

HD43160AH

(Controller with Built-in Character Generator)

Display Controller and Character Generator for Dot Matrix Liquid Crystal Display System

The HD43160AH receives character data written in ASCII code or JIS code from a microcomputer and stores them in its RAM which has 80 words capacity.

The HD43160AH converts these data into a serial character pattern, then transfers them to LCD drivers.

It also generates other control signals for the LCD. The HD44100H LCD driver can be combined with this controller.

Display Characters Types

- Alphanumeric characters: A-Z, a-z, @, #, %, &, etc.
- Japanese characters (katakana)

Ordering Information

Type No.	Package
HD43160AH	54-pin plastic QFP (FP-54)

- 160 characters in internal character generator (ROM)
(Max 256 characters in external ROM)

Number Of Characters

- 4, 8, 16, 24, 32, 40, 64, or 80 characters in 1 or 2 lines

Font

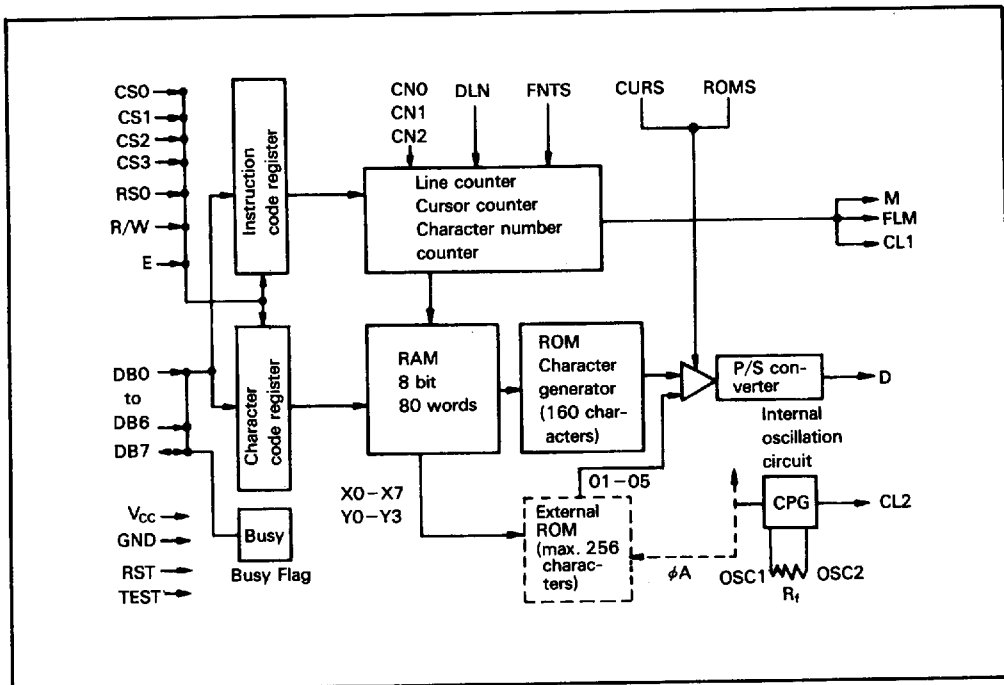
- $5 \times 7 + \text{Cursor}$ or $5 \times 11 + \text{Cursor}$

Other Function Controlled By Microcomputer

- Display clear
- Cursor on/off
- Cursor position preset (character position)
- Cursor return

HD43160AH

Block Diagram



Absolute Maximum Ratings

Item	Symbol	Value	Unit
Supply voltage	V _{CC}	-0.3 to +7.0	V
Input voltage	V _I	-0.3 to V _{CC} + 0.3	V
Operating temperature	T _{opr}	-20 to +75	°C
Storage temperature	T _{stg}	-55 to +125	°C

Electrical Characteristics ($V_{CC} = 5\text{ V} \pm 5\%$, $GND = 0\text{ V}$, $T_a = -20\text{ to }+75^\circ\text{C}$)

Item	Symbol	Terminal No.	min	typ	max	Unit	Test condition
Input voltage (TTL compatible)	V_{IH}	CS0-CS3, E, R/W, DB0-DB7, RS0	2.0	-	V_{CC}	V	
	V_{IL}		0	-	0.8	V	
Input voltage	V_{IHC}	OSC1, TEST, RST, FNTS, CURS, DLN, ROMS, CNO-CN2, O1-O5	0.7 V_{CC}	-	V_{CC}	V	
	V_{ILC}		0	-	0.3 V_{CC}	V	
Output voltage (TTL compatible)	V_{OH}	DB7	2.4	-	-	V	$I_{OH} = -0.205\text{ mA}$
	V_{OL}		-	-	0.4	V	$I_{OL} = 1.6\text{ mA}$
Output voltage	V_{OHC}	FLM, M, D, CL1, CL2	$V_{CC} - 1.0$	-	-	V	$I_{load} = \pm 0.4\text{ mA}$
	V_{OLC}	X0-X7, Y0-Y3	-	-	1.0	V	
Input leak current	I_{LI}	All inputs	-5	-	5	μA	
Output leak current	I_{LO}	DB7	-10	-	10	μA	
Oscillation frequency	f_{CP1}		130	192	250	kHz	$R_f = 200\text{ k}\Omega \pm 2\%$, $\times 7 + \text{Cursor}$
	f_{CP2}		200	288	375	kHz	$R_f = 130\text{ k}\Omega \pm 2\%$, $\times 11 + \text{Cursor}$
Input pull up current	I_{PL}	CS0-CS3, RS0, R/W, DB0-DB7	2	10	20	μA	$V_{in} = 0\text{V}$
Power dissipation	P_T	*	-	-	10	mW	$T_a = 25^\circ\text{C}$, $f_{CP} =$ 400 kHz (external clock)

* Input/output current is excluded. When an input is at the intermediate level in CMOS, excessive current flows through the input circuit to the power supply. To avoid this, input level must be fixed at high or low, CS0-CS3, RS0, R/W, DB0-DB7.

