

INTRODUCTION

KS0070B 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.

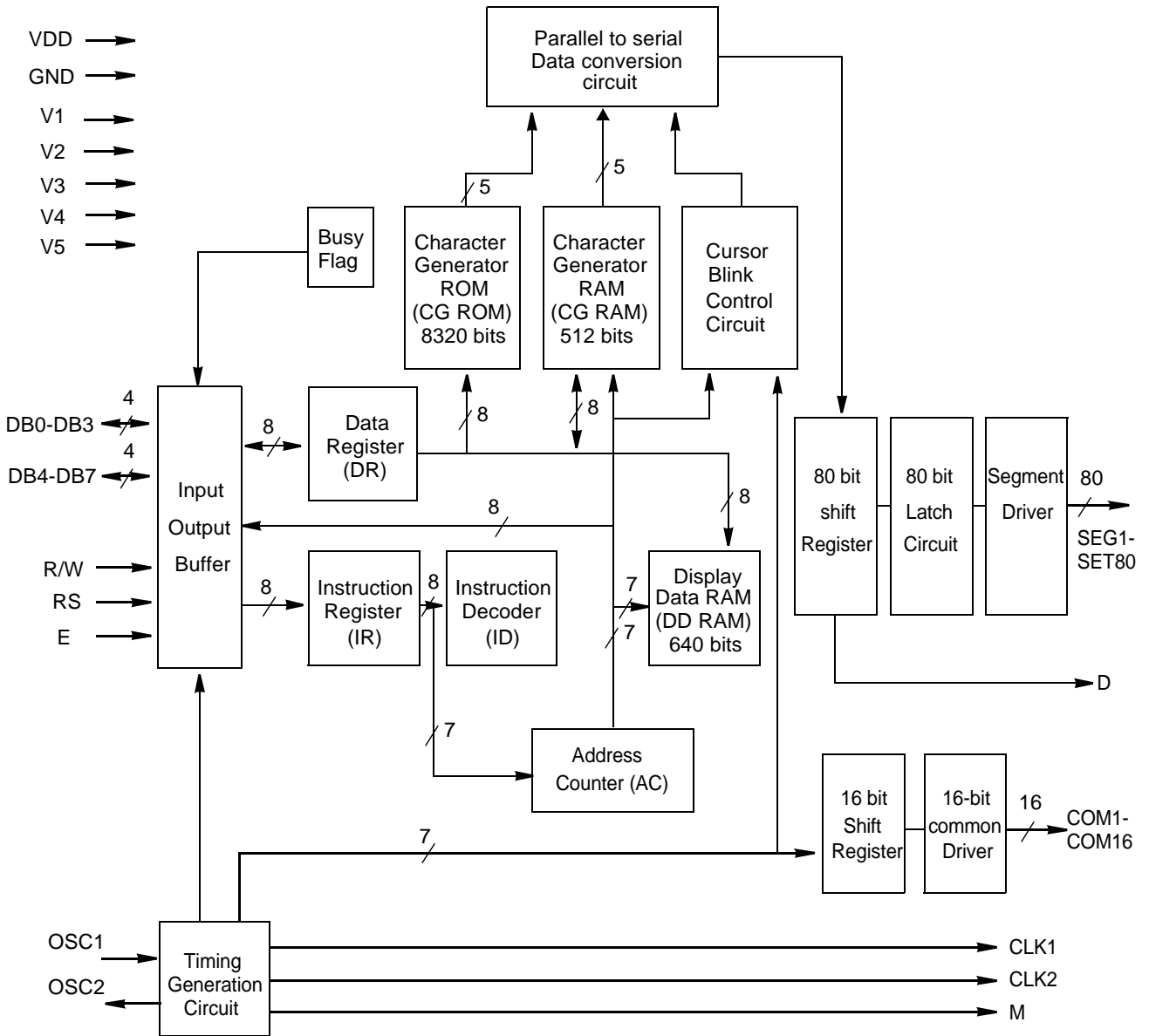
FUNCTIONS

- Character type dot matrix LCD driver & controller
- Internal driver: 16 common and 80 segment signal output
- Easy interface with 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 of 80 characters by using the KS0065B or KS0063B externally.
- Various instruction functions
- Built-in automatic power on reset
- Driving method is A-type (Line inversion)

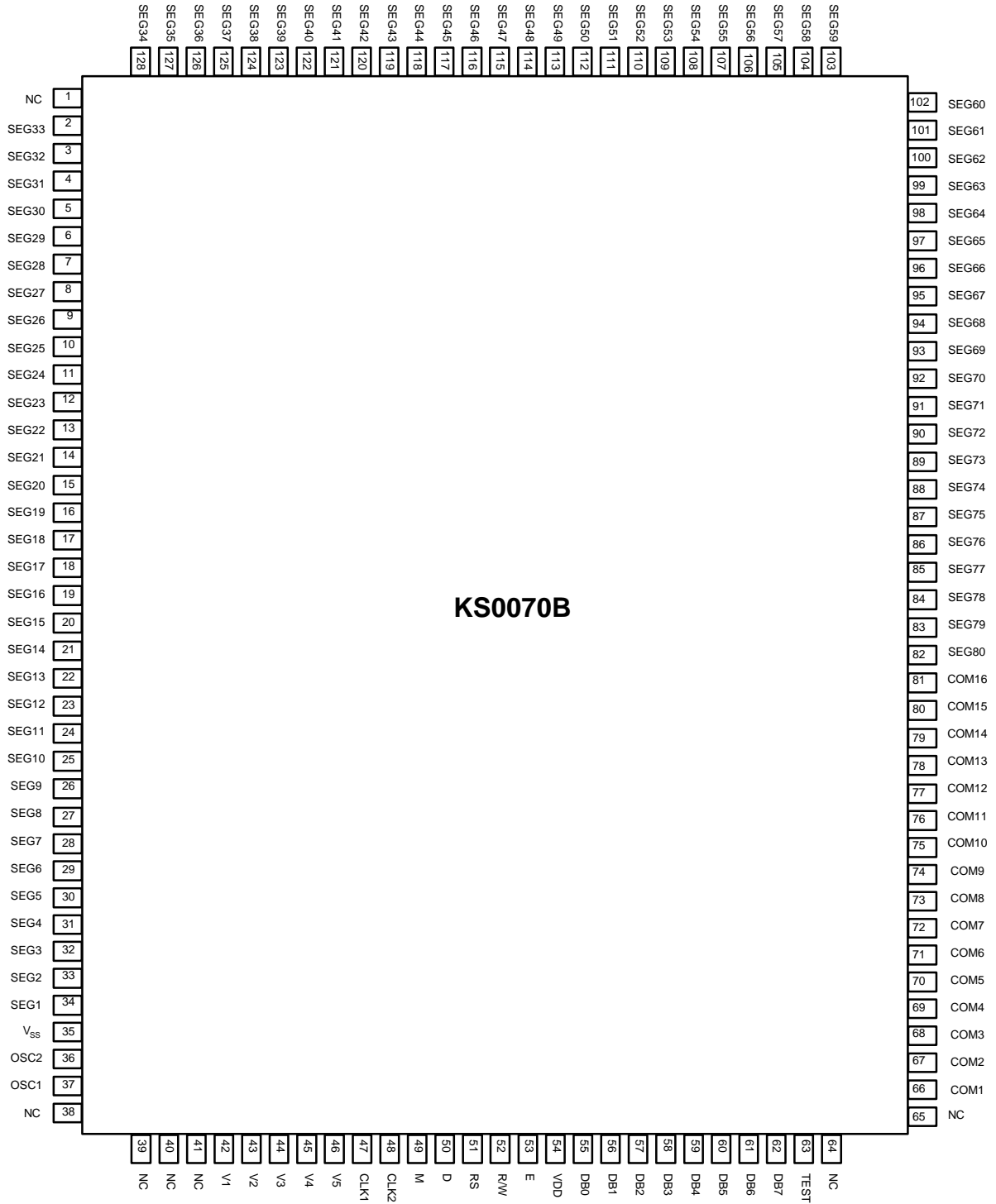
FEATURES

- Internal Memory
 - Character Generator ROM (CGROM): 8,320 bits (192 characters × 5 × 7 dots)
& (32 characters × 5 × 10 dots)
 - Character Generator RAM (CGRAM): 64 × 8 bits (8 characters × 5 × 7 dots)
 - Display Data RAM (DDRAM): 80 × 8 bits (80 characters max.)
- Low power operation
 - Power supply voltage range: 2.7 to 5.5 V (VDD)
 - LCD Drive voltage range: 3.0 to 10.0 V (VDD to V5)
- Supply voltage for display: 0 to -5 V (V5)
- Programmable duty cycle: 1/8, 1/11, 1/16
- Internal oscillator with an external resistor
- Bare chip or bumped chip available

