use it to read instruction data.

To select a register, use RS input pin in 4-bit/8-bit bus mode.

Table 1. Various Kinds of Operations to RS and R/W bits.

RS	R/W	Operation
0	0	Instruction Write operation (MPU writes instruction code into IR)
0	1	Read Busy flag (DB7) and address counter (DB0 - DB7)
1	0	Data Write operation (MPU writes data into DR)
1	1	Data Read operation (MPU reads data into DR)

### Busy Flag (BF)

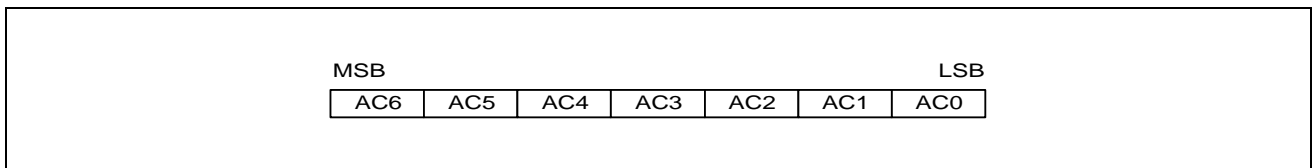
When BF = 1, it indicates that the internal operation is being processed. So during this time the next instruction cannot be accepted. BF can be read, when RS = 0, and R/W = 1. (Read Instruction Operation), through DB7 port. Before executing the next instruction, be sure that BF is not 1.

### Address Counter (AC)

The Address Counter (AC) stores DDRAM/CGRAM addresses, transferred from IR. After writing into (reading from) DDRAM/CGRAM. AC is automatically increased (decreased) by 1. When RS = 0 and R/W = 1, AC can be read through ports DB0 - DB6.

### Display Data RAM (DDRAM)

DDRAM stores display data of maximum 80 x 8 bits (80 characteristics). DDRAM address is set in the address counter (AC) as a hexadecimal number. (Refer to fig-1).



**Figure 1. DDRAM Address**

#### 1) 1-line Display

In the case of a 1-line display, the address range of DDRAM is 00H - 04H. An Extension driver will be used. Figure 2 shows the example when a 40-segment extension driver is added.

#### 2) 2-line Display

In the case of a 2-line display, the address range of DDRAM is 00H - 27H and 40H - 67H. An Extension driver will be used. Figure 3 shows the example a 40 segment extension driver is added.

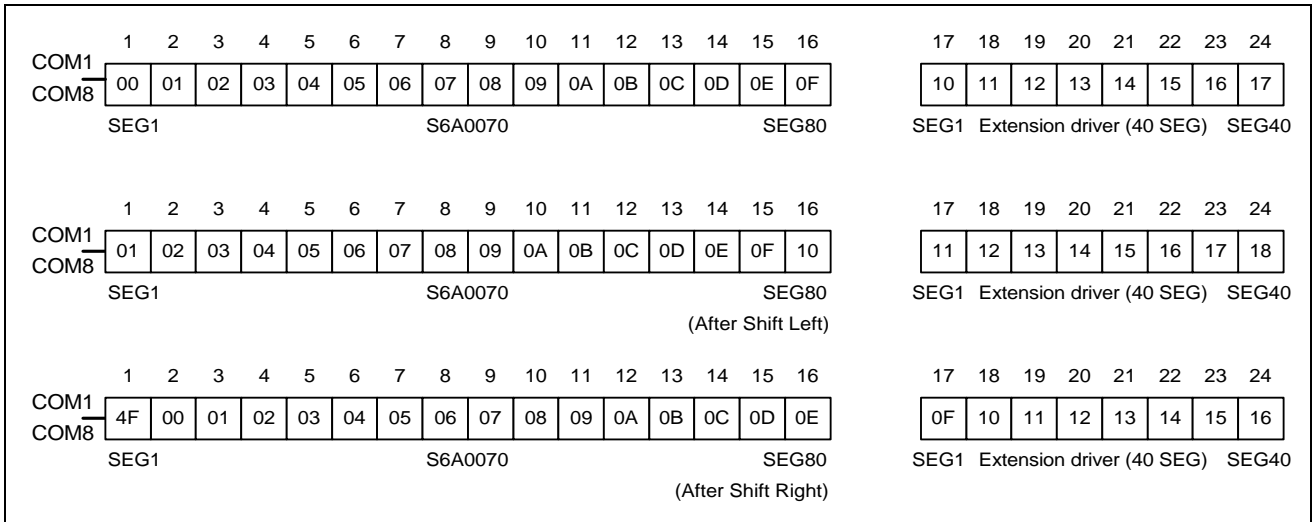


Figure 2. 1-line x 24ch. Display with 40 SEG. Extension Driver

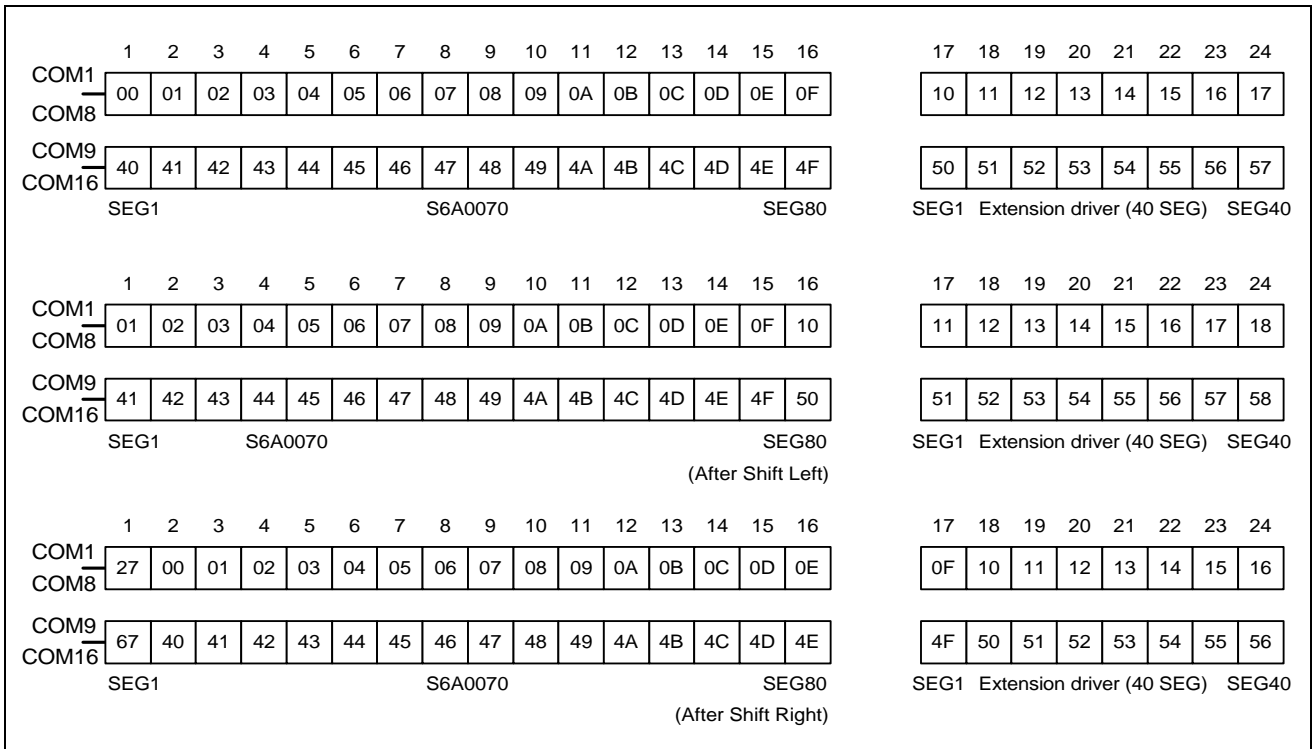


Figure 3. 2-line x 24ch. Display with 40 SEG. Extension Driver

**CGROM (Characteristic Generator ROM)**

CGROM has a 5 x 7 dots 192 character pattern, and a 5 x 7 10 dots 32 character pattern

**CGRAM (Character Generator RAM)**

CDRAM has up to 5 x 8 dots 8 characters. By writing font data to CGRAM, user defined characters can be used (Refer to table 3).

**Timing Generation Circuit**

Timing generation circuit generates clock signals for the internal operations.

**LCD Driver Circuit**

LCD Driver circuit has 16 common and 80 segment signals for LCD driving. Data from CGRAM/CGROM is transferred to an 80-bit segment latch serially, and then stored to an 80-bit shift latch. When each com is selected by a 16-bit common register, segment data is also output through the segment driver from and 80-bit segment latch. In case of a 1-line display mode, COM - COM8 have 1/8 duty or COM1-COM11 have a 1/11 duty. In a 2-line display mode, COM1 - COM16 have a 1/16 duty ratio.

