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

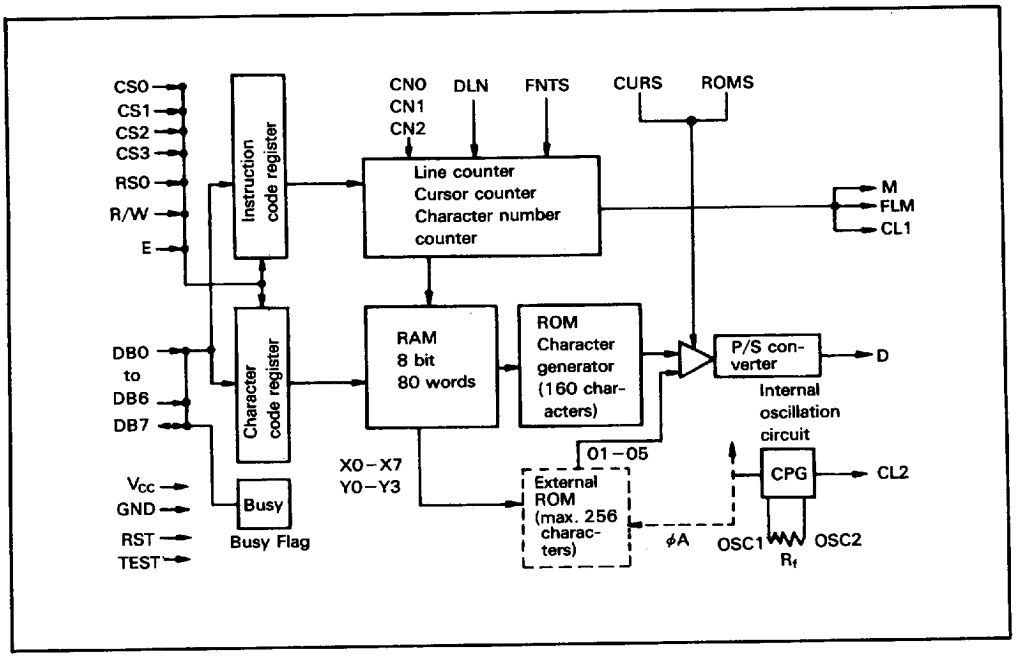
Font

- 5 × 7 + Cursor or 5 × 11 + Cursor

Other Function Controlled By Microcomputer

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

Block Diagram



Absolute Maximum Ratings

Item	Symbol	Value	Unit
Supply voltage	V_{CC}	−0.3 to +7.0	V
Input voltage	V_T	−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 V ± 5%, GND = 0 V, Ta = −20 to +75°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, CN0—CN2, O_1—O_5	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 mA
	V_{OL}		–	–	0.4	V	I_{OL} = 1.6 mA
Output voltage	V_{OHC}	FLM, M, D, CL1, CL2,	V_{CC}−1.0	–	–	V	I_{load} = ±0.4 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 kΩ ±2%, 5 × 7 + Cursor
	f_{CP2}		200	288	375	kHz	R_f = 130 kΩ ±2%, 5 × 11 + Cursor
Input pull up current	I_{PL}	CS0—CS3, RS0, R/W, DB0—DB7	2	10	20	μA	V_{in} = 0V
Power dissipation	P_T	*	–	–	10	mW	Ta = 25°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

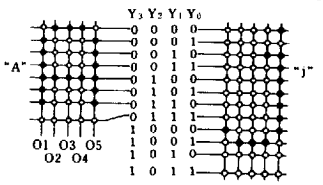
Pin No.	Power sup. OSC	Input	Output
1	GND (−)		
2			X4
3			X3
4			X2
5			X1
6			X0
7			N.C.
8			N.C.
9			N.C.
10		CURS	
11		FNTS	
12		DLN	
13		CN0	
14		CN1	
15		CN2	
16			CL2
17			CL1
18			M

Pin No.	Power sup. OSC	Input	Output
19			D
20			FIM
21			φA
22	OSC1		
23	OSC2		
24		RST	
25		TEST	
26		E	
27	V_{CC}(+)		
28		R/W	
29		RS0	
30		CS0	
31		CS1	
32		CS2	
33		CS3	
34		DB0	
35		DB1	
36		DB2	