BLOCK DIAGRAM

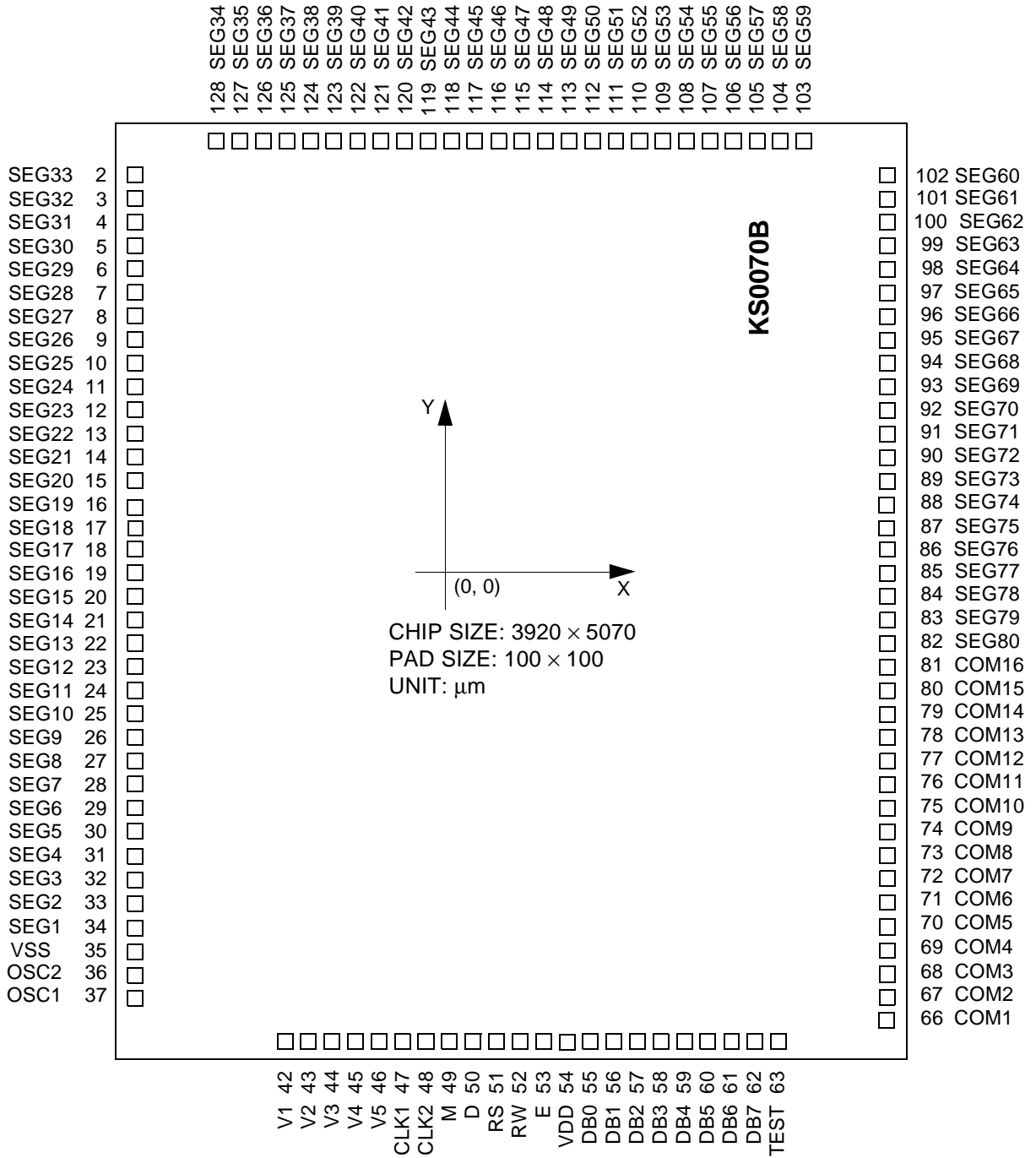


PIN CONFIGURATION



PAD CONFIGURATION

1) NORMAL TYPE PAD CONFIGURATION



PAD COORDINATE

1) NORMAL TYPE PAD COORDINATE

PAD NO.	PAD NAME	COORDINATE		PAD NO.	PAD NAME	COORDINATE		PAD NO.	PAD NAME	COORDINATE		PAD NO.	PAD NAME	COORDINATE	
		X	Y			X	Y			X	Y			X	Y
1	NC	-	-	24	SEG11	-1794	-581	47	CLK1	-530	-2369	70	COM5	1794	-1831
2	SEG33	-1794	2169	25	SEG10	-1794	-706	48	CLK2	-405	-2369	71	COM6	1794	-1706
3	SEG32	-1794	2044	26	SEG9	-1794	-831	49	M	-280	-2369	72	COM7	1794	-1581
4	SEG31	-1794	1919	27	SEG8	-1794	-956	50	D	-155	-2369	73	COM8	1794	-1456
5	SEG30	-1794	1794	28	SEG7	-1794	-1081	51	RS	-30	-2369	74	COM9	1794	-1331
6	SEG29	-1794	1669	29	SEG6	-1794	-1206	52	RW	95	-2369	75	COM10	1794	-1206
7	SEG28	-1794	1544	30	SEG5	-1794	-1331	53	E	220	-2369	76	COM11	1794	-1081
8	SEG27	-1794	1419	31	SEG4	-1794	-1456	54	VDD	345	-2369	77	COM12	1794	-956
9	SEG26	-1794	1294	32	SEG3	-1794	-1581	55	DB0	470	-2369	78	COM13	1794	-831
10	SEG25	-1794	1169	33	SEG2	-1794	-1706	56	DB1	595	-2369	79	COM14	1794	-706
11	SEG24	-1794	1044	34	SEG1	-1794	-1831	57	DB2	720	-2369	80	COM15	1794	-581
12	SEG23	-1794	919	35	VSS	-1794	-1956	58	DB3	845	-2369	81	COM16	1794	-456
13	SEG22	-1794	794	36	OSC2	-1794	-2106	59	DB4	970	-2369	82	SEG80	1794	-331
14	SEG21	-1794	669	37	OSC1	-1794	-2231	60	DB5	1095	-2369	83	SEG79	1794	-206
15	SEG20	-1794	544	38	NC	-	-	61	DB6	1220	-2369	84	SEG78	1794	-81
16	SEG19	-1794	419	39	NC	-	-	62	DB7	1345	-2369	85	SEG77	1794	44
17	SEG18	-1794	294	40	NC	-	-	63	TEST	1470	-2369	86	SEG76	1794	169
18	SEG17	-1794	169	41	NC	-	-	64	NC	-	-	87	SEG75	1794	294
19	SEG16	-1794	44	42	V1	-1155	-2369	65	NC	-	-	88	SEG74	1794	419
20	SEG15	-1794	-81	43	V2	-1030	-2369	66	COM1	1794	-2331	89	SEG73	1794	544
21	SEG14	-1794	-206	44	V3	-905	-2369	67	COM2	1794	-2206	90	SEG72	1794	669
22	SEG13	-1794	-331	45	V4	-780	-2369	68	COM3	1794	-2081	91	SEG71	1794	794
23	SEG12	-1794	-456	46	V5	-655	-2369	69	COM4	1794	-1956	92	SEG70	1794	919

NORMAL TYPE PAD COORDINATE (CONTINUED)

PAD NO.	PAD NAME	COORDINATE		PAD NO.	PAD NAME	COORDINATE		PAD NO.	PAD NAME	COORDINATE		PAD NO.	PAD NAME	COORDINATE	
		X	Y			X	Y			X	Y			X-	Y-
93	SEG69	1794	1044	102	SEG60	1794	2169	111	SEG51	563	2369	120	SEG42	-562	2369
94	SEG68	1794	1169	103	SEG59	1563	2369	112	SEG50	438	2369	121	SEG41	-687	2369
95	SEG67	1794	1294	104	SEG58	1438	2369	113	SEG49	313	2369	122	SEG40	-812	2319
96	SEG66	1794	1419	105	SEG57	1313	2369	114	SEG48	188	2369	123	SEG39	-937	2369
97	SEG65	1794	1544	106	SEG56	1188	2369	115	SEG47	63	2369	124	SEG38	-1062	2369
98	SEG64	1794	1669	107	SEG55	1063	2369	116	SEG46	-62	2369	125	SEG37	-1187	2369
99	SEG63	1794	1794	108	SEG54	938	2369	117	SEG45	-187	2369	127	SEG36	-1312	2369
100	SEG62	1794	1919	109	SEG53	813	2369	118	SEG44	-312	2369	127	SEG35	-1437	2369
101	SEG61	1794	2044	110	SEG52	688	2369	119	SEG43	-437	2369	128	SEG34	-1562	2369

2) MIRROR TYPE PAD COORDINATE

PAD NO.	PAD NAME	COORDINATE		PAD NO.	PAD NAME	COORDINATE		PAD NO.	PAD NAME	COORDINATE		PAD NO.	PAD NAME	COORDINATE	
		X	Y			X	Y			X	Y			X	Y
1	NC	-	-	24	COM15	-1794	-581	47	DB2	-720	-2369	70	SEG1	1794	-1831
2	SEG60	-1794	2169	25	COM14	-1794	-706	48	DB1	-595	-2369	71	SEG2	1794	-1706
3	SEG61	-1794	2044	26	COM13	-1794	-831	49	DB0	-470	-2369	72	SEG3	1794	-1581
4	SEG62	-1794	1919	27	COM12	-1794	-956	50	VDD	-345	-2369	73	SEG4	1794	-1456
5	SEG63	-1794	1794	28	COM11	-1794	-1081	51	E	-220	-2369	74	SEG5	1794	-1331
6	SEG64	-1794	1669	29	COM10	-1794	-1206	52	RW	-95	-2369	75	SEG6	1794	-1206
7	SEG65	-1794	1544	30	COM9	-1794	-1331	53	RS	30	-2369	76	SEG7	1794	-1081
8	SEG66	-1794	1419	31	COM8	-1794	-1456	54	D	155	-2369	77	SEG8	1794	-956
9	SEG67	-1794	1294	32	COM7	-1794	-1581	55	M	280	-2369	78	SEG9	1794	-831
10	SEG68	-1794	1169	33	COM6	-1794	-1706	56	CLK2	405	-2369	79	SEG10	1794	-706
11	SEG69	-1794	1044	34	COM5	-1794	-1831	57	CLK1	530	-2369	80	SEG11	1794	-581
12	SEG70	-1794	919	35	COM4	-1794	-1956	58	V5	655	-2369	81	SEG12	1794	-456
13	SEG71	-1794	794	36	COM3	-1794	-2081	59	V4	780	-2369	82	SEG13	1794	-331
14	SEG72	-1794	669	37	COM2	-1794	-2206	60	V3	905	-2369	83	SEG14	1794	-206
15	SEG73	-1794	544	38	COM1	-1794	-2331	61	V2	1030	-2369	84	SEG15	1794	-81
16	SEG74	-1794	419	39	NC	-	-	62	V1	1155	-2369	85	SEG16	1794	44
17	SEG75	-1794	294	40	NC	-	-	63	NC	-	-	86	SEG17	1794	169
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19	SEG77	-1794	44	42	DB7	-1345	-2369	65	NC	-	-	88	SEG19	1794	419
20	SEG78	-1794	-81	43	DB6	-1220	-2369	66	NC	-	-	89	SEG20	1794	544
21	SEG79	-1794	-206	44	DB5	-1095	-2369	67	OSC1	1794	-2231	90	SEG21	1794	669
22	SEG80	-1794	-331	45	DB4	-970	-2369	68	OSC2	1794	-2106	91	SEG22	1794	794
23	COM16	-1794	-456	46	DB3	-845	-2369	69	VSS	1794	-1956	92	SEG23	1794	919

MIRROR TYPE PAD COORDINATE (CONTINUED)