**Cursor/Blink Control Circuit**

It controls cursor/blink ON/OFF at cursor position.

Table 3. Relationship Between Character Code (DDRAM) and Character Pattern (CGROM)

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	x	x	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	0	0	0	0	0	0	x	x	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	

"x": Don't care.



## INSTRUCTION DESCRIPTION

### OUTLINE

To overcome the speed difference between internal clock of S6A0070 and MPU clock, S6A0070 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. (refer to Table 5) Instruction can be divided largely four kinds,

- (1) S6A0070 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.

**NOTE:** During internal operation, Busy Flag (DB7) is read "1". Busy Flag check must be precede by the next instruction. When you make an MPU program with checking the Busy Flag (DB7) is made, it must be necessary 1/2 fosc for executing the next instruction by falling E signal after the Busy Flag (DB7) goes to "0".

### Contents

#### 1) Clear Display

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" in the AC (address counter). Return cursor to the original status, namely, bring the cursor to the left edge on first line of the display. Make entry mode increment (I/D = "1").

#### 2) 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" in the address counter. Return cursor to its original site and return display to its original status, if shifted. Contents of DDRAM does not change.

**3) Entry Mode Set**

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

Set the moving direction of cursor and display.

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

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

When I/D = "0", cursor/blink moves to left and DDRAM address is decreased by 1.

\* CGRAM operates the same as DDRAM, when reading from or writing to CGRAM.

**SH: Shift of Entire Display**

When DDRAM read (CGRAM read/write) operation or SH = "0", shift of entire display is not performed. If SH = "1" and DDRAM write operation, shift of entire display is performed according to I/D value (I/D = "1" : shift left, I/D = "0" : shift right).

**4) Display ON / OFF Control**

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 = "1", entire display is turned on.

When D = "0", display is turned off, but display data remained in DDRAM.

**C : Cursor ON/OFF Control Bit**

When C = "1", cursor is turned on.

When C = "0", cursor is disappeared in current display, but I/D register remains its data.

**B : Cursor Blink ON/OFF Control Bit**

When B = "1", cursor blink is on, which performs alternate between all the "1" data and display character at the cursor position. When B = "0", blink is off.

**5) Cursor or Display Shift**

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

Without waiting or reading the display data, shift right/left cursor position or display. This instruction is used to correct or search display data. (Refer to table 4) During 2-line mode display, cursor moves to the 2nd line after the 40th digit of the 1st line. Note that display shift is performed simultaneously in all the lines. When displayed data is shifted repeatedly, each line is shifted individually. When display shift is performed, the contents of the address counter are not changed.

**Table 4. Shift Patterns According to S/C and R/L Bits**

S/C	R/L	Operation
0	0	Shift cursor to the left, AC is decreased by 1
0	1	Shift cursor to the right, AC 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

**6) Function Set**

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

**DL : Interface data length control bit**

When DL = "1", it means 8-bit bus mode with MPU.

When DL = "0", it means 4-bit bus mode with MPU. So to speak, DL is a signal to select 8-bit or 4-bit bus mode.

When 4-bit bus mode, it needs to transfer 4-bit data in two times.

**N : Display line number control bit**

When N = "0", it means 1-line display mode.

When N = "1", 2-line display mode is set.

**F : Display font type control bit**

When F = "0", 5 × 7 dots format display mode

When F = "1", 5 × 10 dots format display mode.

**7) Set CGRAM Address**

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.

**8) Set DDRAM Address**

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

**9) Read Busy Flag & Address**

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

This instruction shows whether S6A0070 is in internal operation or not. If the resultant BF is "1", it means the internal operation is in progress and you have to wait until BF to be Low, and then the next instruction can be performed. In this instruction you can read also the value of address counter.

**10) 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. The selection of RAM from DDRAM, and CGRAM, is set by the previous address set instruction: DDRAM address set, CGRAM address set). RAM set instruction can also determine the AC direction to RAM. After write operation, the address is automatically increased/decreased by 1, according to the entry mode.

**11) 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. The selection of RAM is set by the previous address set instruction. If the address set instruction of RAM is not performed before this instruction, the data that is read first is invalid, because the direction of AC is not determined. If you read RAM data several times without RAM address set instruction before read operation, you can get correct RAM data from the second, but the first data would be incorrect, because there is no time margin to transfer RAM data. In case of DDRAM read operation, cursor shift instruction plays the same role as DDRAM address set instruction; it also transfer RAM data to output data register. After read operation address counter is automatically increased/decreased by 1 according to the entry mode. After CGRAM read operation, display shift may not be executed correctly.

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

Table 5. Instruction Table

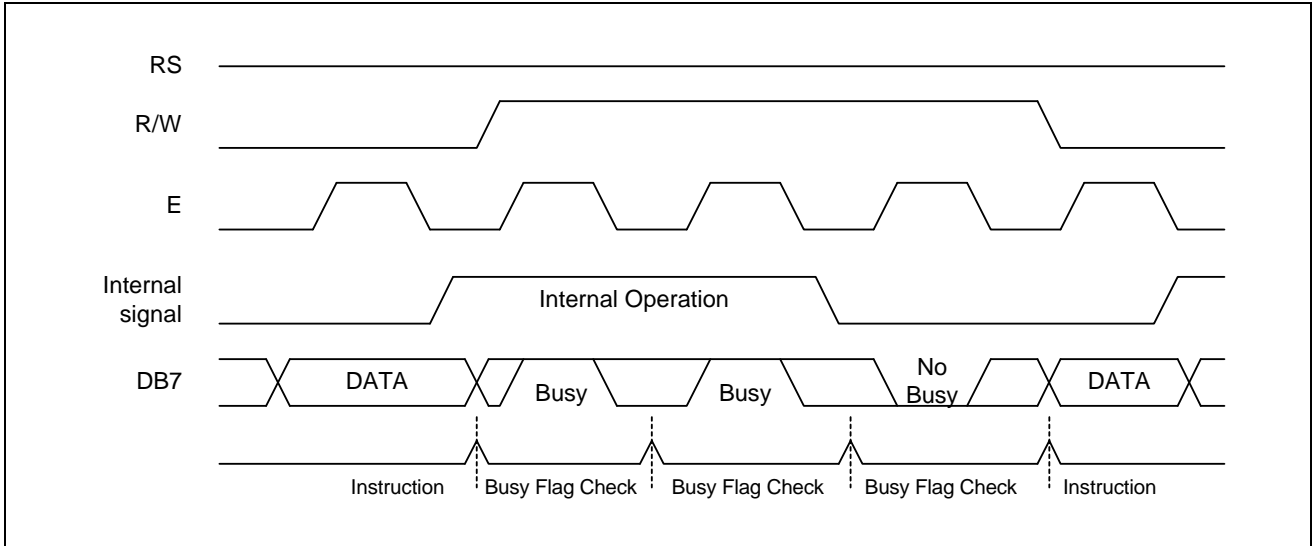
Instruction	Instruction Code										Description Instruction Code	Execution Time (f <sub>soc</sub> =270kHz)	
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0			
Clear Display	0	0	0	0	0	0	0	0	0	0	1	Write "20H" to DDRAM. and set DDRAM address to "00H" from AC.	1.53ms
Return Home	0	0	0	0	0	0	0	0	0	1	X	Set DDRAM address to "00H" from AC and return cursor to its original position if shifted.	1.53ms
Entry Mode Set	0	0	0	0	0	0	0	0	1	I/D	SH	Assign cursor moving direction and enable the shift of entire display	39μs
Display ON/OFF Control	0	0	0	0	0	0	0	1	D	C	B	Set display(D), cursor(C), and blinking of cursor(B) on/off control bit.	39μs
Cursor or Display Shift	0	0	0	0	0	0	1	S/C	R/L	X	X	Set cursor moving and display shift control bit, and the direction, without changing DDRAM data.	39μs
Function Set	0	0	0	0	1	DL	N	F	X	X	X	Set interface data length (DL : 4-bit/8-bit), numbers of display line (N : 1-line/2-line), display font type(F : 0 ..)	39μs
Set CGRAM Address	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	AC0	Set CGRAM address in address counter.	39μs
Set DDRAM Address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	AC0	Set DDRAM address in address counter.	39μs
Read Busy Flag and Address	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0	AC0	Whether during internal operation or not can be known by reading BF. The contents of address counter can also be read.	0μs
Write Data to RAM	1	0	D7	D6	D5	D4	D3	D2	D1	D0	D0	Write data into internal RAM (DDRAM/CGRAM).	43μs
Read Data from RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	D0	Read data from internal RAM (DDRAM/CGRAM).	43μs

**NOTE:** When an MPU program with checking the Busy Flag (DB7) is made, it must be necessary 1/2 f<sub>soc</sub> is necessary for executing the next instruction by the falling edge of the 'E' signal after the Busy Flag (DB7) goes to "0".