Pin No.	Power sup. OSC	Input	Output
37		DB3	
38		DB4	
39		DB5	
40		DB6	
41		DB7	DB7
42		ROMS	
43		O5	
44		O4	
45		O3	
46		O2	
47		O1	
48			Y3
49			Y2
50			Y1
51			Y0
52			X7
53			X6
54			X5

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 No. 4: CN0 GND, CN1 GND, CN2 GND No. 8: CN0 V_{CC}, CN1 GND, CN2 GND No. 16: CN0 GND, CN1 V_{CC}, CN2 GND No. 24: CN0 V_{CC}, CN1 V_{CC}, CN2 GND No. 32: CN0 GND, CN1 GND, CN2 V_{CC} No. 40: CN0 V_{CC}, CN1 GND, CN2 V_{CC} No. 64: CN0 GND, CN1 V_{CC}, CN2 V_{CC} No. 80: CN0 V_{CC}, CN1 V_{CC}, CN2 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 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 X0: LSB ex: character 'A' MSB: 0 1 0 0 0 0 0 LSB: 1 '1' = High '0' = Low
Y0 Y1 Y2 Y3	4	ROM	O	Character row code for external character generator 5 × 7 + Cursor 5 × 11 + 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 × 7 + Cursor: R_f = 200 kΩ (typ) 5 × 11 + Cursor: R_f = 130 kΩ (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.

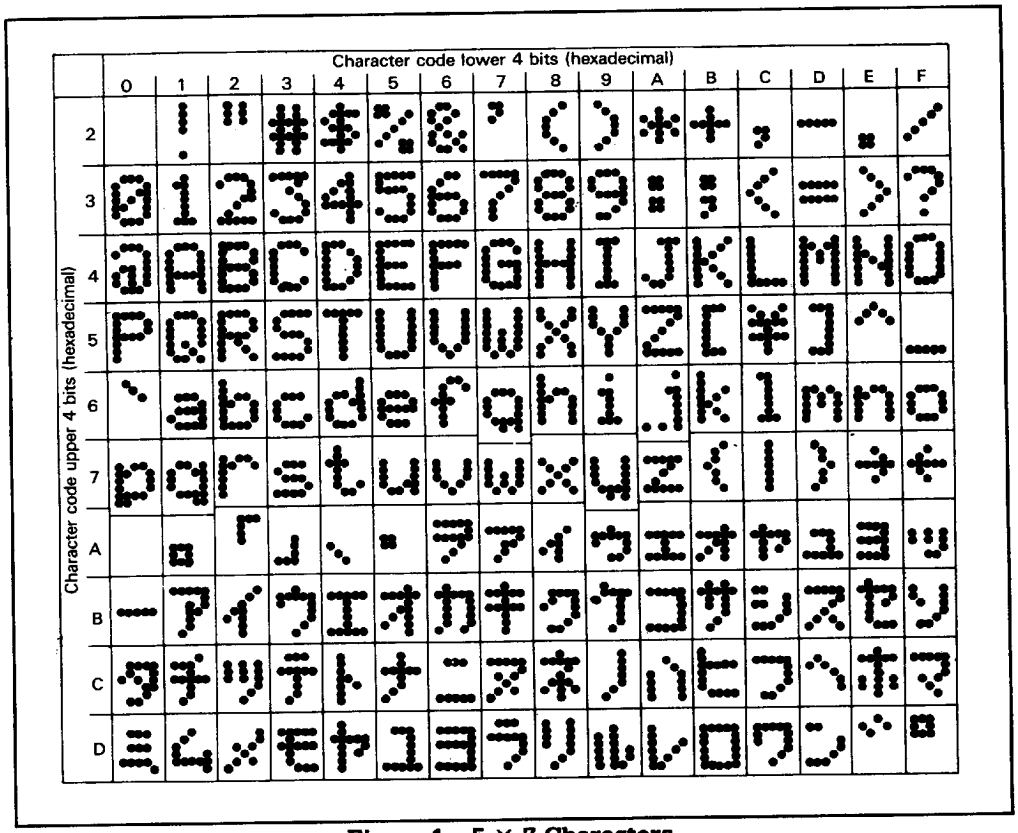


Figure 1 5 × 7 Characters

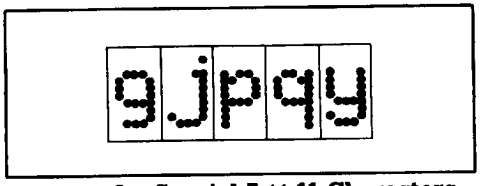


Figure 2 Special 5 × 11 Characters

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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