PAD NO.	PAD NAME	COORDINATE		PAD NO.	PAD NAME	COORDINATE		PAD NO.	PAD NAME	COORDINATE		PAD NO.	PAD NAME	COORDINATE	
		X	Y			X	Y			X	Y			X	Y
93	SEG24	1794	1044	102	SEG33	1794	2169	111	SEG42	562	2369	120	SEG51	-563	2369
94	SEG25	1794	1169	103	SEG34	1562	2369	112	SEG43	437	2369	121	SEG52	-688	2369
95	SEG26	1794	1294	104	SEG35	1437	2369	113	SEG44	312	2369	122	SEG53	-813	2369
96	SEG27	1794	1419	105	SEG36	1312	2369	114	SEG45	187	2369	123	SEG54	-938	2369
97	SEG28	1794	1544	106	SEG37	1187	2369	115	SEG46	62	2369	124	SEG55	-1063	2369
98	SEG29	1794	1669	107	SEG38	1062	2369	116	SEG47	-63	2369	125	SEG56	-1188	2369
99	SEG30	1794	1794	108	SEG39	937	2369	117	SEG48	-188	2369	127	SEG57	-1313	2369
100	SEG31	1794	1919	109	SEG40	812	2369	118	SEG49	-313	2369	127	SEG58	-1438	2369
101	SEG32	1794	2044	110	SEG41	687	2369	119	SEG50	-438	2369	128	SEG59	-1563	2369

PAD DESCRIPTION

Pad No. (Normal/Mirror)	Input/ Output	Name	Description	Interface
VDD (54/50)	-	Power supply	For logical circuit (+3 V, + 5 V)	Power Supply
VSS(35, 69)			0 V (GND)	
V1 ~ V5 (42~46/62~58)			Bias voltage level for LCD driving.	
SEG1 ~ SEG80 (34~2, 128~82/ 70~128, 2~22)	Output	Segment output	Segment signal output for LCD drive.	LCD
COM1 ~ COM16 (66~81/38~23)	Output	Common output	Common signal output for LCD drive.	LCD
OSC1,OSC2 (37,36/67,68)	Input (OSC1)/ Output (OSC2)	Oscillator	When using internal oscillator, connect external Rf resistor. If external clock is used, connect it to OSC1.	External resistor/ 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 as 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 0~7	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)			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-bit 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 DDRAM/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 According 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 ~ DB6)
1	0	Data Write operation (MPU writes data into DR)
1	1	Data Read operation (MPU reads data from 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 characters). DDRAM address is set in the address counter (AC) as a hexadecimal number. (Refer to Fig-1.)

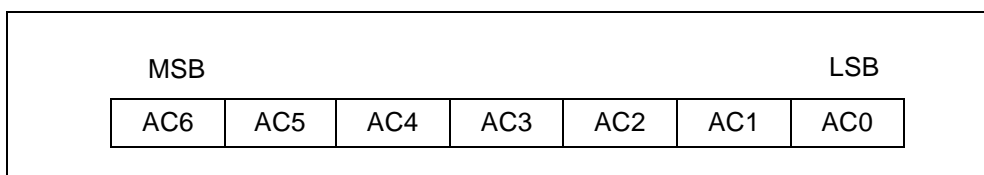


Fig-1. DDRAM Address

1) 1-line display

In the case of a 1-line display, the address range of DDRAM is 00H ~ 4FH. An Extension driver will be used. Fig-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. Fig-3 shows the example when a 40 segment extension driver is added.

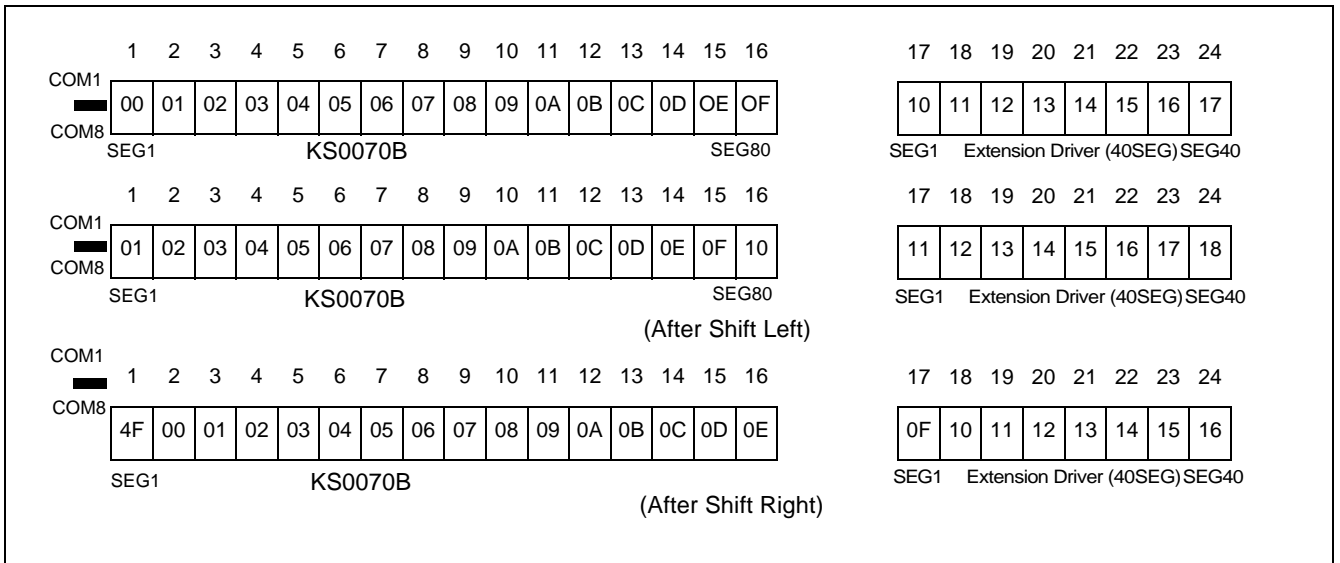


Fig-2. 1-line 24ch. Display With 40 SEG. Extension Driver.

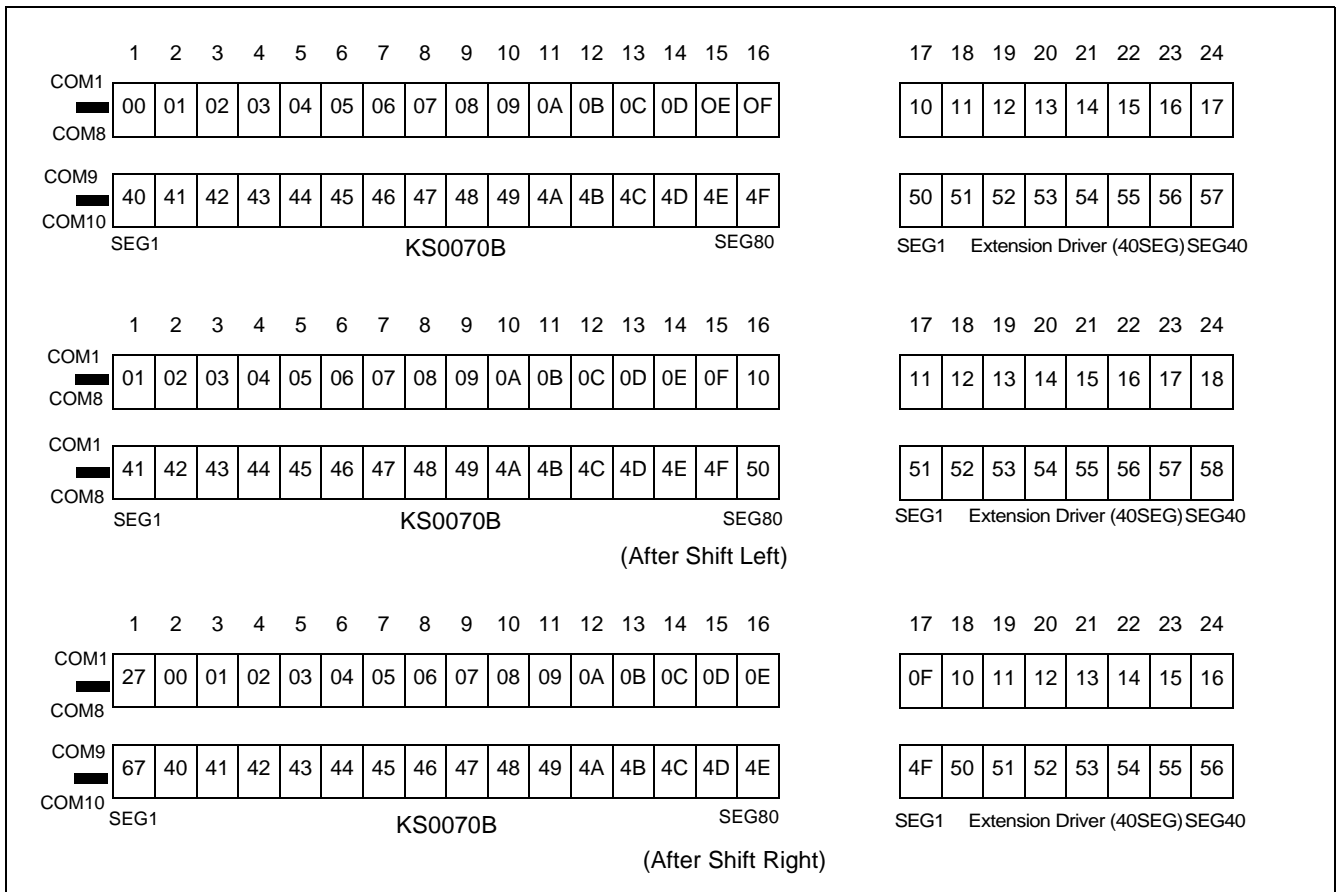


Fig-3. 2-line 24ch. Display With 40 SEG. Extension Driver.

CGROM (Character Generator ROM)

CGROM has a 5×7 -dot 192 character pattern, and a 5×10 -dot 32 character pattern (Refer to Table 2).

CGRAM (Character Generator RAM)

CGRAM has up to 5×8 -dot 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 an 80-bit segment latch.

In the case of a 1-line display mode, COM1 ~ 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 2. CGROM Character Code Table

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

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	1	1	1	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": dont care

INSTRUCTION DESCRIPTION

Outline

To overcome the speed difference between the internal clock of KS0070B and the MPU clock, KS0070B performs internal operations 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 into four kinds:

- (1) KS0070B 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 the internal RAM is automatically increased or decreased by 1.

* NOTE: During internal operation, Busy Flag (DB7) is read "1". Busy Flag check must be preceded by the next instruction.