**INTERFACE WITH MPU**

**1) Interface with 8-bit MPU**

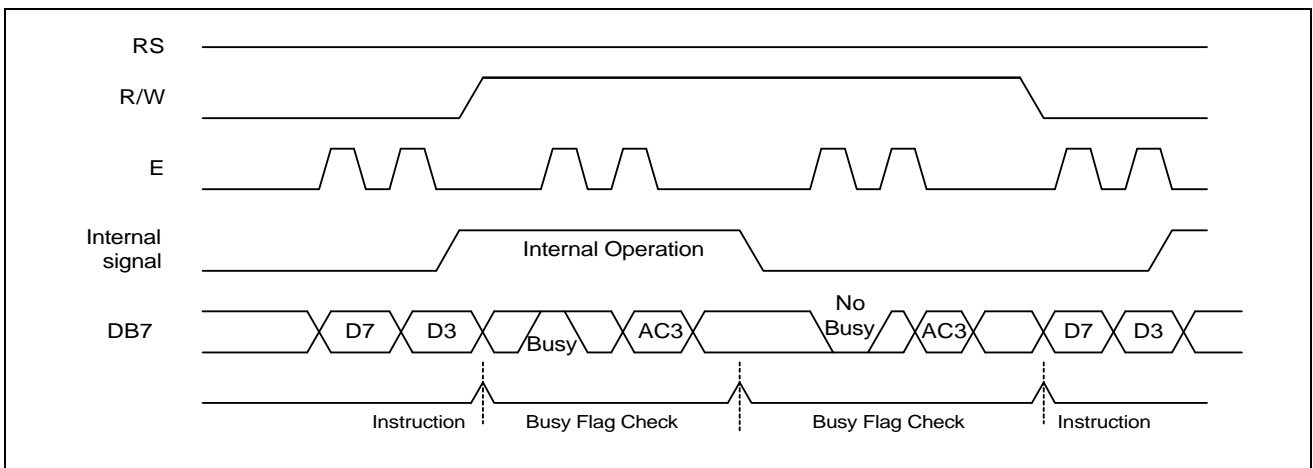
When interfacing data length are 8-bit, transfer is performed all at once through 8 ports, from DB0 to DB7. Example of timing sequence is shown below.



**Figure 4. Example of 8-bit Bus Mode Timing Diagram**

**2) Interface with 4-bit MPU**

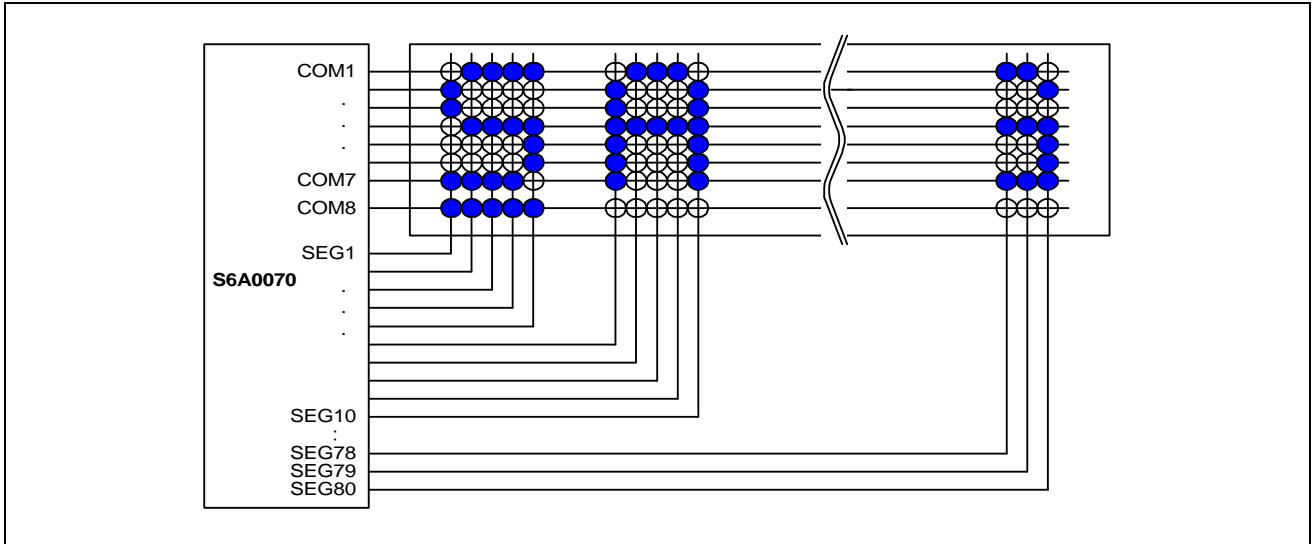
When interfacing data length is 4-bit, only 4 ports, from DB4 to DB7, are used as data bus. At first higher 4-bit (in case of 8-bit bus mode, the contents of DB4 - DB7) are transferred, and then lower 4-bit (in case of 8-bit bus mode, the contents of DB0 - DB3) are transferred. So transfer is performed by two parts. Busy Flag outputs "1" after the second transfer are ended. Example of timing sequence is shown below.



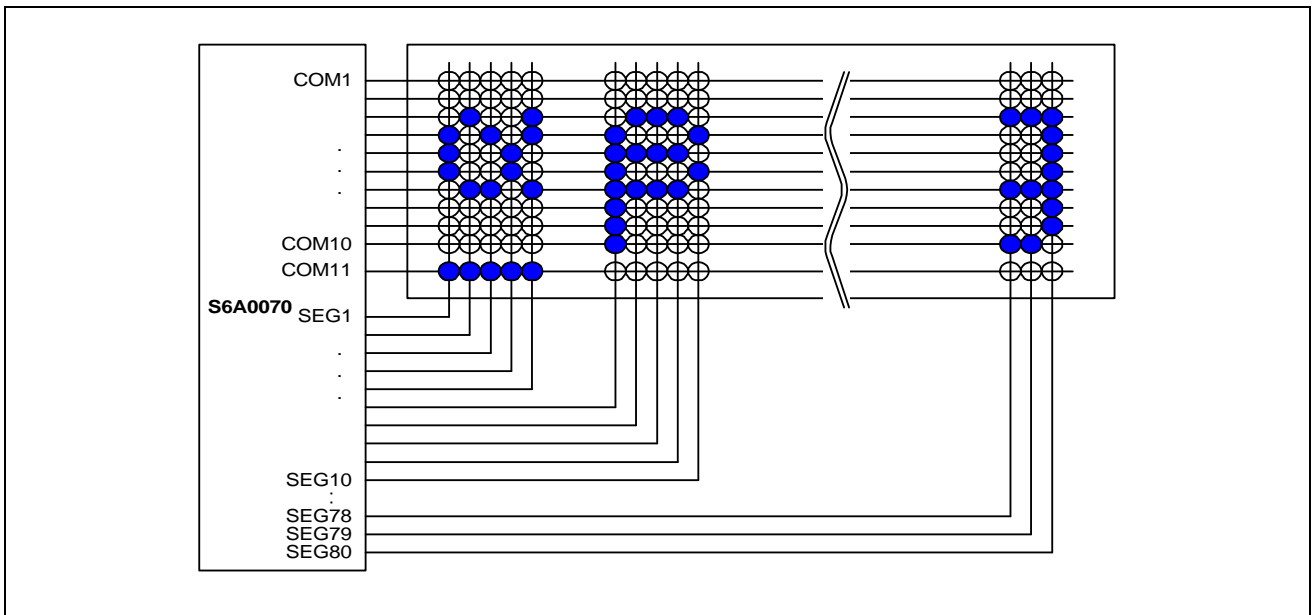
**Figure 5. Example of 4-bit Bus Mode Timing Diagram**

