

Memory:

The HD44780 provides an 80x8 bit Display Data RAM (DDRAM). This is used to store the data that is being displayed on the screen. This allows the HD44780 to store up to 40 characters per line. It is important to note that the DMC-16204 will display only 16 characters per line. The extra memory here can be used to store characters that may then be shifted onto the screen. All data to be displayed must be stored in the form of an 8 bit ASCII code character.

Figure 2: 1 Line Display

Display position (digit)	1	2	3	4	5	.....	79	80
DDRAM address (hexadecimal)	00	01	02	03	04	.....	4E	4F

Figure 3: 2 Line Display

Display position	1	2	3	4	5	.....	39	40
DDRAM address (hexadecimal)	00	01	02	03	04	.....	26	27
	40	41	42	43	44	.....	66	67

Instructions:

The HD44780 has a number of different instructions that it can execute. These instructions are listed in the following table:

Table 2: Instructions

Instruction	Code										Description	Execution Time (max) (when f_{clk} or f_{osc} is 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	Clears entire display and sets DDRAM address 0 in address counter.		
Return home	0	0	0	0	0	0	0	0	0	1	—	Sets DDRAM address 0 in address counter. Also returns display from being shifted to original position. DDRAM contents remain unchanged.	1.52 ms
Entry mode set	0	0	0	0	0	0	0	1	I/D	S	Sets cursor move direction and specifies display shift. These operations are performed during data write and read.	37 μ s	
Display on/off control	0	0	0	0	0	0	1	D	C	B	Sets entire display (D) on/off, cursor on/off (C), and blinking of cursor position character (B).	37 μ s	
Cursor or display shift	0	0	0	0	0	1	S/C	R/L	—	—	Moves cursor and shifts display without changing DDRAM contents.	37 μ s	
Function set	0	0	0	0	1	DL	N	F	—	—	Sets interface data length (DL), number of display lines (N), and character font (F).	37 μ s	
Set CGRAM address	0	0	0	1	ACG	ACG	ACG	ACG	ACG	ACG	Sets CGRAM address. CGRAM data is sent and received after this setting.	37 μ s	
Set DDRAM address	0	0	1	ADD	ADD	ADD	ADD	ADD	ADD	ADD	Sets DDRAM address. DDRAM data is sent and received after this setting.	37 μ s	
Read busy flag & address	0	1	BF	AC	AC	AC	AC	AC	AC	AC	Reads busy flag (BF) indicating internal operation is being performed and reads address counter contents.	0 μ s	
Write data to CG or DDRAM	1	0	Write data									Writes data into DDRAM or CGRAM.	37 μ s $t_{acc} = 4 \mu$ s*
Read data from CG or DDRAM	1	1	Read data									Reads data from DDRAM or CGRAM.	37 μ s $t_{acc} = 4 \mu$ s*
I/D = 1: Increment I/D = 0: Decrement S = 1: Accompanies display shift S/C = 1: Display shift S/C = 0: Cursor move R/L = 1: Shift to the right R/L = 0: Shift to the left DL = 1: 8 bits, DL = 0: 4 bits N = 1: 2 lines, N = 0: 1 line F = 1: 5 x 10 dots, F = 0: 5 x 8 dots BF = 1: Internally operating BF = 0: Instructions acceptable											DDRAM: Display data RAM CGRAM: Character generator RAM ACG: CGRAM address ADD: DDRAM address (corresponds to cursor address) AC: Address counter used for both DD and CGRAM addresses	Execution time changes when frequency changes Example: When f_{clk} or f_{osc} is 250 kHz, 37μ s $\times \frac{270}{250} = 40 \mu$ s	

Note: — indicates no effect.

It is important to note that the HD44780 can only execute one instruction at a time. Before sending an instruction to the display, the busy flag must be read. If the busy flag is zero, then the instruction can be sent to the display, otherwise the instruction must be held by the microprocessor until the current instruction has completed execution and the busy flag is cleared.

Instruction Descriptions:

Clear Display

This instruction writes a 0x20 to all locations in the DDRAM. It also sets the DDRAM address to zero and unshifts the display, if it had been shifted. It also sets the display to increment mode.

Return Home

The DDRAM Address is set to zero and the display is unshifted, if it had been shifted.

Entry Mode Set

This instruction has two parameters, which it controls. The first is I/D. If this bit is high, the display increments the DDRAM address by one every time a character is written to the screen. If it is low, then the display address will be decremented by one every time a character is written. The second parameter is S. When S is high, the display shifts after a character is written to the screen. It will shift to the right if I/D = 0 or to the left if I/D=1. When S is low, the display does not shift when a character is written.

Display Control On/Off

This instruction has 3 parameters that the user can set. The first is D. This turns the display on when it is high and off when it is low. The second parameter is C. This displays the cursor when it is high and turns the cursor off when it is low. The last parameter is B. When this is high the character indicated by the cursor will blink. When it is low the display will not blink.

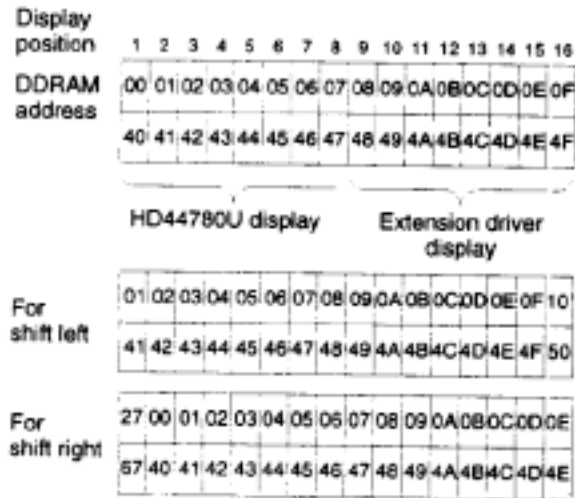
Cursor or Display Shift

This instruction shifts either the cursor or display by 1 character, without modifying the data stored in the DDRAM. The direction of the shift is determined by the value in the R/L bit. Both lines shift simultaneously. The shifting type and direction are summarized in the following table:

Table 3: Shift Functions

S/C	R/L	
0	0	Shifts the cursor position to the left. (AC is decremented by one.)
0	1	Shifts the cursor position to the right. (AC is incremented by one.)
1	0	Shifts the entire display to the left. The cursor follows the display shift.
1	1	Shifts the entire display to the right. The cursor follows the display shift.

Figure 4: 2 Line by 16 Character Display



Function Set

This instruction is used to initialize the display and what format the display will be using. This is done only during the initialization process and it may not be changed later in the program. DL is the data length of the interface. For this program, DL is always high, since the only the 8 bit interface is used. N is the number of display lines and F is the font size.

Table 4: Function Set

N	F	No. of Display Lines	Character Font	Duty Factor	Remarks
0	0	1	5 × 8 dots	1/8	
0	1	1	5 × 10 dots	1/11	
1	*	2	5 × 8 dots	1/16	Cannot display two lines for 5 × 10 dot character font

Note: * Indicates don't care.

Set DDRAM Address

This sets the DDRAM to the address included in the instruction. When the display is in single line mode the addresses range from 0x00 to 0x4F. In 2 line mode, the instructions range from 0x00 to 0x27 for the first line and from 0x40 to 0x67 for the second line.

Read Busy Flag

This instruction sends the state of the Busy Flag to the microcontroller. This appears on bit 7 and is used to determine if the LCD screen controller is still executing an instruction. If the bit is high, then there is an instruction executing that must be completed before another instruction can be written to the LCD screen controller