When you make an MPU program with checking the Busy Flag (DB7), 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 addresses, and set the DDRAM addresses to "00H" in the AC (address counter). Return cursor to 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 the 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 is in read (CGRAM read/write) operation or SH = "0", shift of entire display is not performed.

If SH = "1" and in 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 remains in DDRAM.

C : Cursor ON/OFF control bit

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

When C = "0", cursor disappears in current display, but I/D register retains its data.

B : Cursor Blink ON/OFF control bit

When B = "1", cursor blink is on, which performs alternately between all the "1" data and display characters 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	×	×

Without writing 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 40st digit of the 1st line.

Note that display shift is performed simultaneously in all the lines.

When displayed data is shifted repeatedly, each line shifts 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	×	×

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 parts.

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 in 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 KS0070B 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 is Low. Then the next instruction can be performed. In this instruction you can also read the value of the 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, and 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 the case of DDRAM read operation, cursor shift instruction plays the same role as DDRAM address set instruction; It also transfers RAM data to the output data register.

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

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

Table 5. Instruction Table

Instruction	Instruction Code										Description	Execution Time (fosc = 270 kHz)
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Clear Display	0	0	0	0	0	0	0	0	0	1	Write "20H" to DDRAM and set DDRAM address to "00H" from AC.	1.53 ms
Return Home	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.	1.53 ms
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	SH	Assign cursor moving direction and enable the shift of entire display .	39 μs
Display ON/OFF Control	0	0	0	0	0	0	1	D	C	B	Set display (D), cursor (C), and blinking of cursor (B) on/off control bit.	39 μs
Cursor or Display Shift	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 of DDRAM data.	39 μs
Function Set	0	0	0	0	1	DL	N	F	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 ...)	39 μs
Set CGRAM Address	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM address in address counter.	39 μs
Set DDRAM Address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address counter.	39 μs
Read Busy flag and Address	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Whether during internal operation or not can be known by reading BF. The contents of address counter can also be read.	0 μs
Write Data to RAM	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM).	43 μs
Read Data from RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM (DDRAM/CGRAM).	43 μs

* NOTE : When you make an MPU program with checking the Busy Flag (DB7), it must be necessary 1/2Fosc for executing the next instruction by falling 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. An Example of the timing sequence is shown below.

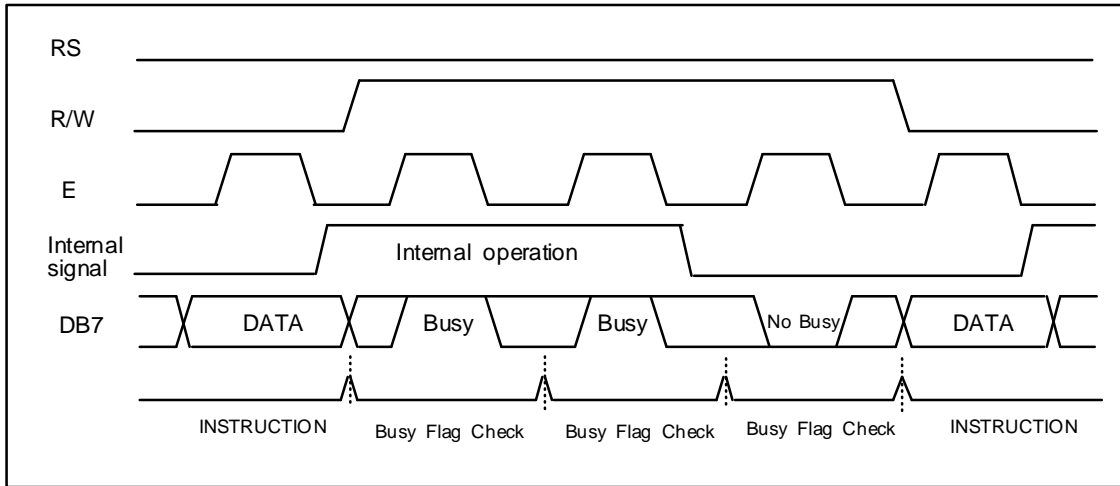


Fig-4. Example of 8-bit Bus Mode Timing Diagram

2) Interface with 4-bit MPU

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 the lower 4-bit (in case of 8-bit bus mode, the contents of DB0 - DB3) are transferred. So transfer is performed in two parts. Busy Flag outputs "1" after the second transfer are ended. Example of timing sequence is shown below.

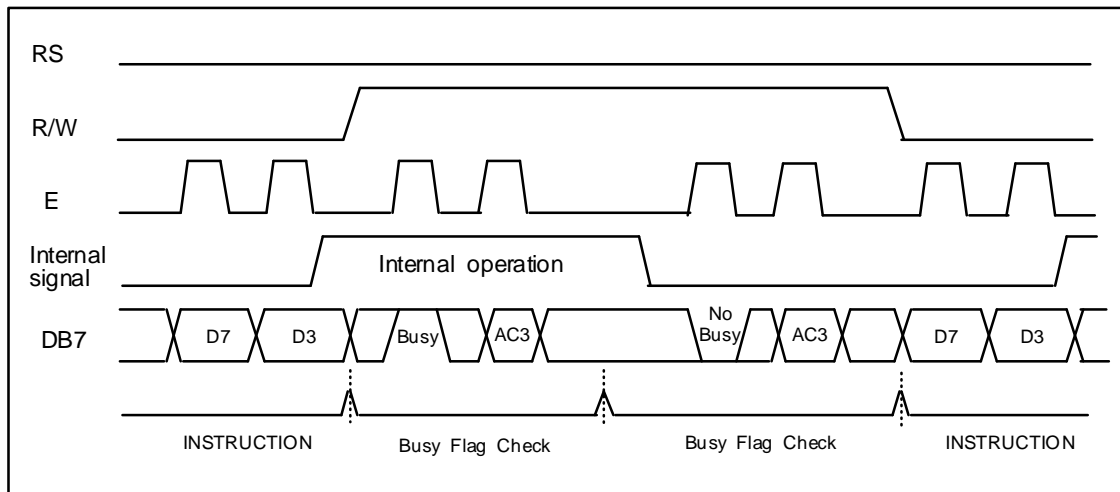
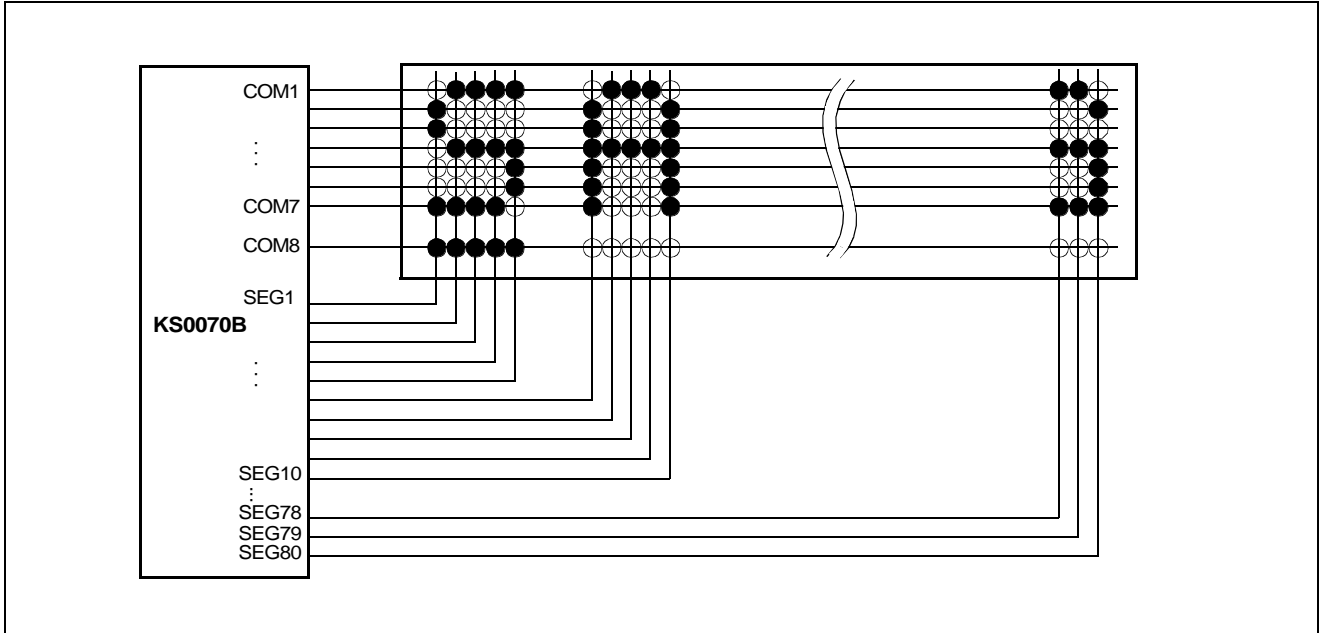


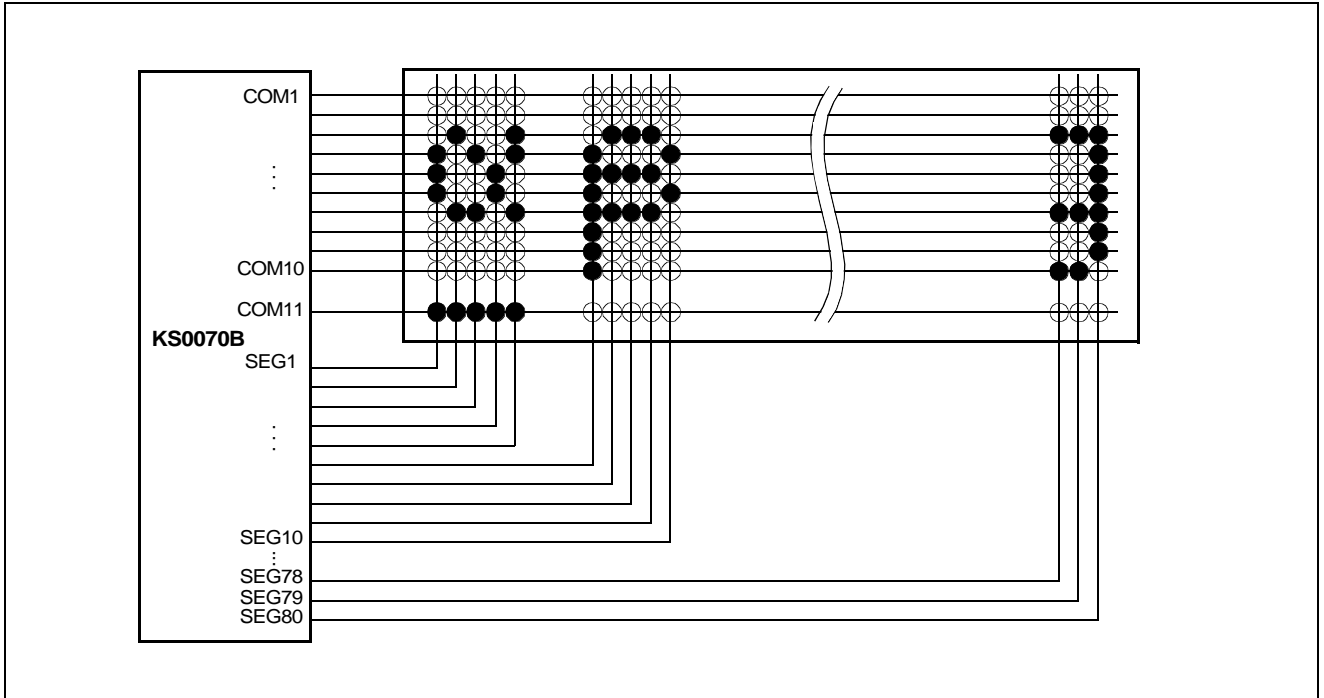
Fig-5. Example of 4-bit Bus Mode Timing Diagram