APPLICATION INFORMATION ACCORDING TO LCD PANEL

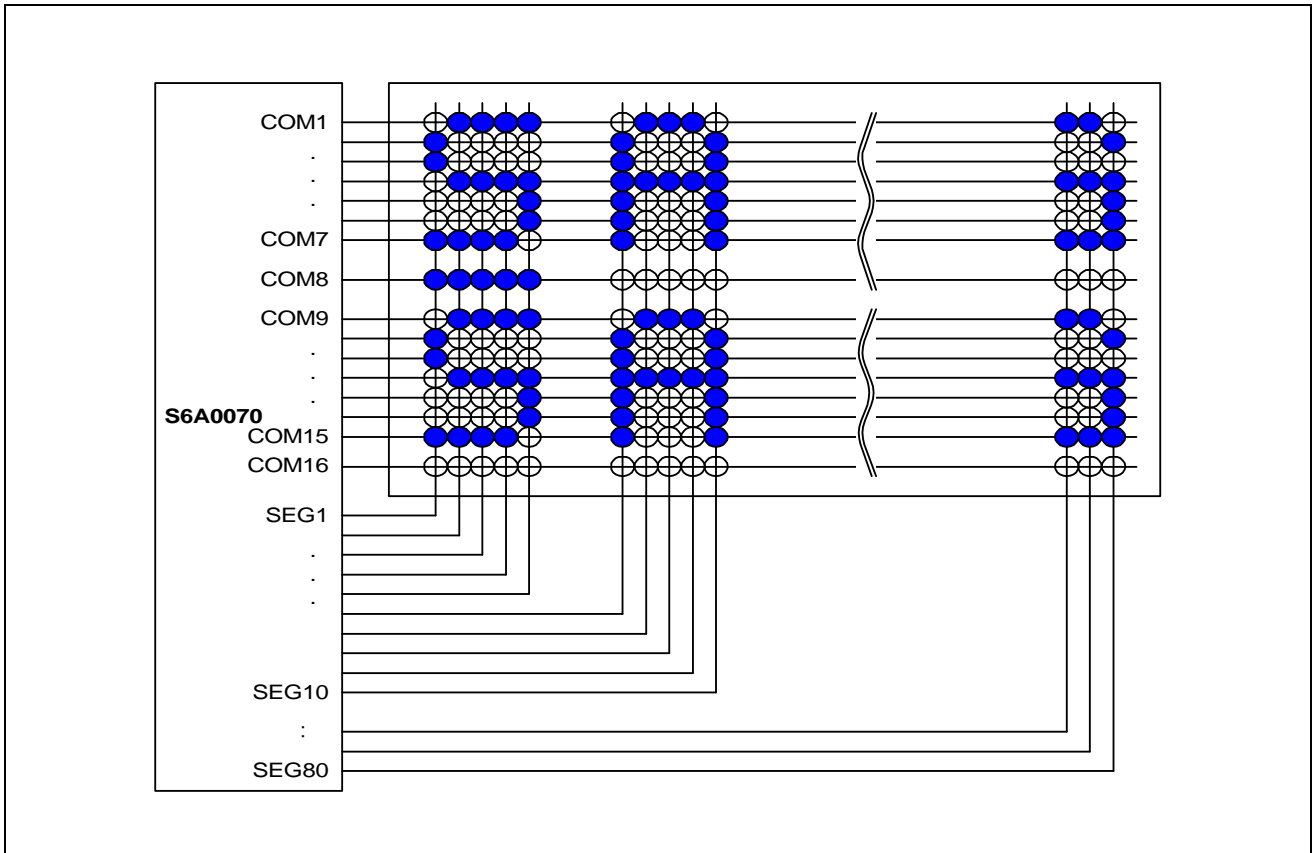
1) LCD Panel: 16 character  $\times$  1-line character format: 5  $\times$  7 dots + 1 cursor line (1/4 bias, 1/8 duty)



2) LCD Panel: 16 character  $\times$  1-line character format; 5  $\times$  10 dots + 1 cursor line (1/4 bias, 1/11 duty)

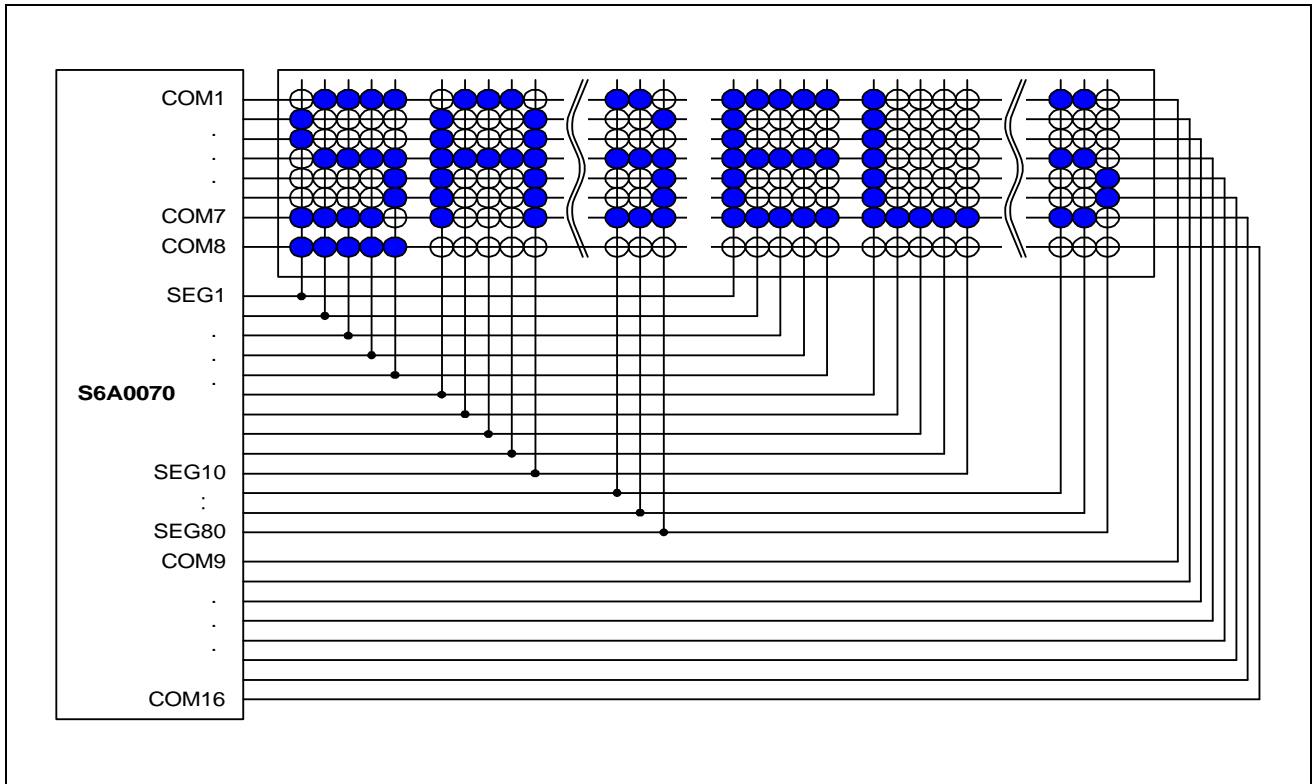


3) LCD Panel: 16 character × 2-line character format; 5 × 7 dots + 1 cursor line (1/5 bias, 1/16 duty)