Pin Arrangement

Pin No.	Power sup.	OSC	Input	Output	Pin No.	Power sup.	OSC	Input	Output	Pin No.	Power sup.	OSC	Input	Output
1		GND (-)			19				D	37				DB3
2				X4	20				FIM	38				DB4
3				X3	21				ϕA	39				DB5
4				X2	22		OSC1			40				DB6
5				X1	23		OSC2			41				DB7 DB7
6				X0	24				RST	42				ROMS
7			N.C.		25				TEST	43				O5
8			N.C.		26				E	44				O4
9			N.C.		27		$V_{CC}(+)$			45				O3
10			CURS		28				R/W	46				O2
11			FNTS		29				RS0	47				O1
12			DLN		30				CS0	48				Y3
13			CNO		31				CS1	49				Y2
14			CN1		32				CS2	50				Y1
15			CN2		33				CS3	51				Y0
16				CL2	34				DB0	52				X7
17				CL1	35				DB1	53				X6
18				M	36				DB2	54				X5

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Pin Function

Pin name	Number of terminals	Connected to	I/O	Function																																				
V _{CC} GND	2	Power supply		+5 V ± 10% Power supply 0 V																																				
CN0 CN1 CN2	3	GND or V _{CC}	I	Total displayed character number select <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>No.</th> <th>4</th> <th>8</th> <th>16</th> <th>24</th> <th>32</th> <th>40</th> <th>64</th> <th>80</th> </tr> </thead> <tbody> <tr> <td>CN0</td> <td>GND</td> <td>V_{CC}</td> <td>GND</td> <td>V_{CC}</td> <td>GND</td> <td>V_{CC}</td> <td>GND</td> <td>V_{CC}</td> </tr> <tr> <td>CN1</td> <td>GND</td> <td>GND</td> <td>V_{CC}</td> <td>V_{CC}</td> <td>GND</td> <td>GND</td> <td>V_{CC}</td> <td>V_{CC}</td> </tr> <tr> <td>CN2</td> <td>GND</td> <td>GND</td> <td>GND</td> <td>GND</td> <td>V_{CC}</td> <td>V_{CC}</td> <td>V_{CC}</td> <td>V_{CC}</td> </tr> </tbody> </table>	No.	4	8	16	24	32	40	64	80	CN0	GND	V _{CC}	GND	V _{CC}	GND	V _{CC}	GND	V _{CC}	CN1	GND	GND	V _{CC}	V _{CC}	GND	GND	V _{CC}	V _{CC}	CN2	GND	GND	GND	GND	V _{CC}	V _{CC}	V _{CC}	V _{CC}
No.	4	8	16	24	32	40	64	80																																
CN0	GND	V _{CC}	GND	V _{CC}	GND	V _{CC}	GND	V _{CC}																																
CN1	GND	GND	V _{CC}	V _{CC}	GND	GND	V _{CC}	V _{CC}																																
CN2	GND	GND	GND	GND	V _{CC}	V _{CC}	V _{CC}	V _{CC}																																
CURS	1	GND or V _{CC}	I	Cursor select V _{CC} : 5 dots ●●●●● GND: 1 dot ●																																				
DLN	1	GND or V _{CC}	I	Display line number select V _{CC} : 2 lines GND: 1 line																																				
FNTS	1	GND or V _{CC}	I	Font select V _{CC} : 5 × 11 + Cursor GND: 5 × 7 + Cursor																																				
RST	1	V _{CC}	I	Only for test. Normally V _{CC} .																																				
TEST	1	GND	I	Only for test. Normally GND.																																				
E	1	MPU	I	Strobe signal Write mode: The HD43160AH latches the data on DB0—DB7 at the falling edge of this signal Read mode: Busy/Ready signal is active on DB7 while this signal is high (Low: Ready, High: Busy)																																				
R/W	1	MPU	I	Read/Write signal L: HD43160AH gets the data from MPU H: MPU gets the Busy/Ready signal from HD43160AH																																				
CS0 CS1 CS2 CS3	4	MPU	I	Chip select When all of CS0—CS3 are 'H', HD43160AH is selected.																																				
RS0	1	MPU	I	Register select HD43160AH has 2 registers. One is for character code and another is for instruction code. Each register latches the data on DB0—DB7 at the falling edge of E, when CS0—CS3 are high and R/W is low. High: Character code register is selected Low: Instruction code register is selected																																				
DB0 to DB7	8	MPU	I/O (DB7)	Data bus Inputs for character code and instruction code from MPU Output for Busy/Ready flag (DB7)																																				
D	1	HD44100H	O	Serial dot data of characters for LCD drivers																																				
CL2	1	HD44100H	O	Dot data shift signal for LCD drivers																																				
CL1	1	HD44100H	O	Dot data latch signal for LCD drivers																																				