APPLICATION INFORMATION ACCORDING TO LCD PANEL

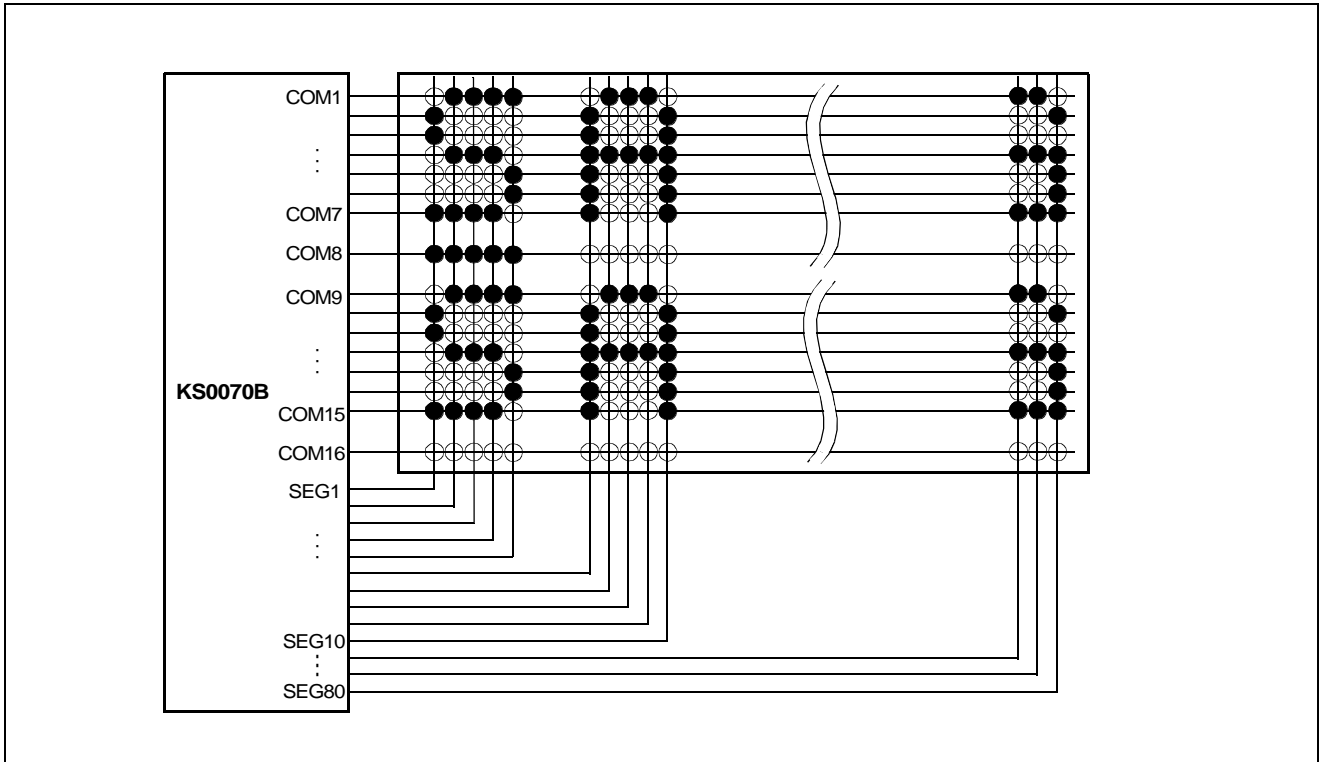
1) LCD Panel: 16 characters \times 1-line format (5 \times 7 dots + 1 cursor line 1/4 bias, 1/8 duty)



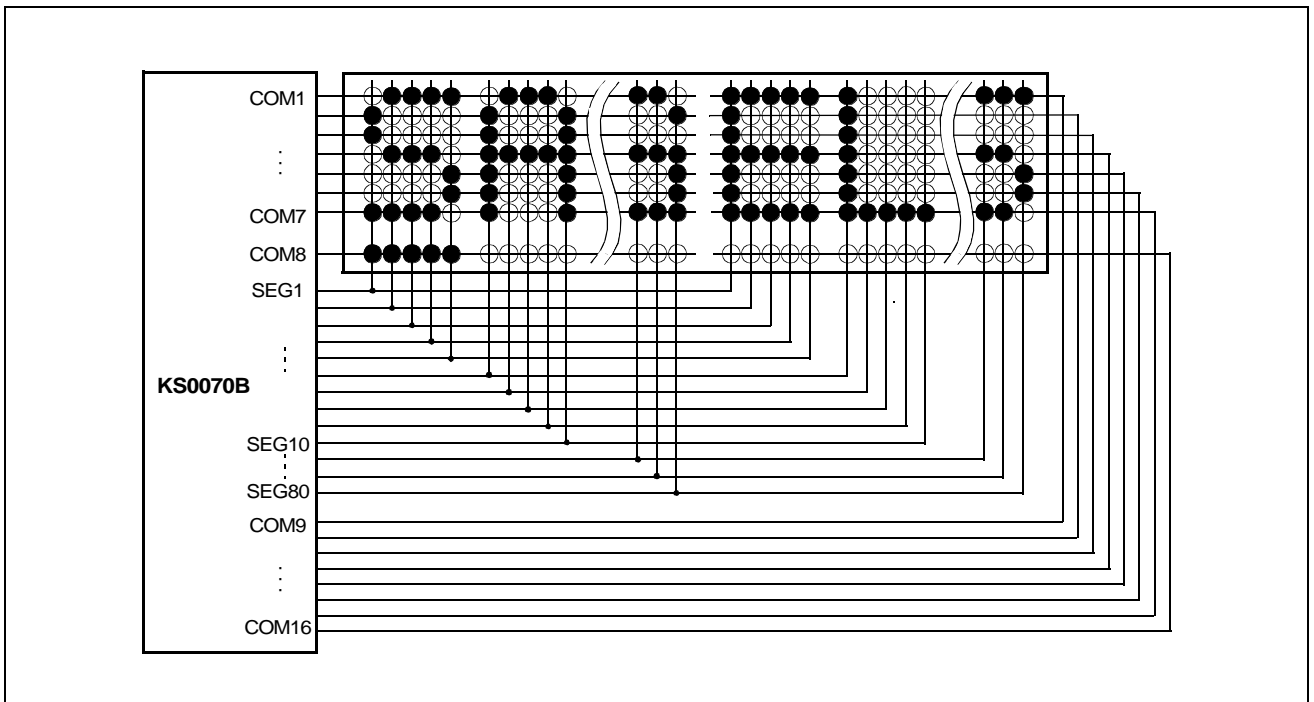
2) LCD Panel: 16 characters \times 1-line format (5 \times 10 dots + 1 cursor line 1/4 bias, 1/11 duty)



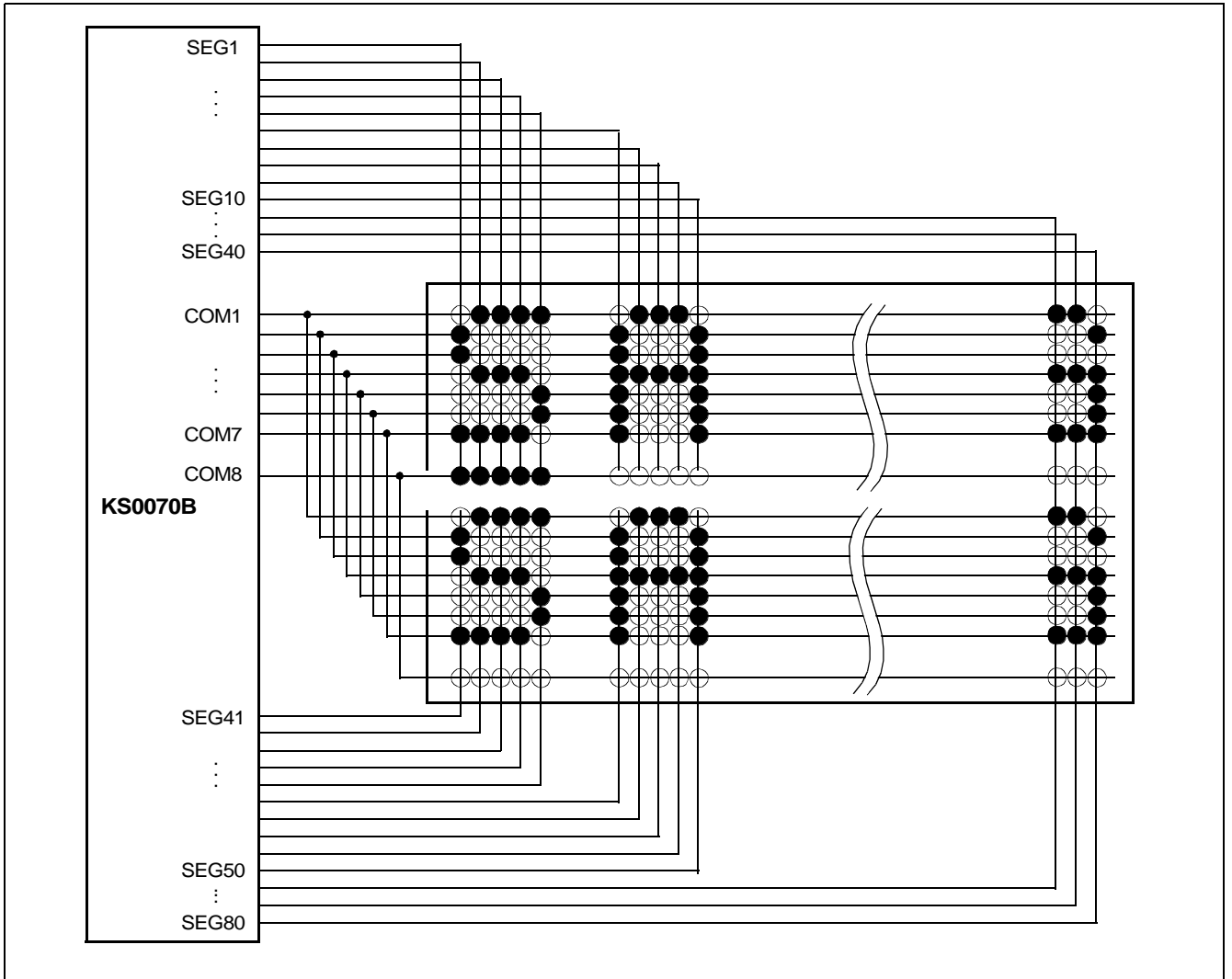
3) LCD Panel : 16 character × 2-line format: (5 × 7 dots + 1 cursor line 1/5 bias, 1/16 duty)