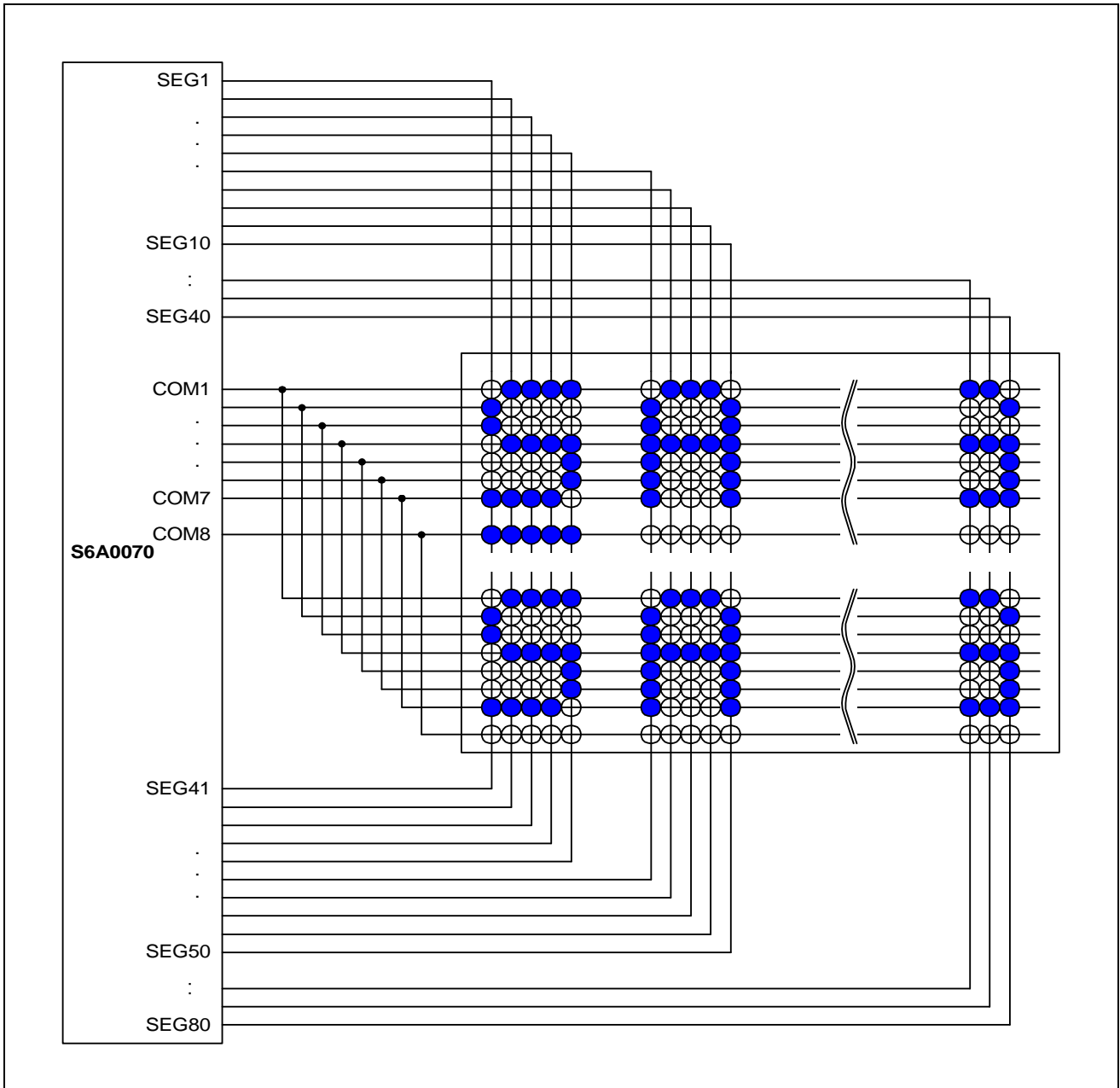




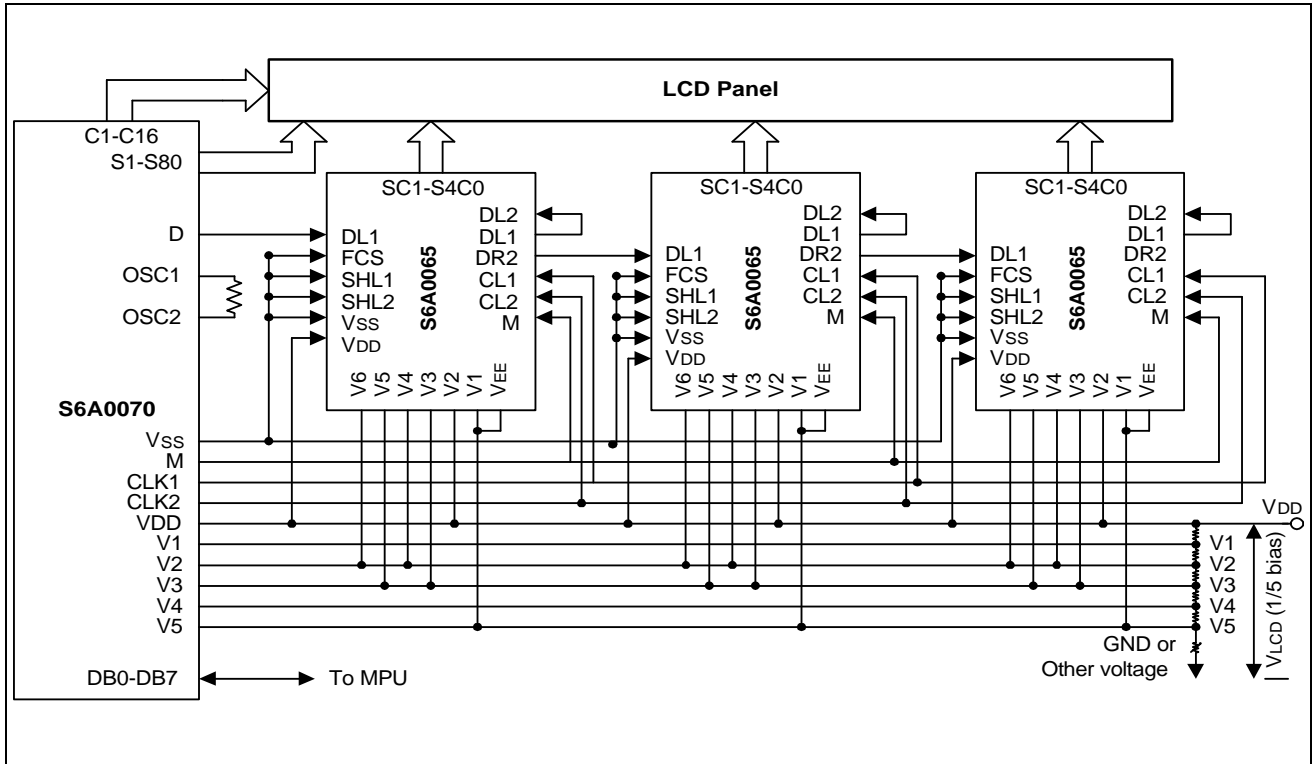
4) LCD Panel: 32 character × 1-line Character format; 5 × 7 dots + 1 cursor line (1/5 bias, 1/16 duty)



5) LCD Panel: 4 character × 2-line character format: 5 × 7 dots + 1 cursor line (1/4 bias, 1/8 duty)



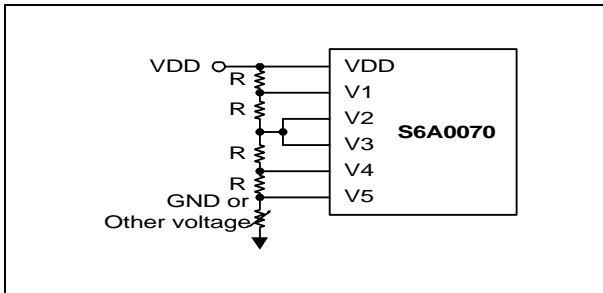
APPLICATION CIRCUIT



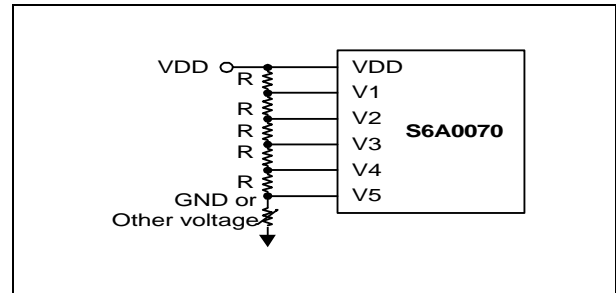
**NOTE:** When S6A0065 is externally connected to the S6A0070, you can increase the number of display digits up to 80 characteristics.

**BIAS VOLTAGE DIVIDE CIRCUIT**

1) 1/4 bias, 1/8 or 1/11 duty



2) 1/5 bias, 1/16 duty

**INITIALIZING**

When the power is turned on, S6A0070 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 = 0 : 1-line display mode

F = 0 : 5 X 7 font type

(3) Control Display ON/OFF instruction

D = 0 : Display OFF

C = 0 : Cursor OFF

B = 0 : Blink OFF

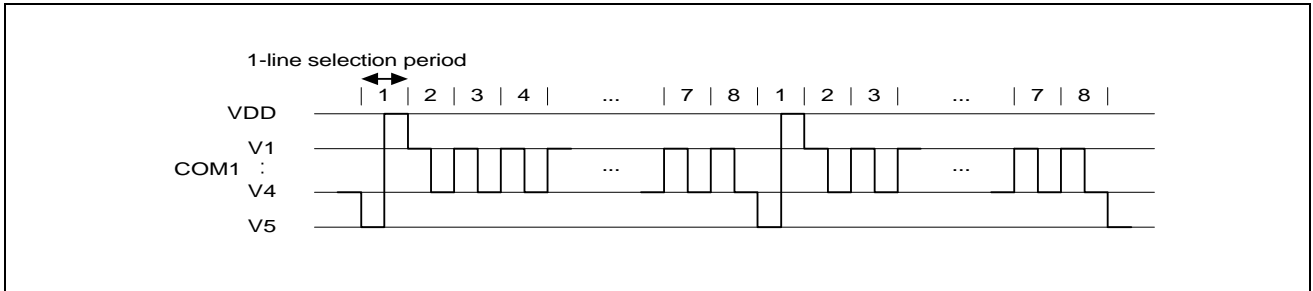
(4) Set Entry Mode instruction

I/D = 1 : Increment by 1

SH = 0 : No entire display shift

**FRAME FREQUENCY**

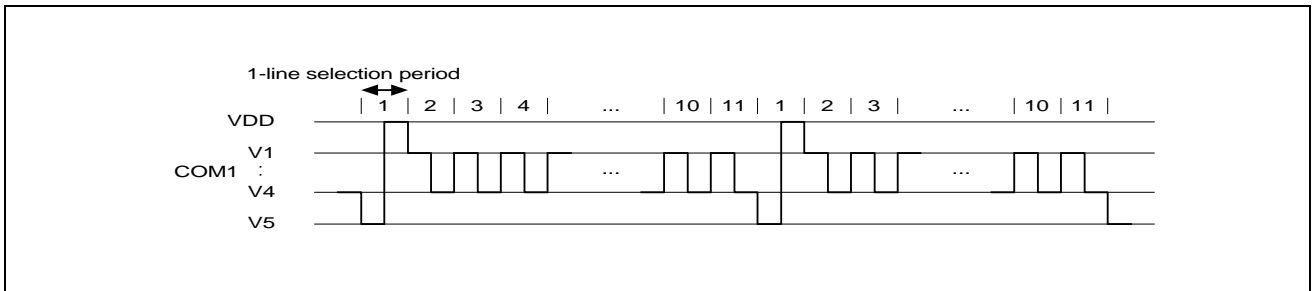
- 1) 1/8 Duty Cycle
- A) A-Type Waveform