Pin name	Number of terminals	Connected to	I/O	Function												
M	1	HD44100H	O	Alternate signal for LCD drivers												
FLM	1	HD44100H	O	Signal for common plates scanning												
X0 to X7	8	ROM	O	Character code outputs for external character generator (for ext ROM) X7: MSB ex: character 'A' X0: LSB												
				<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="padding: 2px;">MSB</td> <td style="padding: 2px;">0</td> <td style="padding: 2px;">1</td> <td style="padding: 2px;">0</td> <td style="padding: 2px;">0</td> <td style="padding: 2px;">0</td> <td style="padding: 2px;">0</td> <td style="padding: 2px;">0</td> <td style="padding: 2px;">0</td> <td style="padding: 2px;">0</td> <td style="padding: 2px;">1</td> <td style="padding: 2px;">LSB</td> </tr> </table> '1' = High '0' = Low	MSB	0	1	0	0	0	0	0	0	0	1	LSB
MSB	0	1	0	0	0	0	0	0	0	1	LSB					
Y0 Y1 Y2 Y3	4	ROM	O	Character row code for external character generator $5 \times 7 + \text{Cursor}$ $5 \times 11 + \text{Cursor}$												
ϕA	1	ROM	O	Clock signal for external character generator (dynamic ROM etc.) if necessary												
O1 to O5	5	ROM	I	Dot data inputs from external character generator 1 (High): On 0 (Low): Off												
ROMS	1	GND or V _{CC}	I	Select internal or external ROM High: External ROM Low: Internal ROM												
OSC1 OSC2	2		(I) (O)	Oscillator $5 \times 7 + \text{Cursor}$: R _f = 200 k Ω (typ) $5 \times 11 + \text{Cursor}$: R _f = 130 k Ω (typ)												
NC	3			Don't connect any signal to these terminals												

Character Dot Patterns

5 × 7

The bottom lines of the English small characters "g, i, p, q, y," are on the cursor line (Figure 1).

5 × 11

Only the English small character "g, j, p, q, y," are displayed as below. The others are the same as for 5 × 7 (Figure 2).

Cursor 5 dots : ●●●●●
1 dot : ●

The cursor is displayed on the 8th or 12th line.

		Character code lower 4 bits (hexadecimal)																			
		0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F				
Character code upper 4 bits (hexadecimal)	2		!	"	#	\$	%	&	'	()	*	+	,	-	.	/				
	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?				
	4	a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O				
	5	P	Q	R	S	T	U	V	W	X	Y	Z	[¥]	^	_				
	6	`	a	b	c	d	e	f	g	h	i	..	j	k	l	m	n	o			
	7	p	q	r	s	t	u	v	w	x	y	z	{		}	+	*				
	A	。	「	」	、	・	ヲ	アイ	ウ	エ	オ	カ	キ	ク	ケ	コ	サ	シ	ス	セ	ソ
	B	一	ア	イ	ウ	エ	オ	カ	キ	ク	ケ	コ	サ	シ	ス	セ	ソ				
	C	タ	チ	ツ	テ	ト	ナ	ニ	ヌ	ネ	ノ	ハ	ヒ	フ	ヘ	ホ	マ				
	D	ミ	ム	メ	モ	ユ	ヨ	ラ	リ	ル	レ	ロ	ワ	ヰ	ヱ	ヰ	ヱ				

Figure 1 5 × 7 Characters

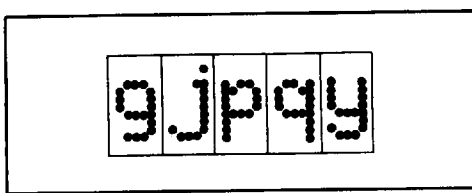


Figure 2 Special 5 × 11 Characters

Application

Setting Up

1. Total character number: CNO—CN2
2. Cursor pattern: CURS
3. Display line number: DLN
4. Font: FNTS

These terminals should be connected to V_{CC} or GND according to the LCD display system. RST and TEST should be connected to V_{CC} and GND respectively.

Interface to the Controller

1. Example 1 Interface to HD6800

In this example (Figure 3), the addresses of HD43160AH in the address area of the HD6800 microcomputer are:

Instruction code register	#'E****'	(R/W=0)
Character code register	#'F****'	(R/W=0)
Busy flag	#'E****' or #'F****'	(R/W=1)