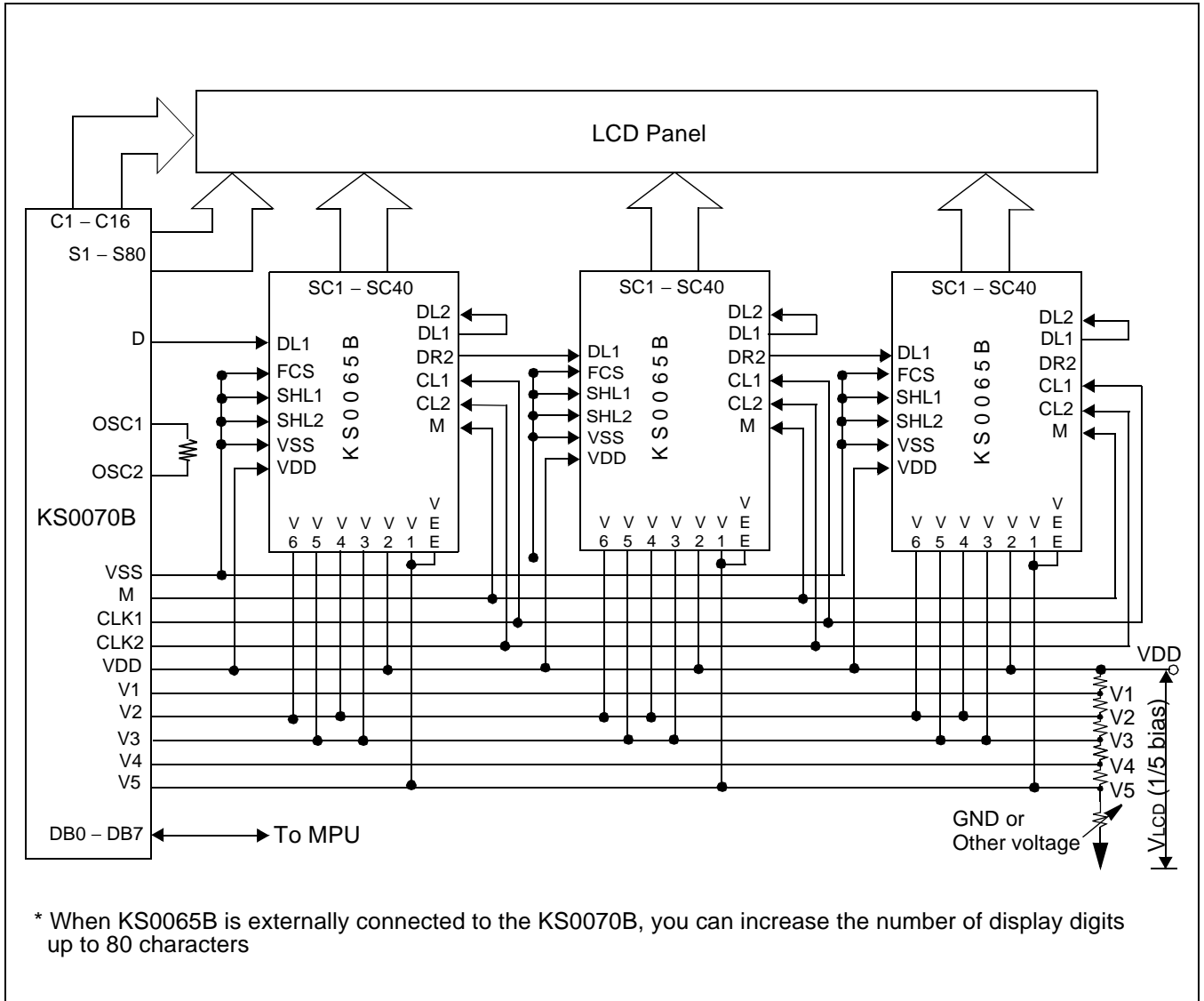
4) LCD Panel : 32 character × 1-line format: (5 × 7 dots + 1 cursor line 1/5 bias, 1/16 duty)



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

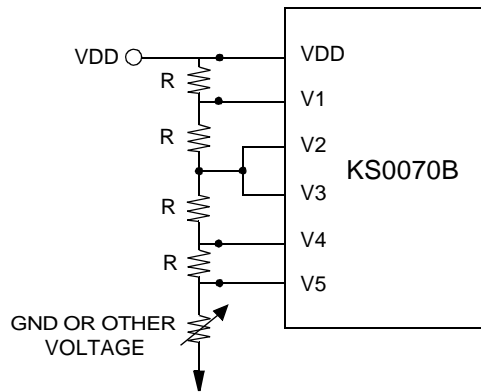


APPLICATION CIRCUIT

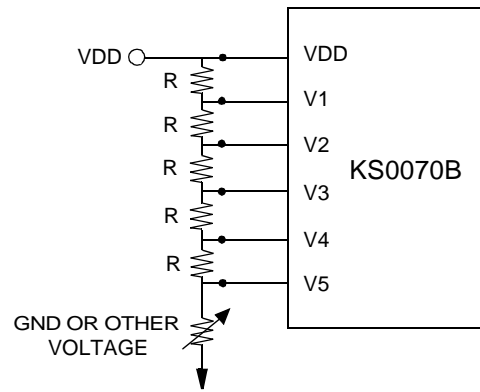


BIAS VOLTAGE DIVIDE CIRCUIT

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



2) 1/5 bias, 1/16 OR 1/11 duty

**INITIALIZING**

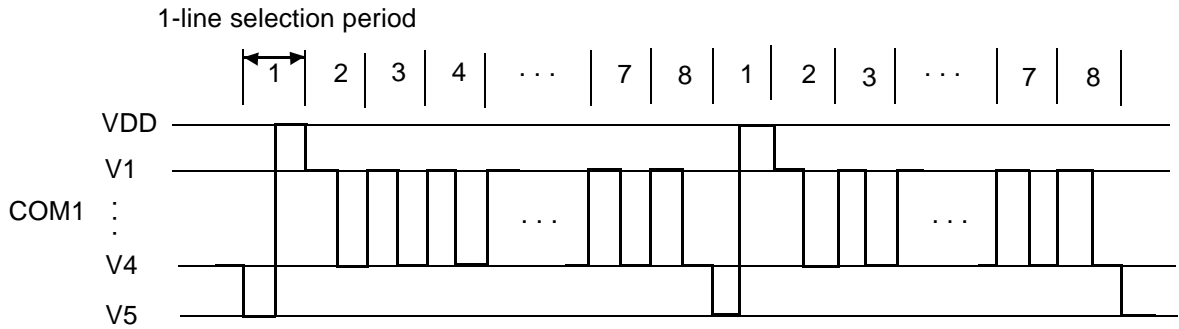
When the power is turned on, KS0070B is initialized automatically by the power on reset circuit. During the initialization, the following instructions are executed, and BF(Busy Flag) is kept "1"(busy state) to the end of initialization.

- (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 : 5×7 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

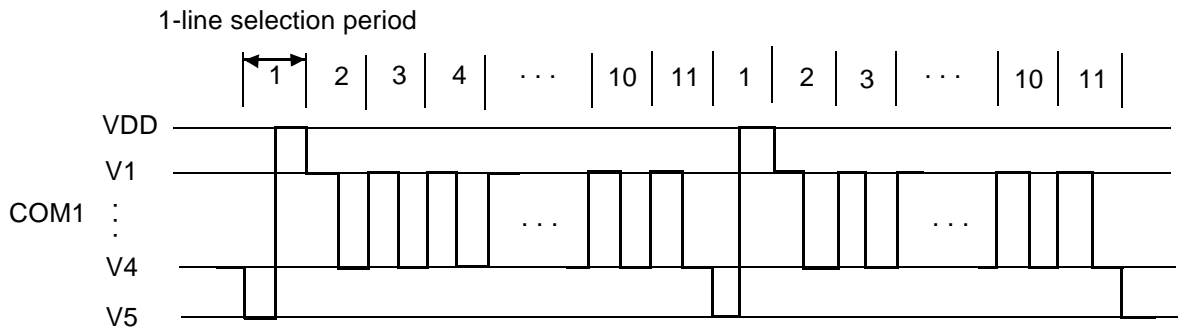


Item	Clock / Frequency
Line selection period	400 clocks
Frame frequency	84.4 Hz

* fosc=270 kHz (1 clock = 3.7 μs)