Item	Clock/Frequency
Line Selection Period	400 clocks
Frame Frequency	84.4Hz

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

- 2) 1/11 Duty Cycle
- A) A-type Waveform

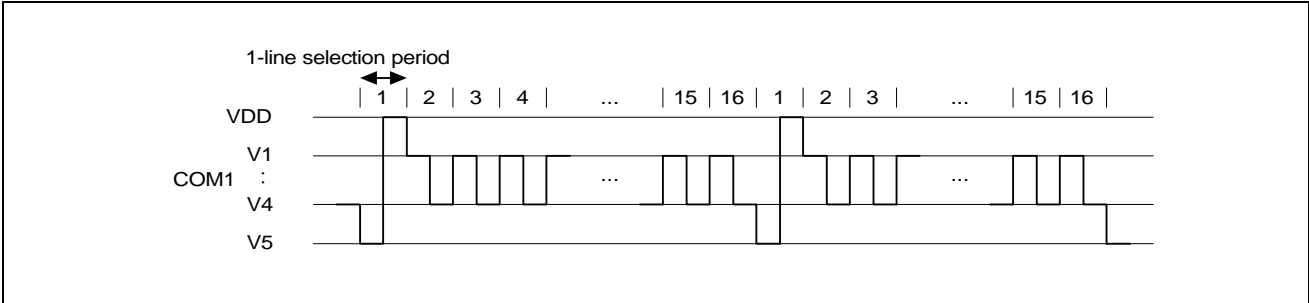


Item	Clock/Frequency
Line Selection Period	400 clocks
Frame Frequency	61.4Hz

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

3) 1/16 Duty Cycle

A) A-type Waveform

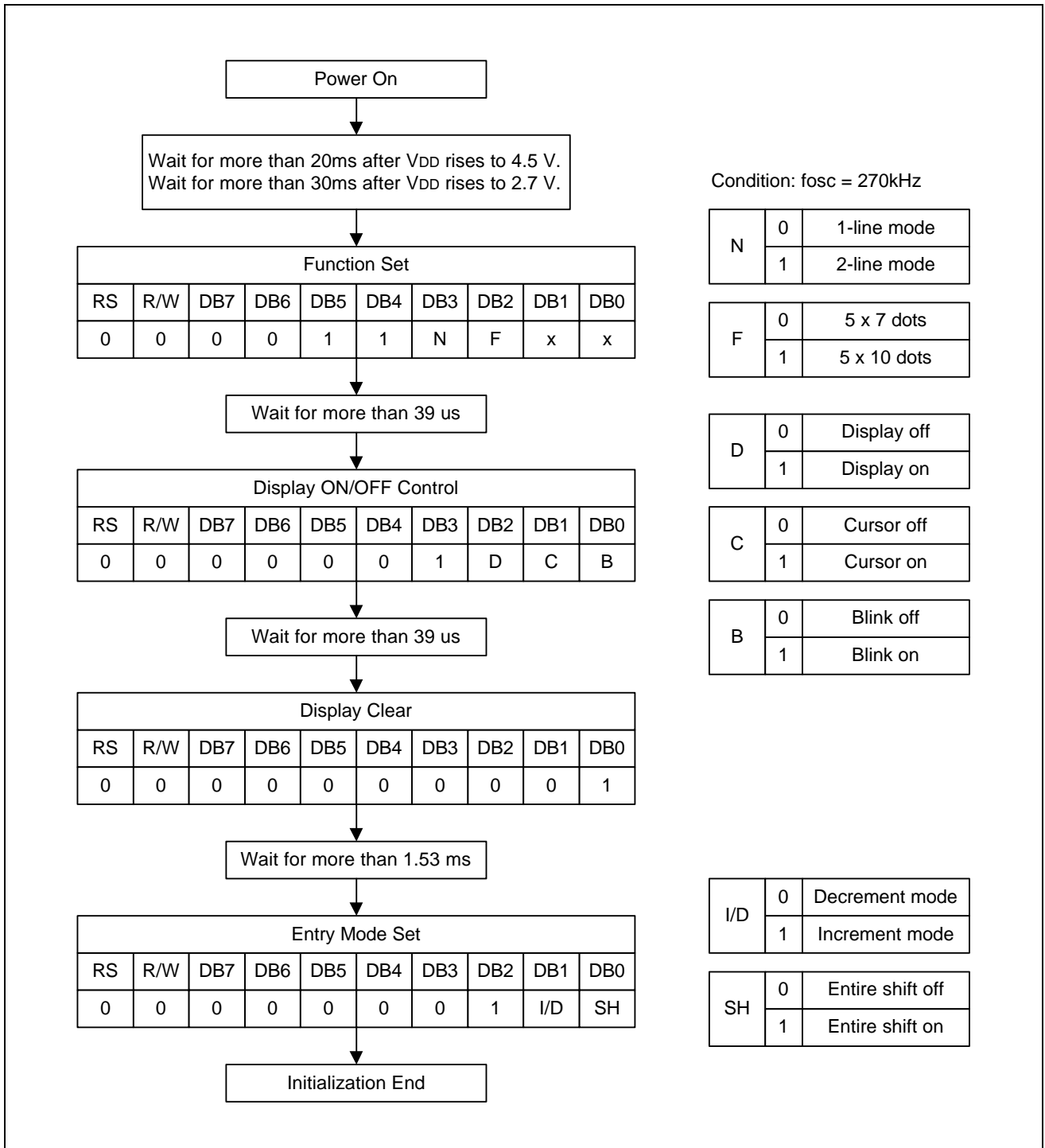


Item	Clock/Frequency
Line Selection Period	200 clocks
Frame Frequency	84.4Hz

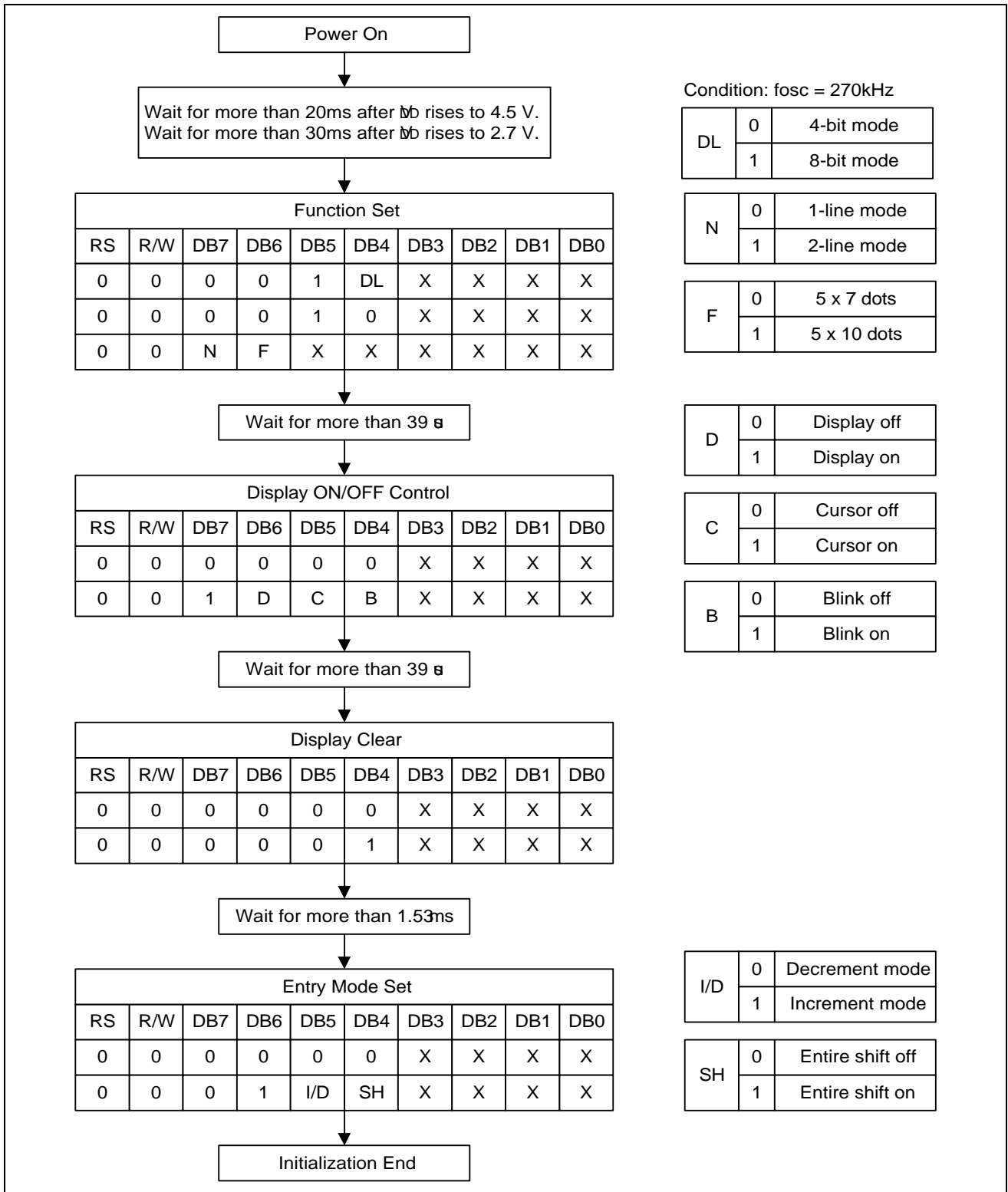
\*  $f_{OSC} = 270kHz$  (1 clock =  $3.7\mu s$ )