*: don't care
#: hexadecimal

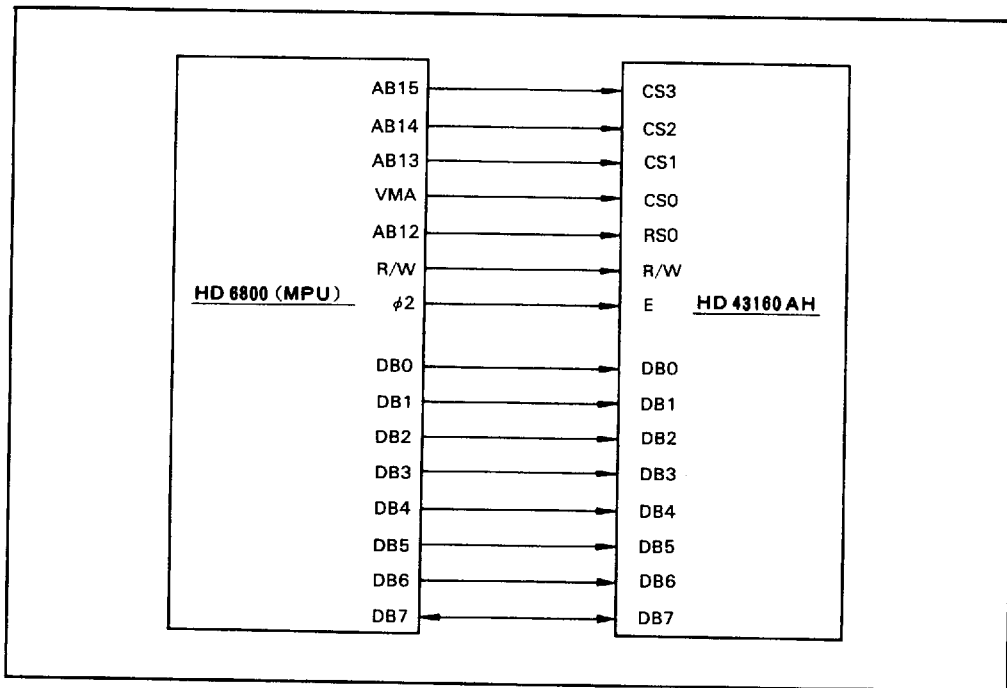


Figure 3 HD6800 Interface

2. Example of display program

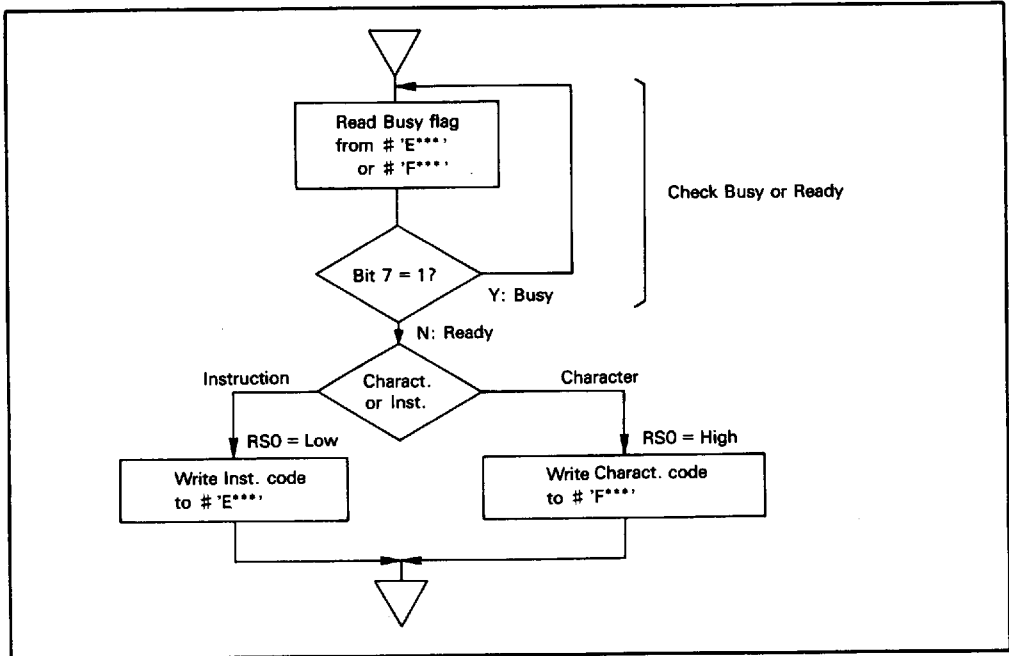


Figure 4 Display Program Example

3. Time length of Busy

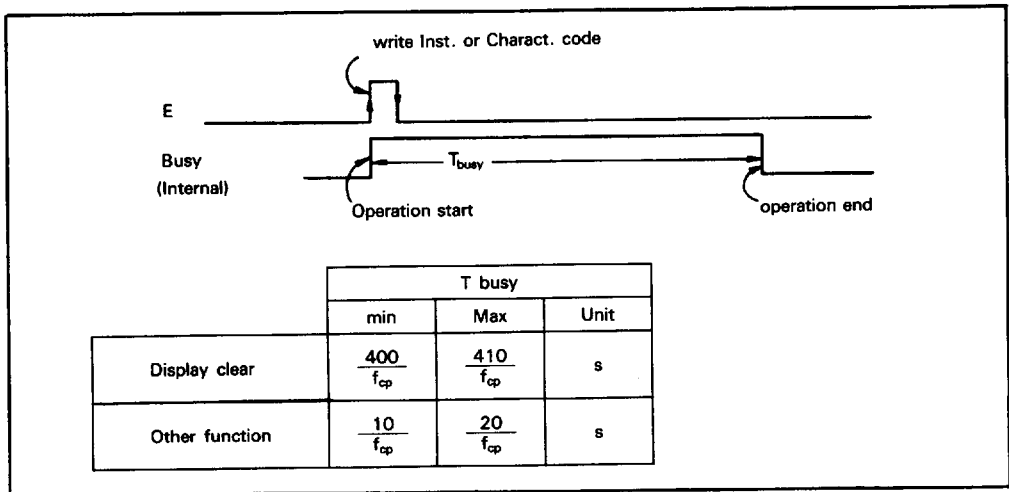


Figure 5 Busy timing

HD43160AH begins the operation from the rising edge of E (Figure 5).
Instruction code register and character code

register latch the data on DB0-DB7 at the falling edge of E.