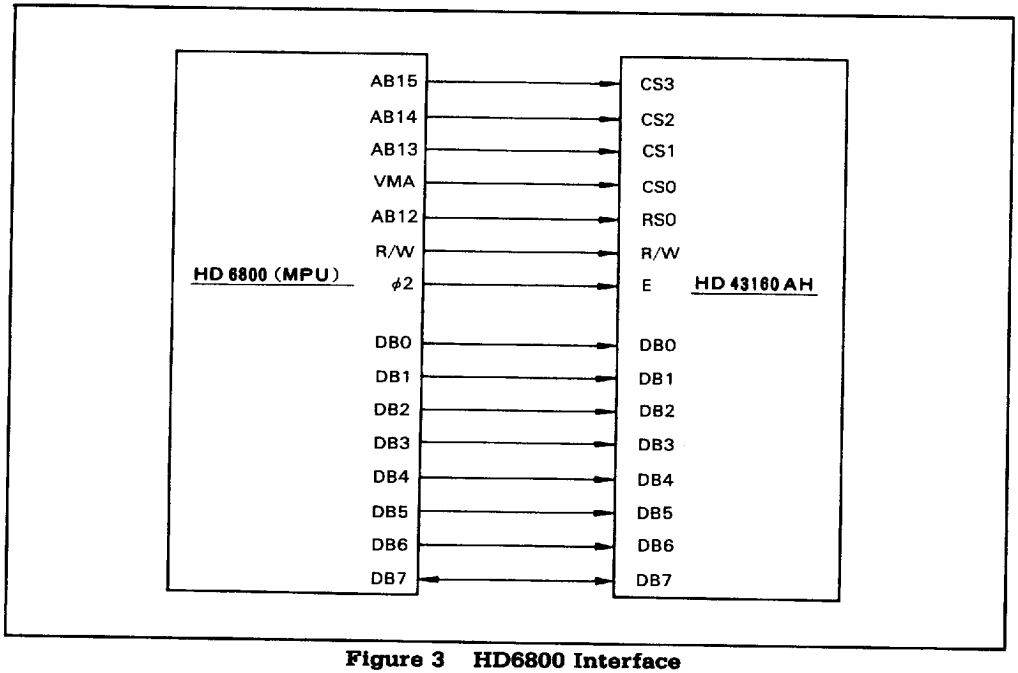


Figure 3 HD6800 Interface

2. Example of display program

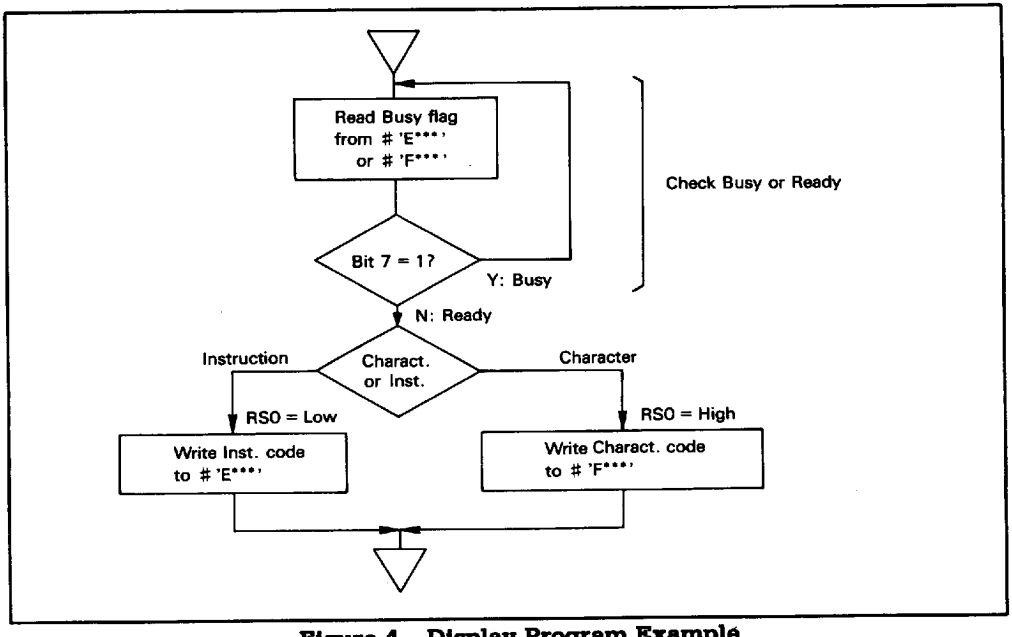
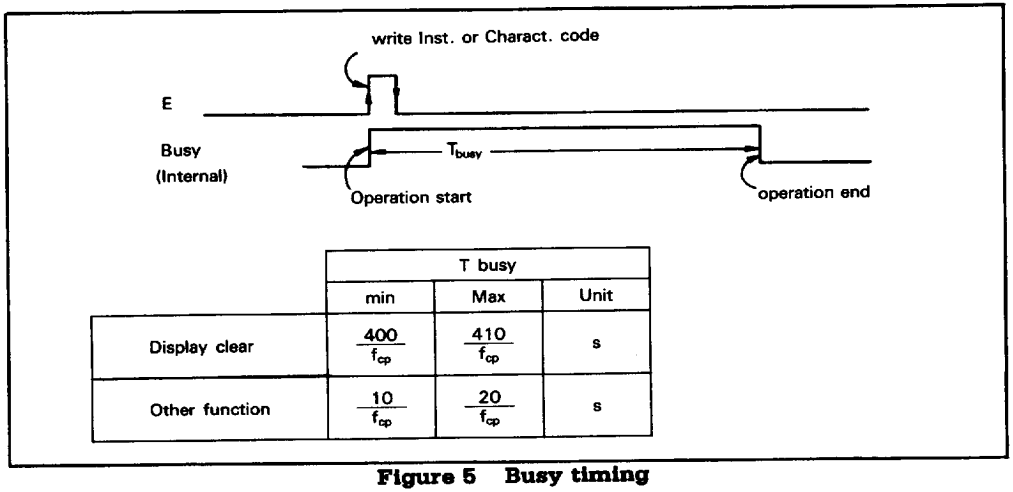


Figure 4 Display Program Example

3. Time length of Busy



	T busy		
	min	Max	Unit
Display clear	$\frac{400}{f_{cp}}$	$\frac{410}{f_{cp}}$	s
Other function	$\frac{10}{f_{cp}}$	$\frac{20}{f_{cp}}$	s

