

OPERATING INSTRUCTIONS (CONTINUED)

INSTRUCTION CODE EXPLANATIONS

The two registers 1) Instruction Register (IR) and the 2) Data Register (DR) in the KS0066 controller chip are directly controlled by the MPU. Control information is temporarily stored in these registers prior to internal operation start. This allows interface to various types of MPUs which operate at different

speeds from that of the KS0066, and allows interface from peripheral control ICs. Internal operations of the KS0066 are determined from the signals sent from the MPU. These signals, including register selection signals (RS), Read/Write (R/W) and data bus signals (DBO - DB7) are polled instructions.

REGISTER SELECTION									
RS	R/W		Operation						
0	0		IR selection, IR write. Internal operation: Display clear						
0	1		Busy flag (DB7) and address counter (DB0 to DB6) read						
1	0		DR selection, DR write. Internal operation: DR to DD RAM or CG RAM						
1	1		DR selection, DR read. Internal operation: DD RAM or CG RAM to DR						

ADDRESS COUNTER (AC)

The counter specifies an address when data is written into DD RAM or CG RAM and the data stored in DD RAM or CG RAM is read out. If an Address Set instruction (for DD RAM or CG RAM) is written in the IR, the address information is transferred from the IR to the AC. When display data is writ-

ten into or read from DD RAM or CG RAM, the AC is automatically incremented or decremented by one according to the Entry Mode Set. The contents of the AC are output to DBO to DB6; refer to above "Register Selection Table" when RS = 0 and R/W= 1.

CLEAR DISPLAY

	RS	R/W	DB7						DB0
Code	0	0	0	0	0	0	0	0	1

Clear all display memory and return the cursor to the

home position. In other words, the cursor returns to the first character block on the first line on all 1, 2, and 4 line character modules except L4044. If the above is entered on E2 (the second controller for lines 3 and 4), the cursor will return to the first character on the third line.

CURSOR HOME

	RS	R/W	DB7						DB0
Code	0	0	0	0	0	0	0	1	*

*Doesn't matter

Returns cursor to home position. First line first character

blocks on all 1, 2 and 4 line display; except L4044 refer "clear display": (Address 0; A,, "80"). The contents of DD RAM remain unchanged.

RESTRICTIONS ON EXECUTION OF DISPLAY CLEAR AND CURSOR HOME INSTRUCTIONS

Conditions of use	Restrictions
When executing the Display Clear or Cursor Home instruction when the display is shifted (after execution of Display Shift instruction).	The Cursor Home instruction should be executed again immediately after the Display Clear or Cursor Home instruction is executed. Do not leave an interval of a multiple of $400/f_{osc}$ * second after the first execution. <ul style="list-style-type: none">L4052: $f_{osc} \square 250$ kHzThe other modules: $f_{osc} = 270$ kHz * f_{osc} : Oscillation frequency
When 23 _H , 27 _H , 63 _H , or 67 _H is used as a DD RAM address to execute Cursor Home instruction.	Before executing the Cursor Home instruction, the data of the four DD RAM addresses given at the left should be read and saved. After execution, write the data again in DD RAM. (This restriction is necessary to prevent the contents of the DD RAM addresses from being destroyed after the Cursor Home instruction has been executed.)

ENTRY MODE SET

	RS	R/W	DB7						DB0	
Code	0	0	0	0	0	0	0	1	I/D	S

I/D: Increments (I/D = 1) or decrements (I/D = 0) the DD RAM address by one block when writing or reading a character code from DD RAM or CG RAM. The cursor automatically moves to the right when incremented by one or to the left if decremented by one.

S: Shifts the entire display to either the right or left when S = 1 (high). When S = 1 and I/D = 1 the display shifts one position to the left. When S = 1 and I/D = 0 the display shifts one position to the right. This right or left shift occurs after each data write to DD RAM. Display is not shifted when reading from DD RAM. Display is not shifted when S = 0.

DISPLAY AND CURSOR ON/OFF CONTROL

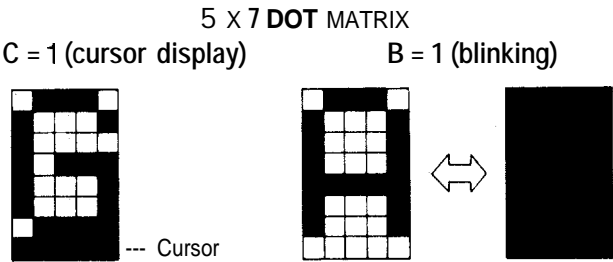
	RS	R/W	DB7						DB0	
Code	0	0	0	0	0	0	1	D	C	B

D: Display is turned ON when D = 1 and OFF when D = 0. When display is OFF, display data in DD RAM remains unchanged. Information comes back immediately when D = 1 is entered.

does not change during display data write. In a 5 x 7 dot matrix there is an eighth line which functions as the cursor.