4. Timing chart

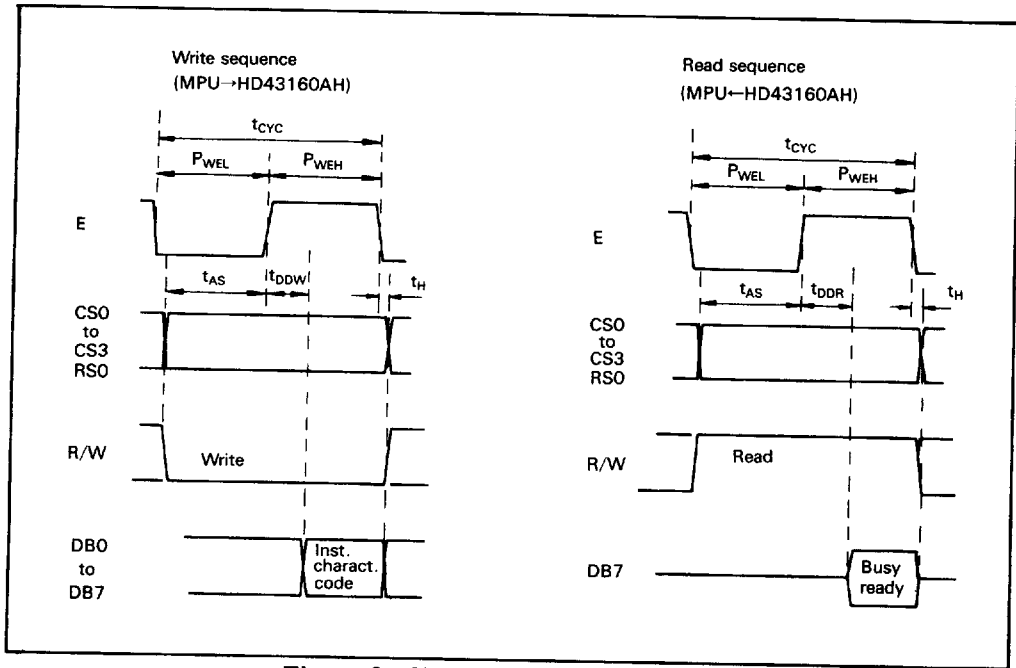


Figure 6 HD6800 Interface Timing

5. Timing characteristics

Item		Symbol	Min	Typ	Max	Unit
Cycle time of E		t_{cyc}	1.0	—	—	μs
Pulse width of E	High level	P_{WEH}	0.45	—	25	μs
	Low level	P_{WEL}	0.45	—	—	μs
Set up time of CS	Write	t_{AS}	140	—	—	ns
Data delay time	Write	t_{DDW}	—	—	225	ns
	Read	t_{DDR}	—	—	300	ns
Hold time		t_H	10	—	—	ns