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

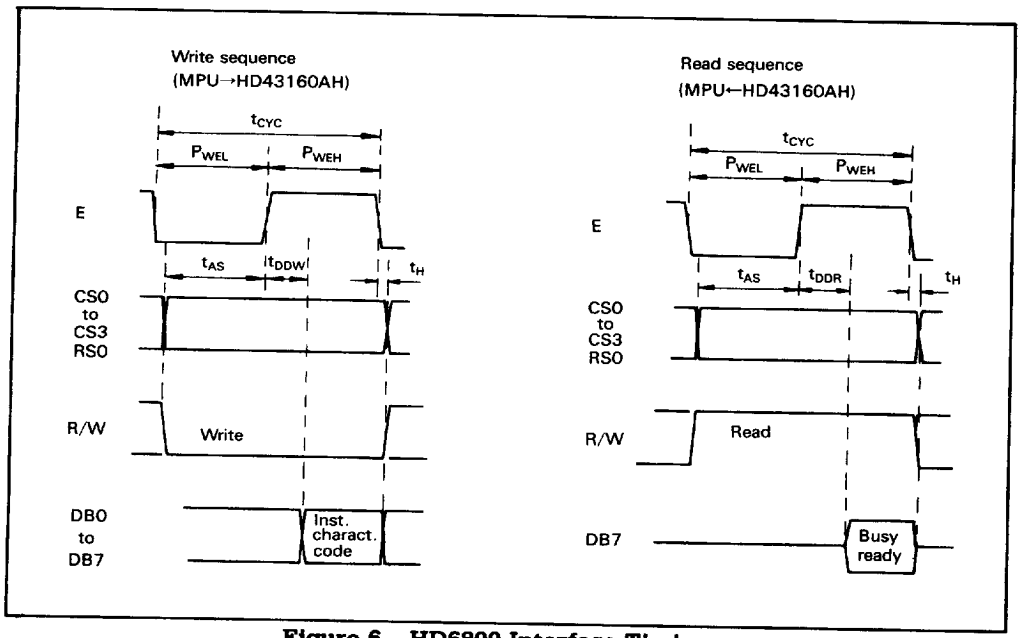


Figure 6 HD6800 Interface Timing

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

6. Example 2 Interface to 8085A (Intel)

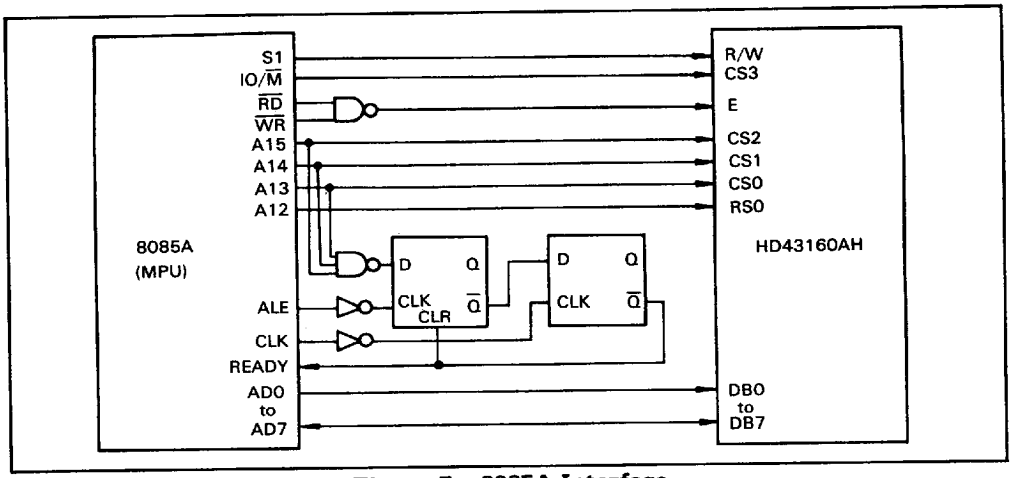


Figure 7 8085A Interface

7. Timing chart

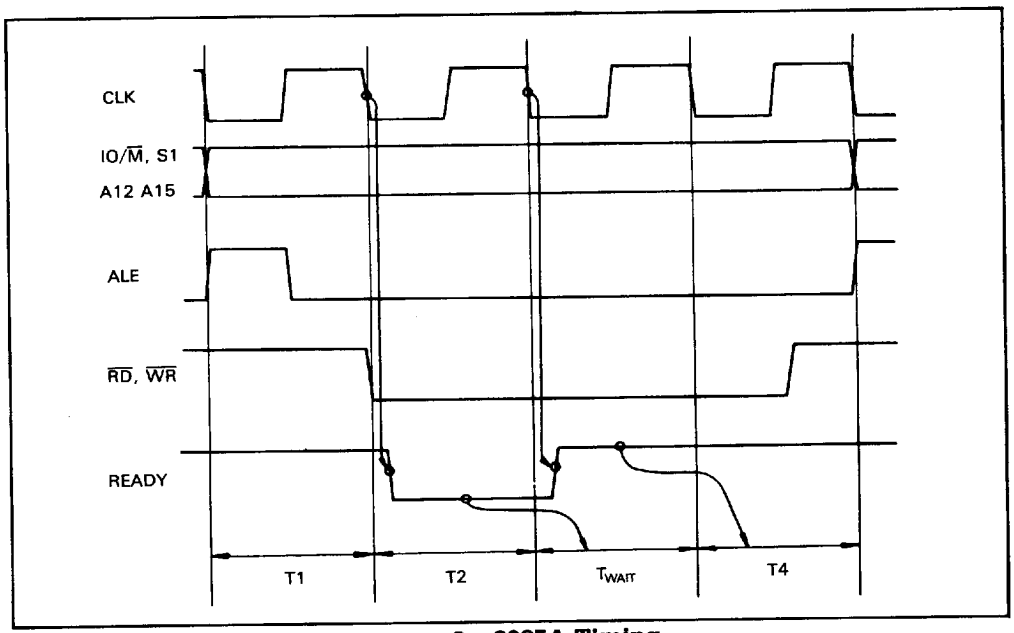


Figure 8 8085A Timing

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	(On)
	0	0	0	0	0	1	0	1	(Off)