C: Cursor is displayed when C = 1 and not displayed when C = 0. If the cursor disappears, function of I/D etc.

B: When B = 1, the character at the cursor position starts blinking. When B = 0 the cursor does not blink. The blink is done by stiching between the all black dot matrix and displayed character at 0.4 second intervals. The cursor and the blink can be set at the same time (fosc = 250 kHz).



CURSOR OR DISPLAY SHIFT

	RS	R/W	DB7						DB0	
Code	0	0	0	0	0	1	S/C	R/L	*	*

* Doesn't Matter

Cursor/Display Shift moves the cursor or shifts the display without changing the DD RAM contents.

The cursor position and the AC contents match. This instruction is available for display correction and retrieval because the cursor position or display can be shifted without writing or reading-display data. In case of a 2-line display, the

cursor is shifted from character block 40 of line 1 to character block 1 of line 2. Displays of lines 1 and 2 are shifted at the same time. In case of a 4-line display, the cursor does not move continuously from line 2 to line 3. The cursor is shifted from character block 40 of line 3 to character block 1 of line 4. Displays of lines 3 and 4 are shifted at the same time. The display pattern of line 2 or 4 is not shifted to line 1 or 3.

S/C	R/L	Operation
0	0	The cursor position is shifted to the left (the AC decrements one)
0	1	The cursor position is shifted to the right (the AC increments one)
1	0	The entire display is shifted to the left with the cursor
1	1	The entire display is shifted to the right with the cursor

OPERATING INSTRUCTIONS (CONTINUED)

FUNCTION SET

	RS	R/W	DB7						DB0
Code		0	0	0	0	1	DLN	F	I *

* Doesn't Matter

Function Set sets the interface data length, the number of display lines and the character font.

N	F	Number of display lines	Character font	Duty cycle	
1	0	2	5 x 7 dot matrix	1/16	L1671, L1681, L1672, L1682 L1692, L1634, L2032 L2022 L2034, L2462, L4052, L4044

The Function Set instruction must be executed prior to all other instructions except for Busy Flag/Address Read. If another instruction is executed first, no function instruction except changing the interface data length can be executed.

DL: Interface data length

When DL = 1, the data length is set at 8 bits (DB7 to DB0).

When DL = 0, the data length is set at 4 bits (DB7 to DB4).

The upper 4 bits are transferred first, then the lower 4 bits follow.

N: Number of display lines

F: Sets character font

CG RAM ADDRESS SET

	RS	R/W	DB7						DB0
Code	0	0	0	1	A	A	A	A	A

← Upper bit Lower bit →

CG RAM addresses, expressed as binary AAAAAA, are set to the AC. Then data in CG RAM is written from or read to the MPU.

DD RAM ADDRESS SET

	RS	R/W	DB7						DB0
Code	0	0	0	1	A	A	A	A	A

← Upper bit Lower bit →

DD RAM addresses expressed as binary AAAAAA are set to the AC. Then data in DD RAM is written from or read to the MPU.

BUSY FLAG/ADDRESS READ

	RS	R/W	DB7						DB0
Code	0	0	0	1	A	A	A	A	A

← Upper bit Lower bit →

The BF signal can be read to verify if the controller is indicating that the module is working on a current instruction.

When BF = 1, the module is working internally and the next instruction cannot be accepted until the BF value becomes 0.

When BF = 0, the next instruction can be accepted.

Therefore, make sure that BF = 0 before writing the next instruction. The AC values of binary AAAAAA are read out at the same time as reading the busy flag. The AC addresses are used for both CG RAM and DD RAM but the address set before execution of the instruction determines which address is to be used.

DATA WRITE TO CG RAM or DD RAM

	RS	R/W	DB7						DB0
Code		1	0	D	D	D	D	D	D

← Upper bit Lower bit →

Binary eight-bit data DDDDDDDD is read from CG RAM or DD RAM. The CG RAM Address Set instruction or the DD RAM Address Set instruction before this instruction selects either RAM. After the write operation, the address and display shift are determined by the entry mode setting.

DATA READ FROM CG RAM or DD RAM

	RS	R/W	DB7						DB0
Code	1	1	D	D	D	D	D	D	D

← Upper bit Lower bit →

Binary eight-bit data DDDDDDDD is read from CG RAM or DD RAM. The CG RAM Address Set instruction or the DD RAM Address Set instruction before this instruction selects either RAM. In addition, either instruction is executed immediately before this instruction. If no Address Set instruction is executed before a read instruction, the first data read becomes invalid. If read instructions are executed consecutively, data is normally read from the second time. However, if the cursor is shifted by the Cursor Shift instruction when reading DD RAM, there is no need to execute an address set instruction because the Cursor Shift instruction does this.

After the read operation, the address is automatically incremented or decremented by one according to the entry mode, but the display is not shifted.

Note: The AC is automatically incremented or decremented by one according to the entry mode after a write instruction is executed to write data in CG RAM or DD RAM. However, the data of the RAM selected by the AC are not read out even if a read instruction is executed immediately afterwards.