HD43160AH

6. Example 2 Interface to 8085A (Intel)

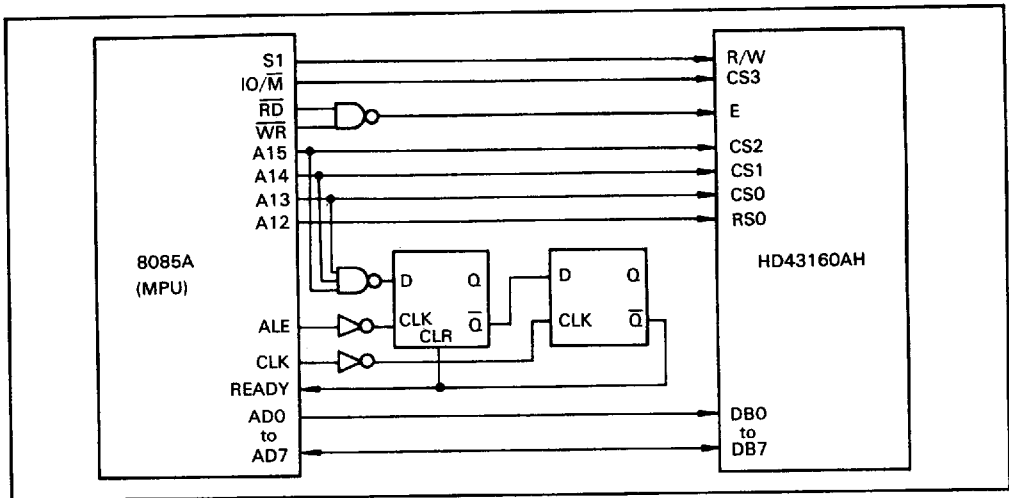


Figure 7 8085A Interface

7. Timing chart

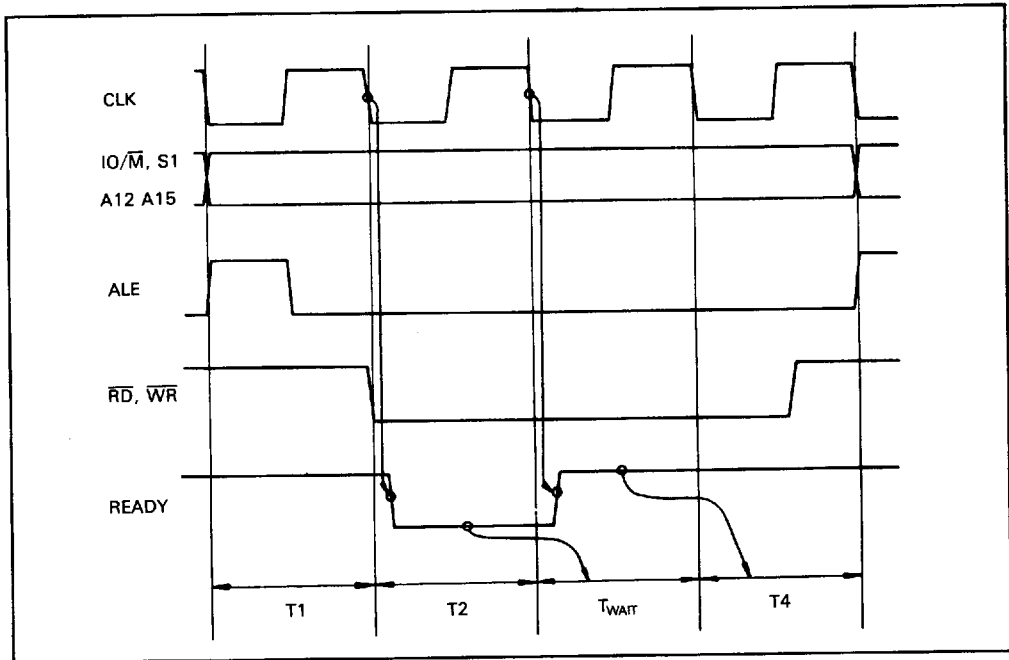


Figure 8 8085A Timing

Pulse widths of \overline{RD} and \overline{WR} signals of the 8085A are 400 ns min, while the pulse width of the E signal of the HD43160AH is 450 ns

min (Figure 8).

Therefore, in this example, \overline{RD} and \overline{WR} signal pulse widths are widened by the T_{wait} cycle.

Display Commands

Display Control Instructions

These instructions should be written into the instruction register of HD43160AH by the microcomputer. (RS0 = Low, R/W = Low)

1. Display clear

MSB								LSB
Code:	0	0	0	0	0	0	0	1

Operation: The screen is cleared and the cursor returns to the 1st digit.

2. Cursor return

MSB								LSB
Code:	0	0	0	0	0	0	1	0

Operation: The cursor returns to the 1st digit and the characters being displayed do not change.

3. Cursor on/off

MSB								LSB
Code:	0	0	0	0	0	1	0	0
	0	0	0	0	0	1	0	1

Operation: The cursor appears (on) or disappears (off).

4. Set cursor position

MSB			LSB
Code:	1 line	1	(N - 1) binary
	2 lines upper	1 0	(n - 1) binary
	lower	1 1	(m - 1) binary

N, n, m: digit number

Operation: The cursor moves to the Nth (nth, mth) digit.

$N \leq$ the total character number
 $n, m \leq 1/2$ total character number

ex 1: 1 line

Set the cursor at digit 55. The code is 10110110.

ex 2: 2 lines

Set the cursor at digit 35 of upper or lower line.

The code is 10100010 (upper).
 11100010 (lower).

Display Character Command

When the character code is written into the character register of HD43160AH, the character with this code appears where the cursor was displayed and the cursor moves to the next digit. (RS0 = High, R/W = Low)

MSB								LSB
code:	(Character code)							

ex. 1

before

ABCD

after

ABCDE

Read Busy Flag

When CS0—CS3 = High, R/W = High and E = High (RS0 = 'don't care'), the Busy/Ready signal appears on DB7.

DB 7 High: Busy
 Low: Ready

Table 1 Time Length of Busy (oscillation frequency = 200 kHz)

	Min	Max	Unit
Display clear	2.0	2.05	ms
Other operations	50	100	μ s

(depends on the operating frequency)