### INITIALIZING BY INSTRUCTION

#### 1) 8-bit Interface Mode



2) 4-bit Interface Mode





## EXAMPLE OF INSTRUCTION AND DISPLAY CORRESPONDENCE

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

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

LCD DISPLAY

2. Function Set: 8-bit, 2-line, 5 x 7 dot

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

3. Display ON/OFF Control: Display/Cursor on/blink off

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

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

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

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

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. 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

SAMSUNG  
-

13. Write Data to DDRAM: Write K

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

SAMSUNG  
K\_

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  
KS\_

15. 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

SAMSUNG  
KS0\_

16. 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

SAMSUNG  
KS00\_

## 17. 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

LCD DISPLAY

<b>SAMSUNG</b> KS007_
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## 18. Write Data to DDRAM: Write 2

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

<b>SAMSUNG</b> KS0072_
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## 19. 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

<b>SAMSUNG</b> KS0072
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## 20. 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

<b>SAMSUNG</b> KS0070_
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## 21. Entry Mode Set: Entire shift Enable

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

<b>SAMSUNG</b> KS0070_
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## 22. 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

<b>SAMSUNG</b> KS0070B_
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## 23. Return Home

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

<b>SAMSUNG</b> KS0070B
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## 24. Clear Display

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

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**MAXIMUM ABSOLUTE LIMIT**

Item	Symbol	Unit	Value
Power Supply Voltage	$V_{DD}$	V	-0.3 to +7.0
LCD Drive Voltage	$V_{LCD}$	V	$V_{DD}-15$ to $V_{DD}+0.3$
Input Voltage	$V_{IN}$	V	-0.3 to $V_{DD}+0.3$

**NOTE:** Voltage greater than above may damage the circuit ( $V_{DD} \geq V_1 \geq V_2 \geq V_3 \geq V_4 \geq V_5$ )

**Temperature Characteristics**

Item	Symbol	Unit	Value
Operating Temperature	$T_{OPR}$	°C	- 30 to +85
Storage Temperature	$T_{STG}$	°C	- 55 to +125

## ELECTRICAL CHARACTERISTICS

## DC Characteristics

(V<sub>DD</sub> = 4.5V to 5.5V, T<sub>a</sub> = - 30 to + 85°C)

Item	Symbol	Condition	Min	Typ	Max	Unit
Operating Voltage	V <sub>DD</sub>	-	4.5	-	5.5	V
Supply Current	I <sub>DD1</sub>	ceramic resonator f <sub>OSC</sub> = 250kHz	-	0.7	1.0	mA
	I <sub>DD2</sub>	Resister oscillation external clock operation f <sub>OSC</sub> = 270kHz	-	0.4	0.6	mA
Input Voltage (1) (except OSC1)	V <sub>IH1</sub>	-	2.2	-	V <sub>DD</sub>	V
	V <sub>IL1</sub>	-	-0.3	-	0.6	V
Input Voltage (2) (except OSC1)	V <sub>IH2</sub>	-	V <sub>DD</sub> -1.0	-	V <sub>DD</sub>	V
	V <sub>IL2</sub>	-	-0.2	-	1.0	V
Output Voltage (1) (DB0 to DB7)	V <sub>OH1</sub>	I <sub>OH</sub> = -0.205mA	2.4	-	-	V
	V <sub>OL1</sub>	I <sub>OL</sub> = 1.2mA	-	-	0.4	V
Output Voltage (2) (except DB0 to DB7)	V <sub>OH2</sub>	I <sub>O</sub> = -40μA	0.9V <sub>DD</sub>	-	-	V
	V <sub>OL2</sub>	I <sub>O</sub> = 40μA	-	-	0.1V <sub>DD</sub>	V
Voltage Drop	V <sub>dCOM</sub>	I <sub>O</sub> = ± 0.1mA	-	-	1	V
	V <sub>dSEG</sub>	I <sub>O</sub> = ± 0.1mA	-	-	1	V
Input Leakage Current	I <sub>IL</sub>	V <sub>IN</sub> = 0V to V <sub>DD</sub>	-1	-	1	μA
Low Input Current	I <sub>IN</sub>	V <sub>IN</sub> = 0V, V <sub>DD</sub> = 5V (pull-up)	-50	-125	-250	μA
Internal Clock (external Rf)	f <sub>IC</sub>	Rf = 91kΩ ± 2% (V <sub>DD</sub> = 5V)	190	270	350	KHz
External Clock	f <sub>EC</sub>	-	150	250	350	KHz
	duty		45	50	55	%
	f <sub>R</sub> , t <sub>F</sub>		-	-	0.2	μs
LCD Driving Voltage	V <sub>LCD</sub>	V <sub>DD</sub> -5V (1/5, 1/4 bias)	4.6	-	10.0	V

(V<sub>DD</sub> = 2.7V to 4.5V, Ta = -30 to +85°C)

Item	Symbol	Condition	Min	Typ	Max	Unit
Operating Voltage	V <sub>DD</sub>	-	2.7	-	4.5	V
Supply Current	I <sub>DD1</sub>	ceramic resonator f <sub>OSC</sub> = 250kHz	-	0.3	0.5	mA
	I <sub>DD2</sub>	Resister oscillation external clock operation f <sub>OSC</sub> = 270kHz	-	0.17	0.3	mA
Input Voltage (1) (except OSC1)	V <sub>IH1</sub>	-	0.7V <sub>DD</sub>	-	V <sub>DD</sub>	V
	V <sub>IL1</sub>	-	-0.3	-	0.4	V
Input Voltage (2) (except OSC1)	V <sub>IH2</sub>	-	0.7V <sub>DD</sub>	-	V <sub>DD</sub>	V
	V <sub>IL2</sub>	-	-	-	0.2V <sub>DD</sub>	V
Output Voltage (1) (DB0 to DB7)	V <sub>OH1</sub>	I <sub>OH</sub> = -0.1mA	2.0	-	-	V
	V <sub>OL1</sub>	I <sub>OL</sub> = 0.1mA	-	-	0.4	V
Output Voltage (2) (except DB0 to DB7)	V <sub>OH2</sub>	I <sub>O</sub> = -40μA	0.8V <sub>DD</sub>	-	-	V
	V <sub>OL2</sub>	I <sub>O</sub> = 40μA	-	-	0.2V <sub>DD</sub>	V
Voltage Drop	V <sub>dCOM</sub>	I <sub>O</sub> = ± 0.1mA	-	-	1	V
	V <sub>dSEG</sub>	I <sub>O</sub> = ± 0.1mA	-	-	1.5	V
Input Leakage Current	I <sub>IL</sub>	V <sub>IN</sub> = 0V to V <sub>DD</sub>	-1	-	1	μA
Low Input Current	I <sub>IN</sub>	V <sub>IN</sub> = 0V, V <sub>DD</sub> = 5V (pull-up)	-10	-50	-120	μA
Internal Clock (external Rf)	f <sub>IC</sub>	Rf = 75kΩ ± 2% (V <sub>DD</sub> = 3V)	190	250	350	KHz
External Clock	f <sub>EC</sub>	-	125	270	350	KHz
	duty		45	50	55	%
	f <sub>R</sub> , t <sub>F</sub>		-	-	0.2	μs
*LCD Driving Voltage	V <sub>LCD</sub>	V <sub>DD</sub> -V <sub>5</sub> (1/5, 1/4 bias)	3.0	-	10.0	V