OPERATING INSTRUCTIONS (CONTINUED)

5x7+ CURSOR

Relationships between CG RAM addresses and character codes (DD RAM) and character patterns (CG RAM data), (5 x 7 dot matrix).

Character code (DD RAM data)								CG RAM address					Character pattern (CG RAM data)							
7	6	5	4	3	2	1	0	5	4	3	2	10	7	6	5	4	3	2	1	0
←Upper bit				Lower bit→				-Upper bit		Lower bit-			←Upper bit				Lower bit→			
0 0 0 0 * 0 0 0								0 0 0 0 0 1 0 10 0 11 0 0 0 1 0 0 10 1 11 0 1 1 1					<div><div><div>*</div><div>*</div><div>*</div></div><div>↓</div></div>				1 1 1 1 0			
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																	0 0 0 0 0			
																	0 0 1 0 0			
																	0 0 1 0 0			
																	0 0 0 0 0			

Example of character pattern (R)

← Cursor position

Example of character pattern (Y)

- NOTES:**
- ▶ In CG RAM data, 1 corresponds to Selection and 0 to Non-selection on the display.
 - ▶ Character code bits 0 to 2 and CG RAM address bits 3 to 5 correspond with each other (three bits, eight types).
 - ▶ CG RAM address bits 0 to 2 specify a line position for a character pattern. Line 8 of a character pattern is the cursor position where the logical sum of the cursor and CG RAM data is displayed. Set the data of line 8 to 0 to display the cursor. If the data is charged to 1, one bit lights, regardless of the cursor.
 - ▶ The character pattern column position corresponds to CG RAM data bits 0 to 4 and bit 4 comes to the left end. CG RAM data bits 5 to 7 are not displayed but can be used as general data RAM.
 - ▶ When reading a character pattern from CG RAM, set to 0 all of character code bits 4 to 7. Bits 0 to 2 determine which pattern will be read out. Since bit 3 is not valid, 00, and 08_H select the same character.

OPERATING INSTRUCTIONS (CONTINUED)

PROGRAMMING THE CHARACTER GENERATOR RAM (CG RAM)

The character generator RAM (CG RAM) allows the user to create up to eight custom 5 x 7 characters + cursor (5 x 8). Once programmed, the custom characters or symbols are accessed exactly as if they were in ROM. However since the RAM is a volatile memory, power must be continually maintained. Otherwise, the custom characters/symbols must be programmed into non-volatile external ROM and sent to the display after each display initialization. All dots in the 5 x 8 dot matrix can be programmed, which includes the cursor position.

The modules RAM are divided into two parts: data display RAM (DD RAM) and custom character generator RAM (CG RAM). This is not to be confused programming the custom character generator RAM with the 192 character generator ROM. The CG RAM is located between hex 40 and 7F and is contiguous. Locations 40 thru 47 hold the first custom character (5 x 8), 48 thru 4F hold the second custom character, 50 thru 57 hold the third CG, and so forth to 78 thru 7F for the eighth CG character/symbol.

If during initialization the display was programmed to automatically increment, then only the single initial address, 40, need be sent. Consecutive row data will automatically appear at 41, 42, etc. until the completed character is formed. All eight custom CG characters can be programmed in 64 consecutive "writes" after sending the single initial 40 address.

The CG RAM is 8 bits wide, although only the right-most 5-bits are used for a custom CG character row. The left-most dot of programming the CG RAM character corresponds to D4 in the most significant nibble (XXxD4) of the data bus code, with the remaining 4 dots in the row corresponding to the least significant nibble (D3 thru D0), D0 being the right-most dot. Thus, hex 1 F equals all dots on and hex 00 equals all dots off. Examples include hex 15 (10101) equal to 3 dots on the hex 0A (01010) equal 2 dots on. In each case the key 5-bits of the 8-bit code program one row of a custom CG character. When all 7 or 8 rows are programmed, the character is complete. A graphic example is shown below:

RS	R/W	Data	Display	Description
0	0	40	—	addresses 1st CG character
1	0	11	* *	result of 11, 1 st row
1	0	0A	* *	result of 0A, 2nd row
1	0	1F	*****	result of 1 F, 3rd row
1	0	04	*	result of 04, 4th row
1	0	1F	*****	result of 1 F, 5th row
1	0	04	*	result of 04, 6th row
1	0	04	*	result of 04, 7th row
1	0	00	—	result of 00, 8th row (cursor position)
1	0	15	***	1st and 2nd CG character. Note: Addressing not now required; hex 48 is next in the sequence.

6) **L2462-SERIES** (20 characters x 2 lines)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Line 1	80	81	82	83	84	85	86	87	88	89	8A	8B	8C	8D	8E	8F	90	91	92	93	94	95	96	97
Line2	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC	CD	CE	CF	D0	D1	D2	D3	D4	D5	D6	D7