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 ≦ the total character number
n, m ≦ 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 thiscode appears where the cursor wasdisplayed 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	μs

(depends on the operating frequency)

Interface to External ROM

1. Example

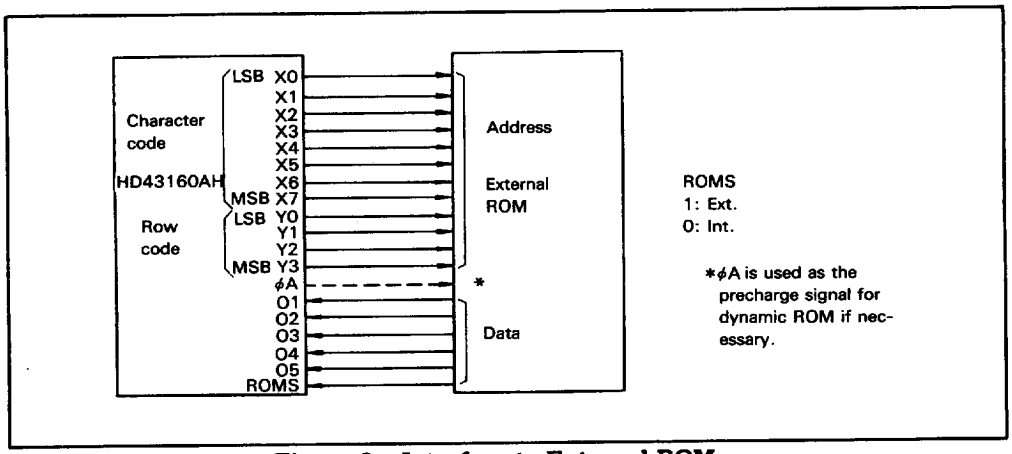


Figure 9 Interface to External ROM

2. Row code

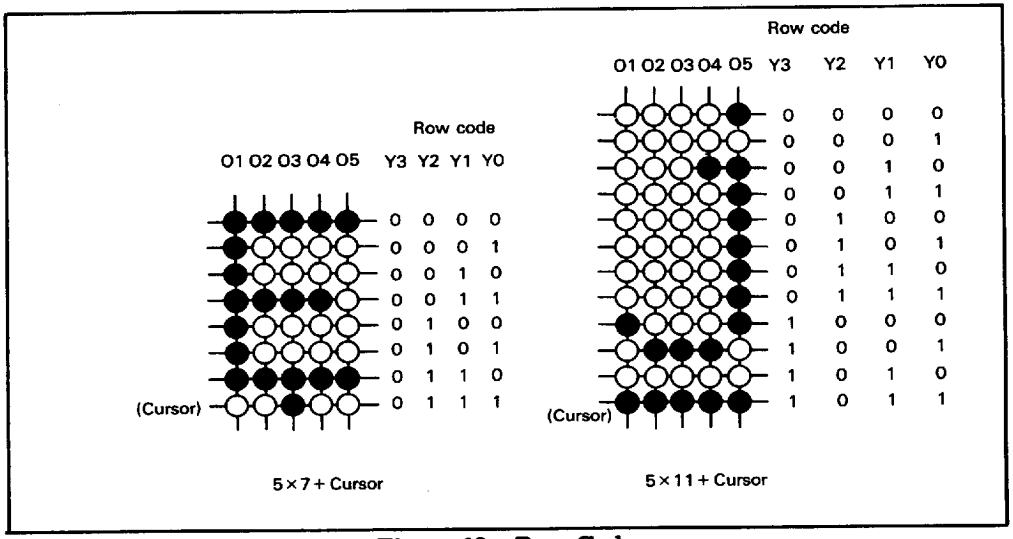


Figure 10 Row Code

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4496204 0046006 T33

3. Timing chart

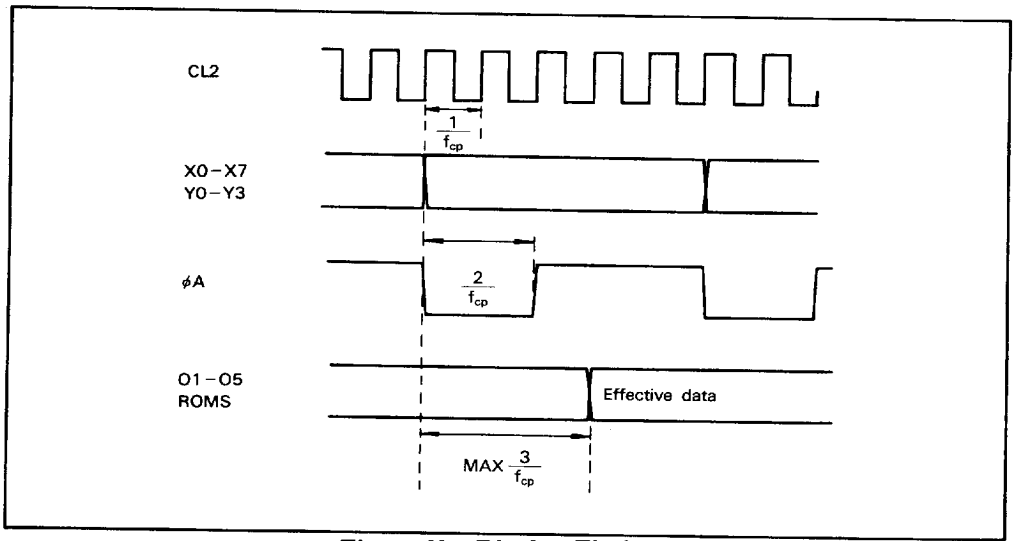

Figure 11 Display Timing

Interface to LCD Drivers