2) 1/11 duty cycle

A) A-type Waveform

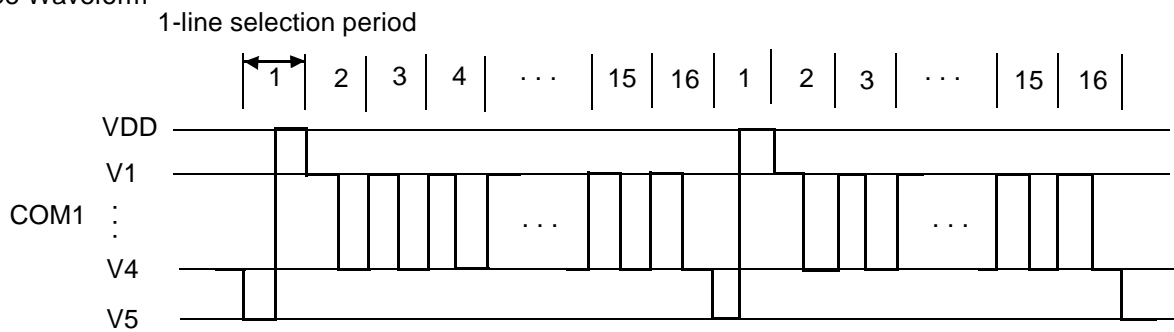


Item	Clock / Frequency
Line selection period	400 clocks
Frame frequency	61.4 Hz

* fosc=270 kHz (1 clock = 3.7 μs)

3) 1/16 duty cycle

A) A-type Waveform



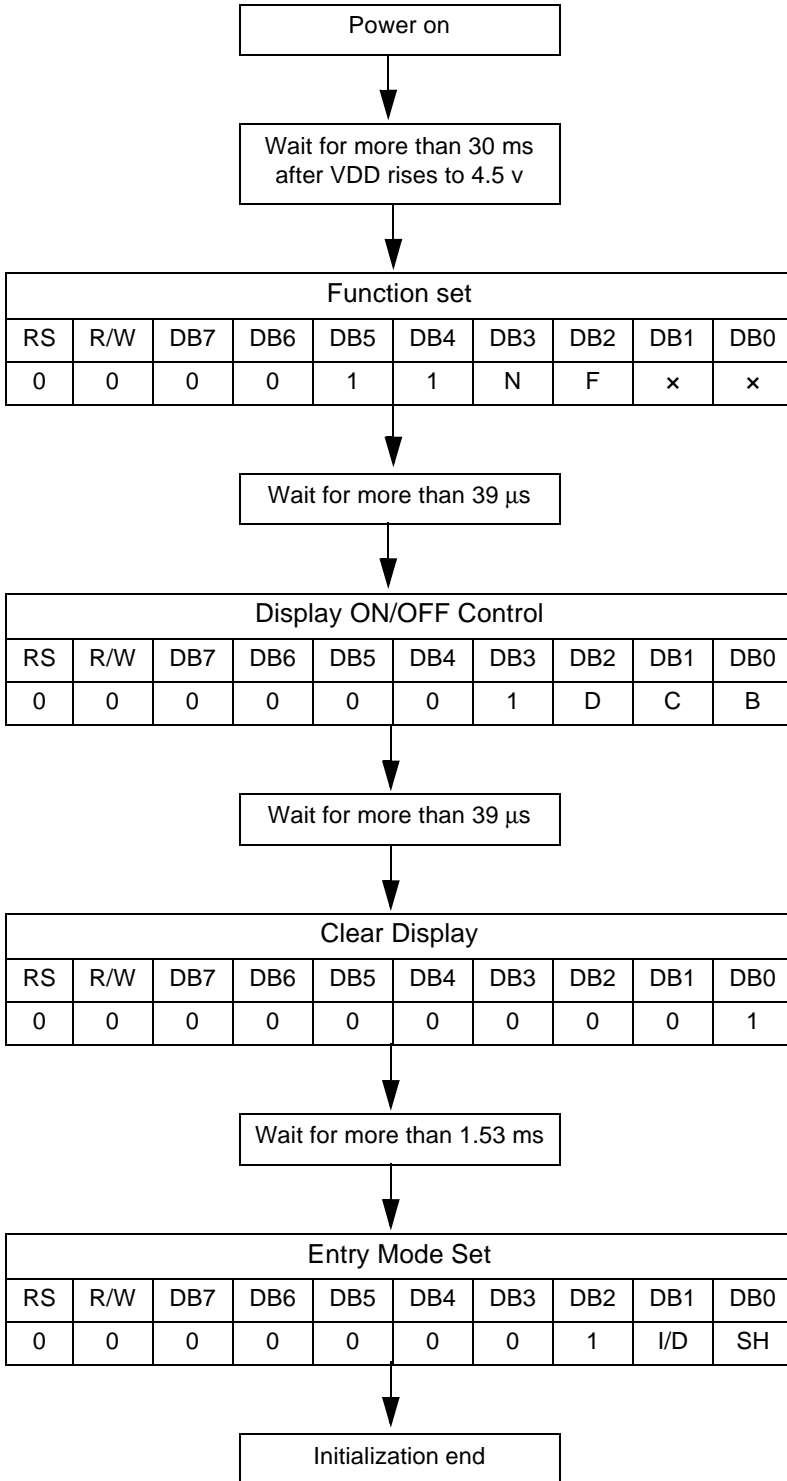
Item	Clock / Frequency
Line selection period	200 clocks
Frame frequency	84.4 Hz

* fosc=270 kHz (1 clock = 3.7 μs)

INITIALIZING BY INSTRUCTION

1) 8-bit interface mode

Condition: fosc=270 kHz



N	0	1-line mode
	1	2-line mode

F	0	5 × 7 dots
	1	5 × 10 dots

D	0	display off
	1	display on

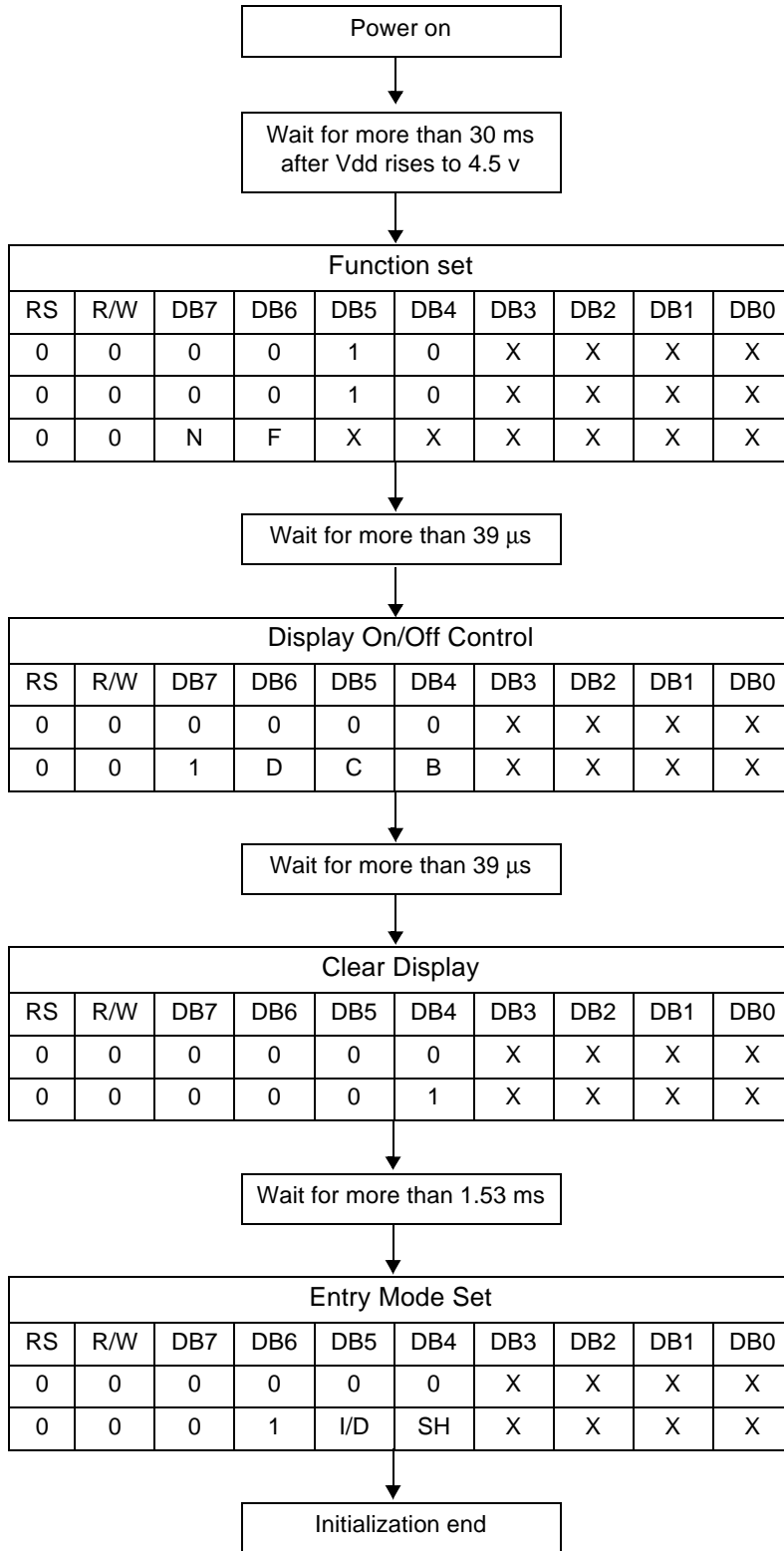
C	0	cursor off
	1	cursor on

B	0	blink off
	1	blink on

I/D	0	decrement mode
	1	increment mode

SH	0	entire shift off
	1	entire shift on

2) 4-bit interface mode



Condition: fosc=270 kHz

N	0	1-line mode
	1	2-line mode

F	0	5 × 7 Dots
	1	5 × 10 Dots

D	0	display off
	1	display on

C	0	cursor off
	1	cursor on

B	0	blink off
	1	blink on

I/D	0	decrement mode
	1	increment mode

SH	0	entire shift off
	1	entire shift on

EXAMPLE OF INSTRUCTION AND DISPLAY CORRESPONDENCE

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

LCD DISPLAY

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

2. Function Set: 8-bit, 2-line, 5x7 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

S_

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

SA_

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

SAM_

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

SAMS_

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

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

SAMSUNG
KS007_

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

SAMSUNG
KS0072_

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

SAMSUNG
KS0072

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

SAMSUNG
KS0070_

21. 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	1	1

SAMSUNG
KS0070_

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

AMSUNG
S0070B_

23. Return Home

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

SAMSUNG
KS0070B

24. Clear Display

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

-

MAXIMUM ABSOLUTE RATE

Maximum Absolute Power Ratings

Item	Symbol	Unit	Value
Power supply voltage(1)	V_{DD}	V	-0.3 to + 7.0
Power supply voltage(2)	V_{LCD}	V	$V_{DD} - 15.0$ 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 ($V_{DD} \geq V1 \geq V2 \geq V3 \geq V4 \geq V5$)