**NOTE:** LCD Driving Voltage

LCD Driving Voltage

Power	DUTY	1/8, 1/11 DUTY	1/16 DUTY
	BIAS	1/4 BIAS	1/5 BIAS
V <sub>DD</sub>		V <sub>DD</sub>	V <sub>DD</sub>
V <sub>1</sub>		V <sub>DD</sub> - V <sub>LCD</sub> /4	V <sub>DD</sub> - V <sub>LCD</sub> /5
V <sub>2</sub>		V <sub>DD</sub> - V <sub>LCD</sub> /2	V <sub>DD</sub> - 2V <sub>LCD</sub> /5
V <sub>3</sub>		V <sub>DD</sub> - V <sub>LCD</sub> /2	V <sub>DD</sub> - 3V <sub>LCD</sub> /5
V <sub>4</sub>		V <sub>DD</sub> - 3V <sub>LCD</sub> /4	V <sub>DD</sub> - 4V <sub>LCD</sub> /5
V <sub>5</sub>		V <sub>DD</sub> - V <sub>LCD</sub>	V <sub>DD</sub> - V <sub>LCD</sub>

## 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
Write Mode (Refer to Figure 6)	E Cycle Time	tc	500	-	-	ns
	E Rise / Fall Time	tr, tf	-	-	25	
	E Pulse Width (High, Low)	tw	220	-	-	
	R/W and RS Setup Time	tsu1	40	-	-	
	R/W and RS Hold Time	th1	10	-	-	
	Data Setup Time	tsu2	60	-	-	
	Data Hold Time	th2	10	-	-	
Read mode (refer to figure 7)	E Cycle Time	tc	500	-	-	
	E Rise / Fall Time	tr, tf	-	-	25	
	E Pulse Width (High, Low)	tw	220	-	-	
	R/W and RS Setup Time	tsu	40	-	-	
	R/W and RS Hold Time	th	10	-	-	
	Data Output Delay Time	t <sub>D</sub>	-	-	120	
	Data Hold Time	t <sub>DH</sub>	20	-	-	

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

Mode	Item	Symbol	Min	Typ	Max	Unit
Write Mode (Refer to Figure 6)	E Cycle Time	tc	1400	-	-	ns
	E Rise / Fall Time	tr, tf	-	-	25	
	E Pulse Width (High, Low)	tw	400	-	-	
	R/W and RS Setup Time	tsu1	60	-	-	
	R/W and RS Hold Time	th1	20	-	-	
	Data Setup Time	tsu2	140	-	-	
	Data Hold Time	th2	10	-	-	
Read mode (refer to figure 7)	E Cycle Time	tc	1400	-	-	
	E Rise / Fall Time	tr, tf	-	-	25	
	E Pulse Width (High, Low)	tw	400	-	-	
	R/W and RS Setup Time	tsu	60	-	-	
	R/W and RS Hold Time	th	20	-	-	
	Data Output Delay Time	t <sub>D</sub>	-	-	360	
	Data Hold Time	t <sub>DH</sub>	5	-	-	

Mode	Item	Symbol	Min	Typ	Max	Unit
Interface Mode with Extension Driver (refer to figure 8)	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	$t_{DW}$	-1000	-	1000	

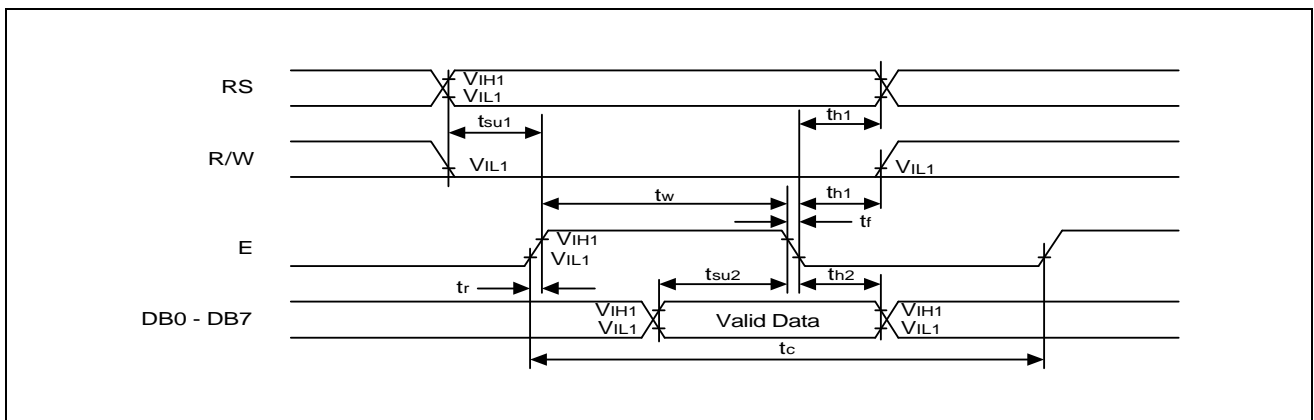


Figure 6. Write Mode Timing Diagram



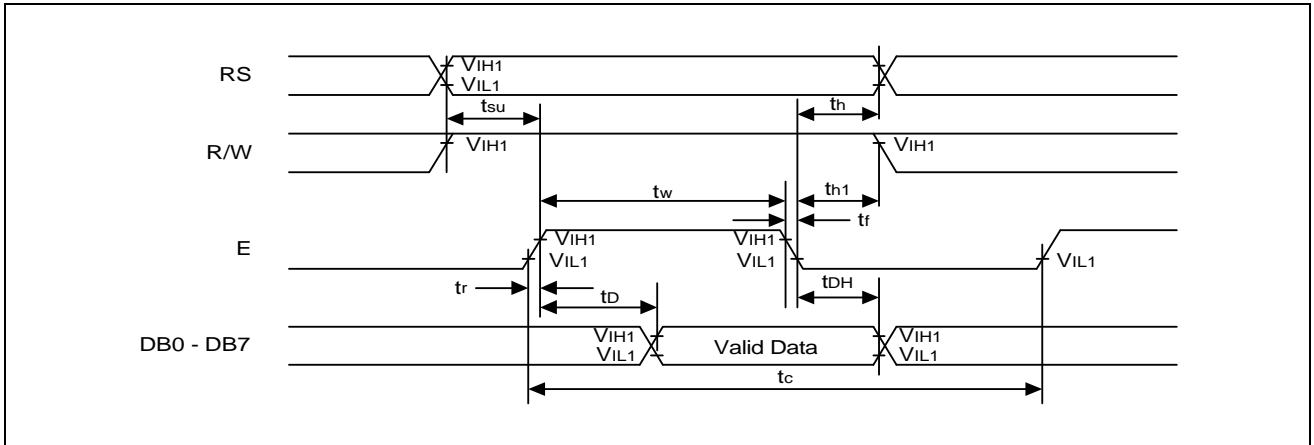


Figure 7. Read Mode Timing Diagram

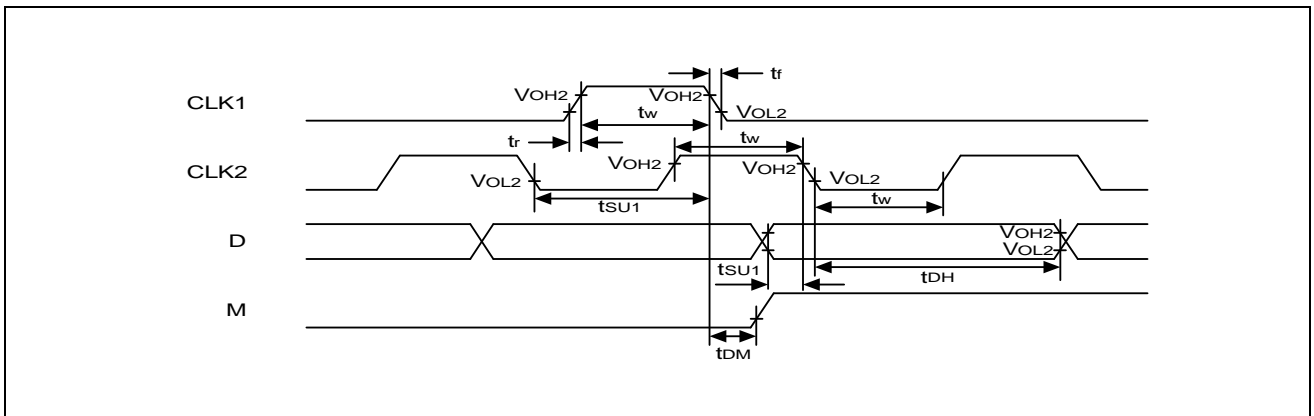


Figure 8. Interface Mode with Extension Driver Timing Diagram