1. Example

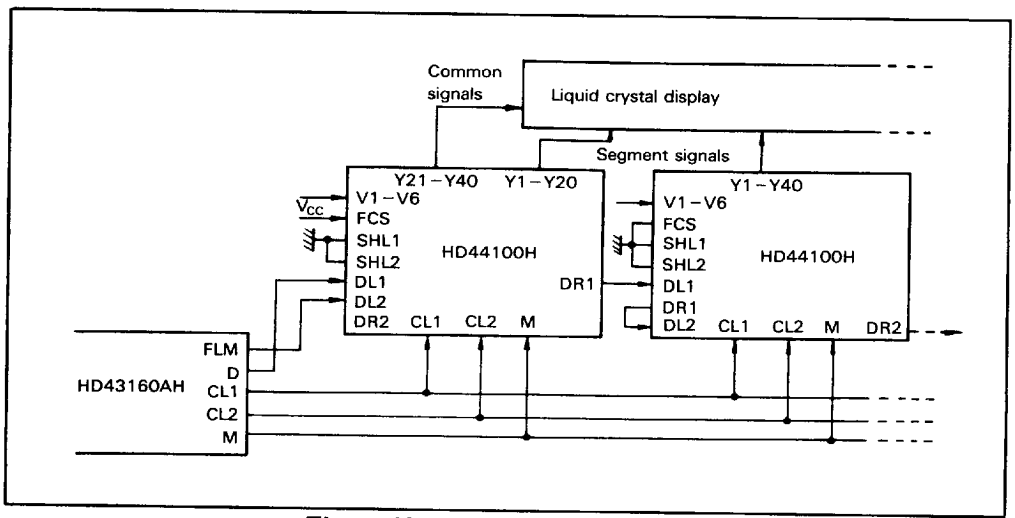

Figure 12 Interface to HD44100H

2. Waveforms (5 × 7 + Cursor 1 line)

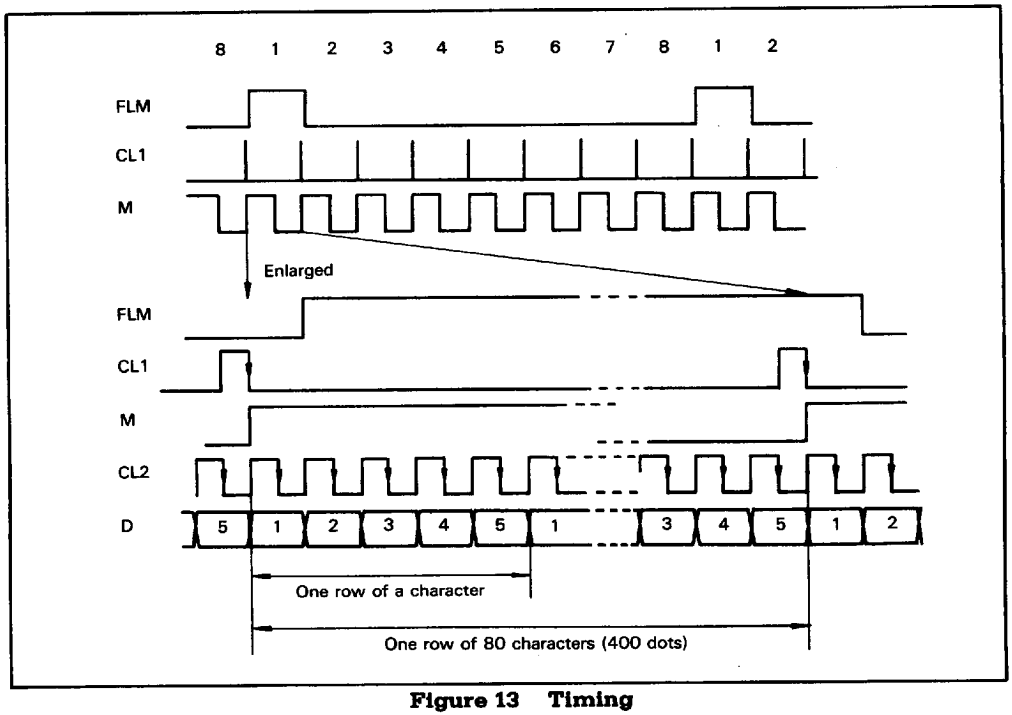

Figure 13 Timing

Dot Matrix Liquid Crystal Display System

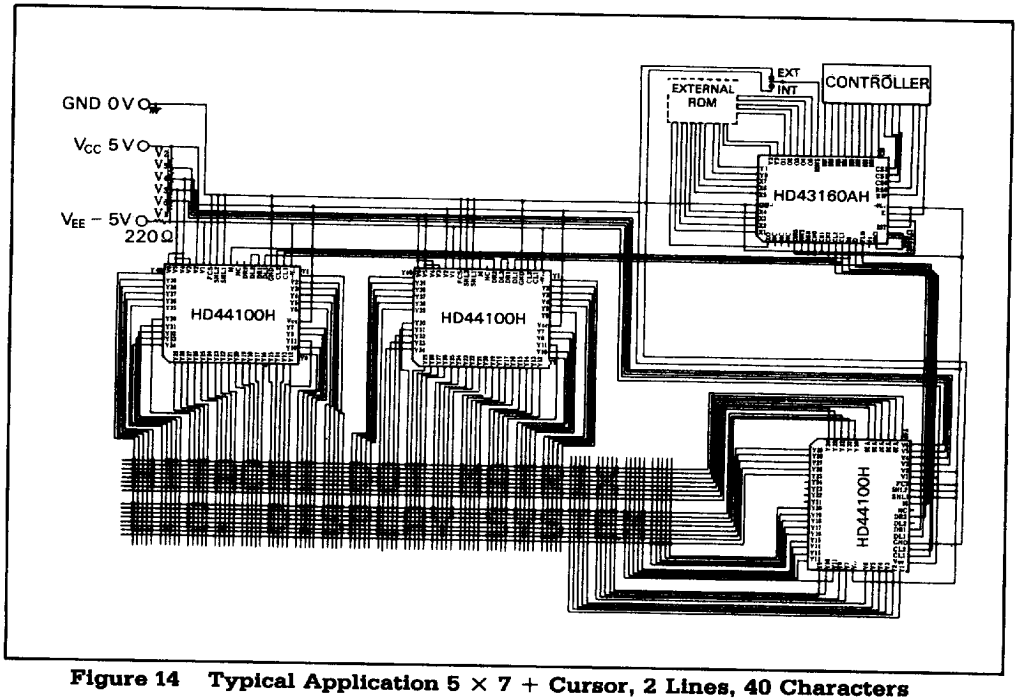

Figure 14 Typical Application 5 × 7 + Cursor, 2 Lines, 40 Characters