HD43160AH

Interface to External ROM

1. Example

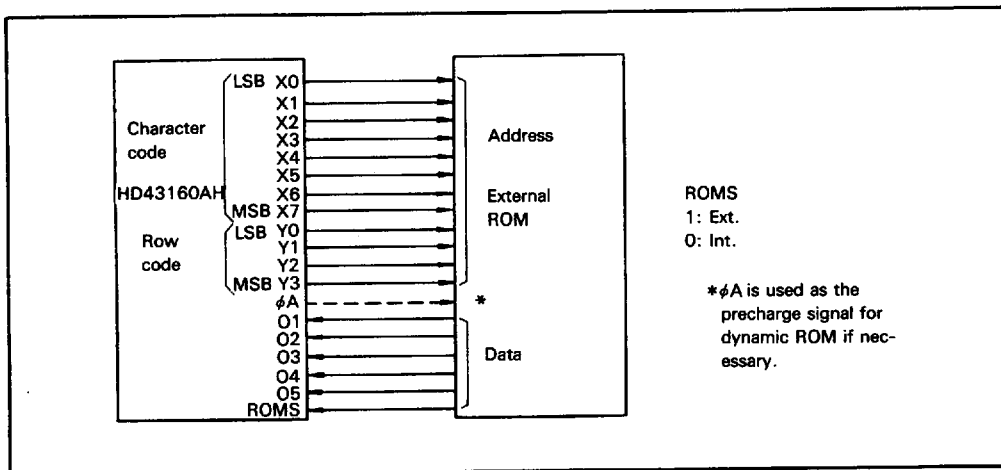


Figure 9 Interface to External ROM

2. Row code

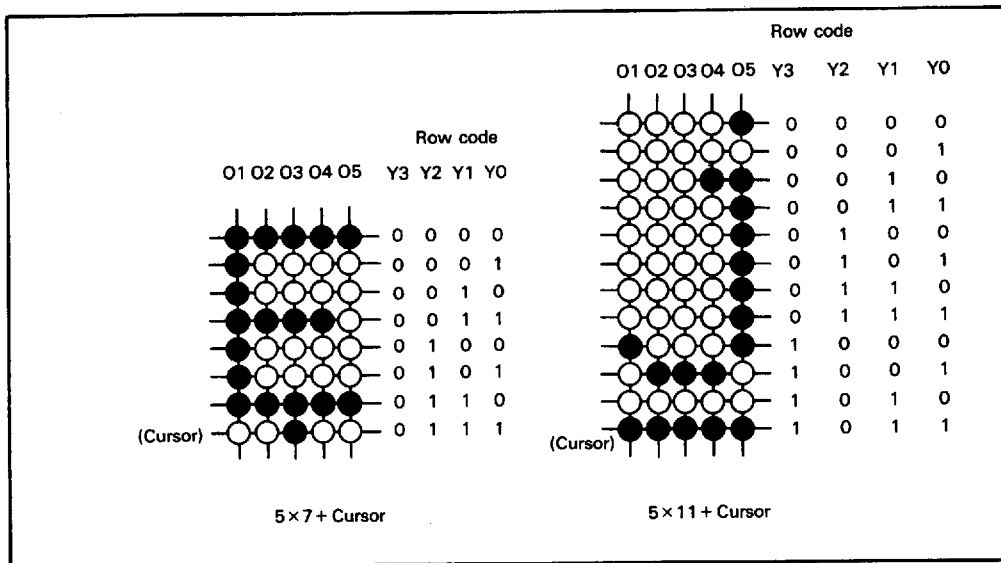


Figure 10 Row Code

3. Timing chart

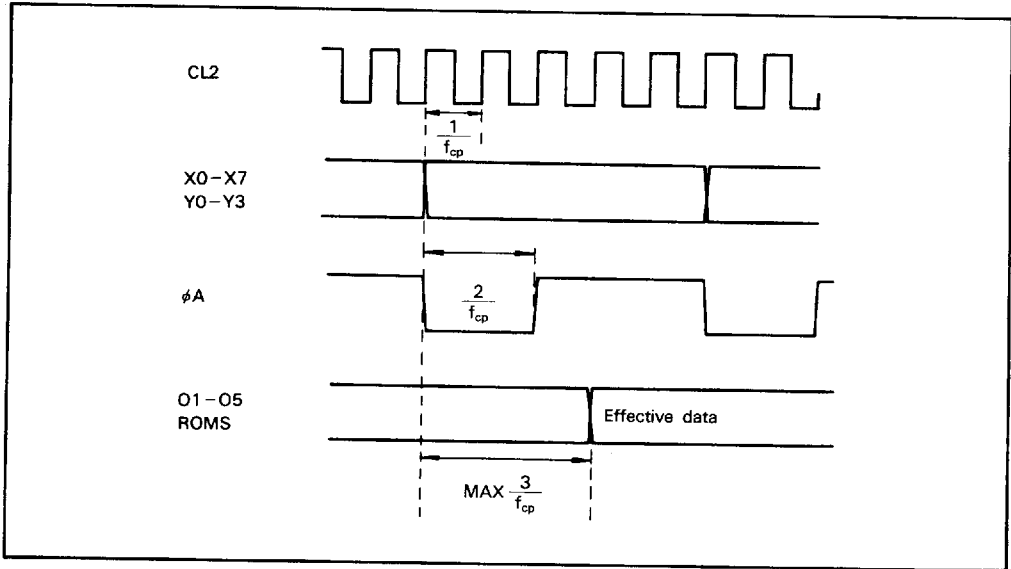


Figure 11 Display Timing

Interface to LCD Drivers

1. Example

