Visualización de datos en un display digital 16x2 con controlador Hitachi HD44780.

1. Descripción.

Este proyecto tiene como objeto la visualización de mensajes en un display de dos líneas de 16 caracteres cada una. Este display incorpora un controlador que es el encargado de mostrar la información y gestionar el estado y posicionado de los caracteres en el display. El objetivo principal es el de ser capaces de enviar caracteres al display de modo que se visualicen los datos deseados por nosotros. En este caso, dado que deseamos que se controle desde la FPGA que incorpora la placa de pruebas utilizada en la sesión inicial de Xilinx, emplearemos un dispositivo XC4010E-3 para la implementación. El control del display se realiza mediante los interruptores de entrada que posee la placa de pruebas, de tal modo que responde a estos comandos:

Nº interruptor	**2**	**3**	**4**	**5..8**	**Operación**
Vector **SWITCH(6:0)**	**6**	**5**	**4**	**3..0**	
		0	0	**Clave**	Introducción de clave para acceso
		0	1		
		1	0	**Clave supervisor**	Modo supervisor para nueva clave
		1	1	**Nueva clave**	Cambio de clave de acceso

El interruptor 1 (switch7) es el que hace las funciones de <enter> cuando pasa de nivel bajo a alto. Los mensajes predefinidos estarán guardados en memoria ROM interna (recordemos que una FPGA puede incorporar memoria RAM y ROM) y consisten en lo siguiente:

Mensaje 1: “Introduzca clave: ”
Mensaje 2: “Clave válida ”
Mensaje 3: “Acceso denegado ”

El mensaje 1 se estará mostrando constantemente hasta que se ejecute uno de los comandos y se evalúe la clave, una vez evaluada, se muestran el mensaje 2 ó 3 según corresponda durante un tiempo determinado (2 segundos, por ejemplo). En el caso de cambio de clave, primero se introduce la clave supervisor que defino como 1111, y a continuación se pide la nueva clave, mostrando el mensaje de clave válida durante otros 2 segundos para después retornar al modo introducción de clave.

http://home.iae.nl/users/pouweha/lcd/lcd.shtml

How to control a HD44780-based Character-LCD

1. General

1.1. Disclaimer

THIS DOCUMENT IS PROVIDED TO THE USER "AS IS". Etc.etc.

2. HD44780-based LCD modules

Data from *HITACHI LIQUID CRYSTAL CHARACTER DISPLAY MODULE* and *OPTREX DOT MATRIX LCD MODULE* databooks.

2.1. Pin assignment

The pin assignment shown in *Table 2.1.* is the industry standard for character LCD-modules with a *maximum of* 80 characters.
The pin assignment shown in *Table 2.2.* is the industry standard for character LCD-modules with *more than* 80 characters.

To be sure **always** check the manufacturers datasheet!
To locate pin 1 on a module check the manufacturers datasheet!

Table 2.1., Pin assignment for <= 80 character displays

Pin number	Symbol	Level	I/O	Function
1	Vss	-	-	Power supply (GND)
2	Vcc	-	-	Power supply (+5V)
3	Vee	-	-	Contrast adjust
4	RS	0/1	I	0 = Instruction input 1 = Data input
5	R/W	0/1	I	0 = Write to LCD module 1 = Read from LCD module
6	E	1, 1-->0	I	Enable signal
7	DB0	0/1	I/O	Data bus line 0 (LSB)
8	DB1	0/1	I/O	Data bus line 1
9	DB2	0/1	I/O	Data bus line 2
10	DB3	0/1	I/O	Data bus line 3
11	DB4	0/1	I/O	Data bus line 4
12	DB5	0/1	I/O	Data bus line 5
13	DB6	0/1	I/O	Data bus line 6
14	DB7	0/1	I/O	Data bus line 7 (MSB)

Table 2.2., Pin assignment for > 80 character displays

Pin number	Symbol	Level	I/O	Function
1	DB7	0/1	I/O	Data bus line 7 (MSB)
2	DB6	0/1	I/O	Data bus line 6
3	DB5	0/1	I/O	Data bus line 5
4	DB4	0/1	I/O	Data bus line 4
5	DB3	0/1	I/O	Data bus line 3
6	DB2	0/1	I/O	Data bus line 2
7	DB1	0/1	I/O	Data bus line 1
8	DB0	0/1	I/O	Data bus line 0 (LSB)
9	E1	1, 1->0	I	Enable signal row 0 & 1
10	R/W	0/1	I	0 = Write to LCD module 1 = Read from LCD module
11	RS	0/1	I	0 = Instruction input 1 = Data input
12	Vee	-	-	Contrast adjust
13	Vss	-	-	Power supply (GND)
14	Vcc	-	-	Power supply (+5V)
15	E2	1, 1->0	I	Enable signal row 2 & 3
16	n.c.			