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_{DD} = 4.5V to 5.5V, Ta = -30 to +85 °C)

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

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

Item	Symbol	Condition	Min	Typ	Max	Unit
Operating Voltage	V_{DD}	-	2.7	-	4.5	V
Supply Current	I_{DD1}	ceramic resonator $f_{osc} = 250 \text{ kHz}$	-	0.3	0.5	mA
	I_{DD2}	Resistor oscillation external clock operation $f_{osc} = 270 \text{ kHz}$	-	0.17	0.3	
Input Voltage (1) (except OSC1)	V_{IH1}	-	$0.7V_{DD}$	-	V_{DD}	V
	V_{IL1}	-	-0.3	-	0.4	
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}	$I_{OH} = -0.1 \text{ mA}$	2.0	-	-	V
	V_{OL1}	$I_{OL} = 0.1 \text{ mA}$	-	-	0.4	
Output Voltage (2) (except DB0 to DB7)	V_{OH2}	$I_O = -40 \mu\text{A}$	$0.8V_{DD}$	-	-	V
	V_{OL2}	$I_O = 40 \mu\text{A}$	-	-	$0.2V_{DD}$	
Voltage Drop	V_{dCOM}	$I_O = \pm 0.1 \text{ mA}$	-	-	1	V
	V_{dSEG}		-	-	1.5	
Input Leakage Current	I_{IL}	$V_{IN} = 0 \text{ V to } V_{DD}$	-1	-	1	μA
Low Input Current	I_{IN}	$V_{IN} = 0 \text{ V}, V_{DD} = 3 \text{ V}$ (PULL UP)	-10	-50	-120	
Internal Clock (external Rf)	f_{IC}	$R_f = 75 \text{ k}\Omega \pm 2\%$ ($V_{DD} = 3 \text{ V}$)	190	250	350	kHz
External Clock	f_{EC}	-	125	270	350	kHz
	duty		45	50	55	%
	tr, tf		-	-	0.2	μs
* LCD Driving Voltage	V_{LCD}	$V_{DD} - V_5$ (1/5, 1/4 Bias)	3.0	-	10.0	V

* LCD Driving Voltage (next page)

* LCD Driving Voltage

POWER	DUTY	1/8, 1/11 DUTY	1/16 DUTY
	BIAS	1/4 BIAS	1/5 BIAS
	V_{DD}	V_{DD}	V_{DD}
	V1	$V_{DD} - V_{LCD}/4$	$V_{DD} - V_{LCD}/5$
	V2	$V_{DD} - V_{LCD}/2$	$V_{DD} - 2V_{LCD}/5$
	V3	$V_{DD} - V_{LCD}/2$	$V_{DD} - 3V_{LCD}/5$
	V4	$V_{DD} - 3V_{LCD}/4$	$V_{DD} - 4V_{LCD}/5$
	V5	$V_{DD} - V_{LCD}$	$V_{DD} - V_{LCD}$

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 Fig-6)	E Cycle Time	t_c	500	-	-	ns
	E Rise / Fall Time	$t_{r,tf}$	-	-	25	
	E Pulse Width (High, Low)	t_w	220	-	-	
	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	-	-	
Read Mode (Refer to Fig-7)	E Cycle Time	t_c	500	-	-	ns
	E Rise / Fall Time	$t_{r,tf}$	-	-	25	
	E Pulse Width (High, Low)	t_w	220	-	-	
	R/W and RS Setup Time	t_{su}	40	-	-	
	R/W and RS Hold Time	t_h	10	-	-	
	Data Output Delay Time	t_D	-	-	120	
	Data Hold Time	t_{DH}	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 Fig-6)	E Cycle Time	t_c	1400	-	-	ns
	E Rise / Fall Time	$t_{r,tf}$	-	-	25	
	E Pulse Width (High, Low)	t_w	400	-	-	
	R/W and RS Setup Time	t_{su1}	60	-	-	
	R/W and RS Hold Time	t_{h1}	20	-	-	
	Data Setup Time	t_{su2}	140	-	-	
	Data Hold Time	t_{h2}	10	-	-	
Read Mode (Refer to Fig-7)	E Cycle Time	t_c	1400	-	-	ns
	E Rise / Fall Time	$t_{r,tf}$	-	-	25	
	E Pulse Width (High, Low)	t_w	400	-	-	
	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	-	-	

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

Mode	Item	Symbol	Min	Type	Max	Unit
Interface Mode with Extension Driver (Refer to Fig-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	

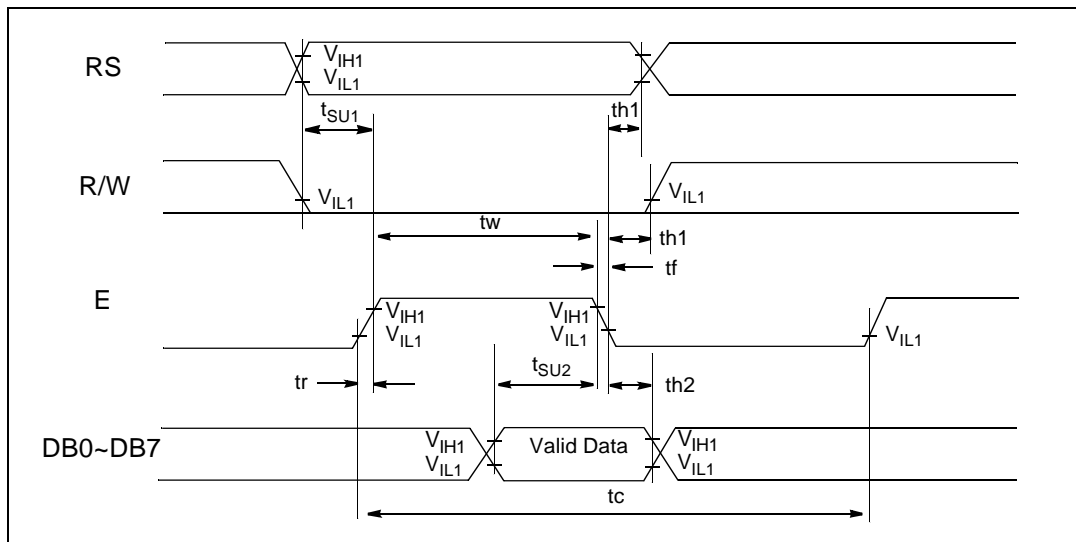


Fig-6. Write Mode Timing Diagram

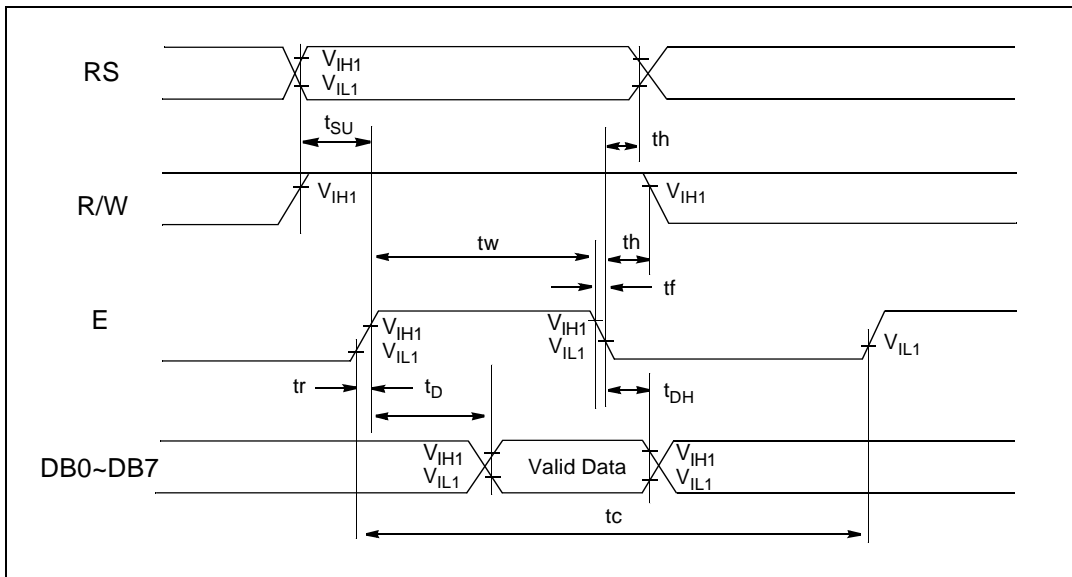


Fig-7. Read Mode Timing Diagram

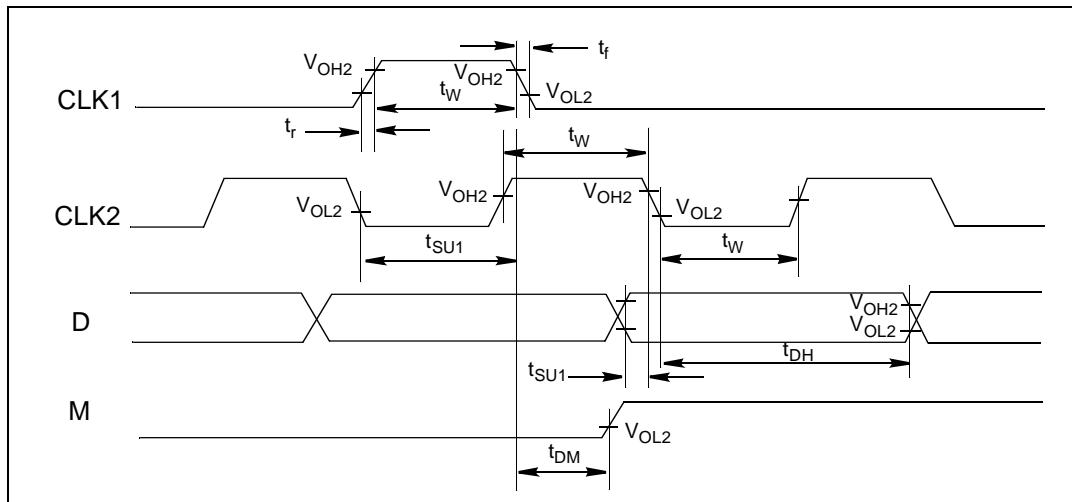


Fig-8. Interface Mode with Extension Driver Timing Diagram