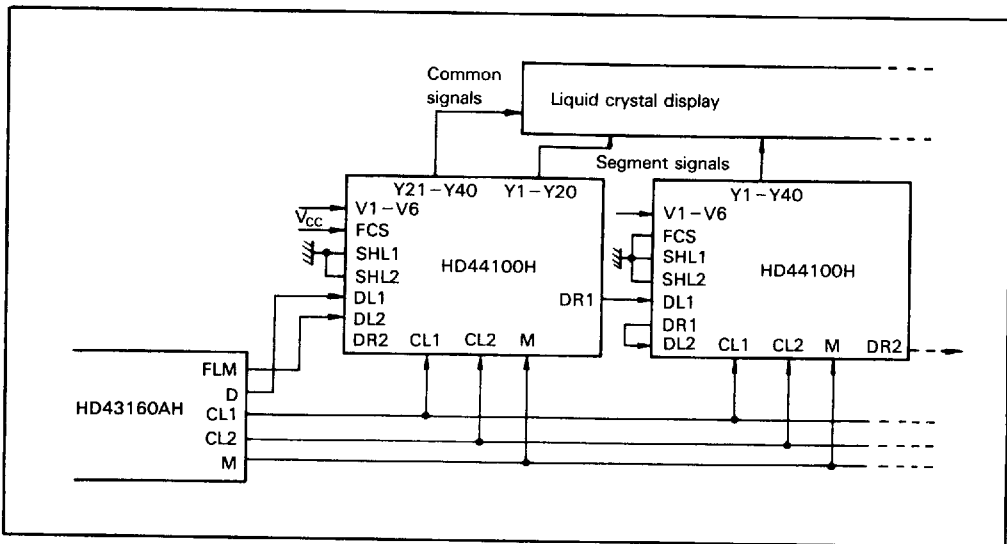


Figure 12 Interface to HD44100H

2. Waveforms (5 × 7 + Cursor 1 line)

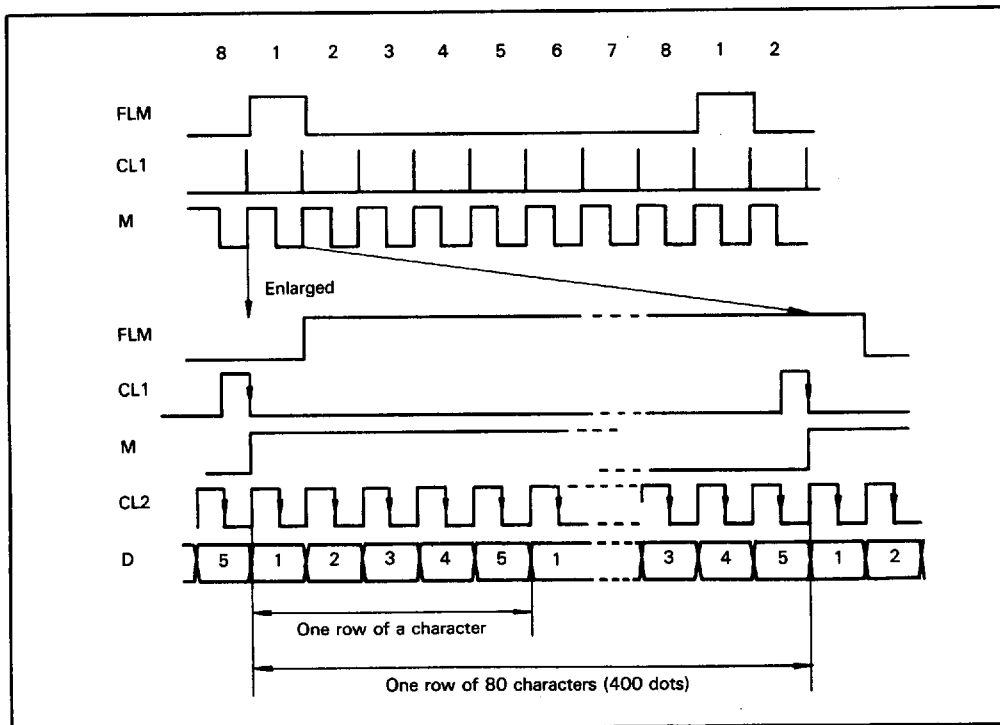


Figure 13 Timing

Dot Matrix Liquid Crystal Display System

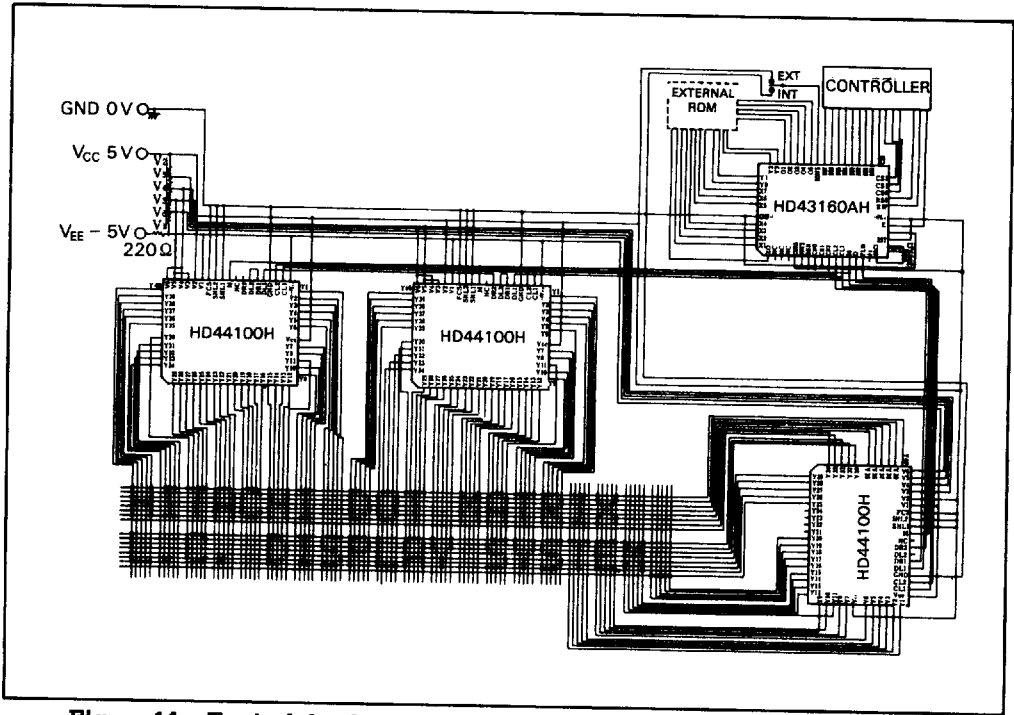


Figure 14 Typical Application 5 × 7 + Cursor, 2 Lines, 40 Characters