2.2. Instruction set

Table 2.3. HD44780 instruction set

Instruction	Code										Description	Execution time**
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Clear display	0	0	0	0	0	0	0	0	0	1	Clears display and returns cursor to the home position (address 0).	1.64mS
Cursor home	0	0	0	0	0	0	0	0	1	*	Returns cursor to home position (address 0). Also returns display being shifted to the original position. DDRAM contents remains unchanged.	1.64mS
Entry mode set	0	0	0	0	0	0	0	1	I/D	S	Sets cursor move direction (I/D), specifies to shift the display (S). These operations are performed during data read/write.	40uS
Display On/Off control	0	0	0	0	0	0	1	D	C	B	Sets On/Off of all display (D), cursor On/Off (C) and blink of cursor position character (B).	40uS
Cursor/display shift	0	0	0	0	0	1	S/C	R/L	*	*	Sets cursor-move or display-shift (S/C), shift direction (R/L). DDRAM contents remains unchanged.	40uS
Function set	0	0	0	0	1	DL	N	F	*	*	Sets interface data length (DL), number of display line (N) and character font(F).	40uS
Set CGRAM address	0	0	0	1	CGRAM address						Sets the CGRAM address. CGRAM data is sent and received after this setting.	40uS
Set DDRAM address	0	0	1	DDRAM address							Sets the DDRAM address. DDRAM data is sent and received after this setting.	40uS
Read busy-flag and address counter	0	1	BF	CGRAM / DDRAM address							Reads Busy-flag (BF) indicating internal operation is being performed and reads CGRAM or DDRAM address counter contents (depending on previous instruction).	0uS
Write to CGRAM or DDRAM	1	0	write data								Writes data to CGRAM or DDRAM.	40uS
Read from CGRAM or DDRAM	1	1	read data								Reads data from CGRAM or DDRAM.	40uS

Remarks:
- DDRAM = Display Data RAM.- CGRAM = Character Generator RAM. - DDRAM address corresponds to cursor position.
- * = Don't care. - ** = Based on Fosc = 250KHz.

Table 2.4. Bit names

Bit name	Settings	
I/D	0 = Decrement cursor position	1 = Increment cursor position
S	0 = No display shift	1 = Display shift
D	0 = Display off	1 = Display on
C	0 = Cursor off	1 = Cursor on
B	0 = Cursor blink off	1 = Cursor blink on
S/C	0 = Move cursor	1 = Shift display
R/L	0 = Shift left	1 = Shift right
DL	0 = 4-bit interface	1 = 8-bit interface
N	0 = 1/8 or 1/11 Duty (1 line)	1 = 1/16 Duty (2 lines)
F	0 = 5x7 dots	1 = 5x10 dots
BF	0 = Can accept instruction	1 = Internal operation in progress

2.3. Visible DDRAM addresses

2.3.1. 1-line displays

Shown after reset (with N=0).

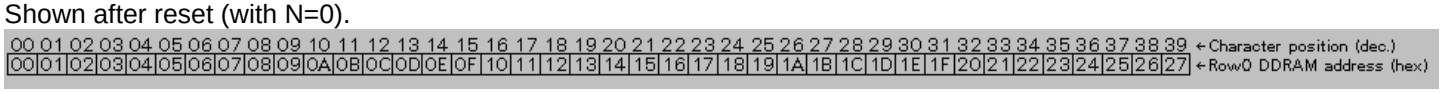


Table 2.5. DDRAM address usage for a 1-line LCD		
Display size	Visible	
	Character positions	DDRAM addresses
1*8	00..07	00h..07h
1*16	00..15	00h..0Fh
1*20	00..19	00h..13h
1*24	00..23	00h..17h
1*32	00..31	00h..1Fh
1*40	00..39	00h..27h

2.3.2. 2-line displays

Shown after reset (with N=1).

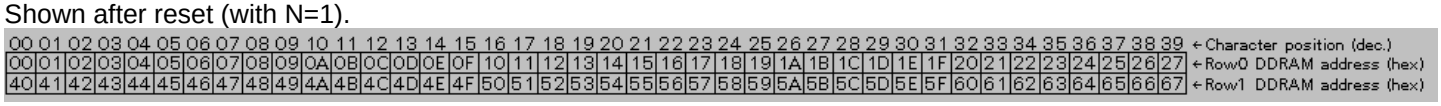


Table 2.6. DDRAM address usage for a 2-line LCD		
Display size	Visible	
	Character positions	DDRAM addresses
2*16	00..15	00h..0Fh + 40h..4Fh
2*20	00..19	00h..13h + 40h..53h
2*24	00..23	00h..17h + 40h..57h
2*32	00..31	00h..1Fh + 40h..5Fh
2*40	00..39	00h..27h + 40h..67h

2.3.3. 4-line displays

Shown after reset (with N=1).

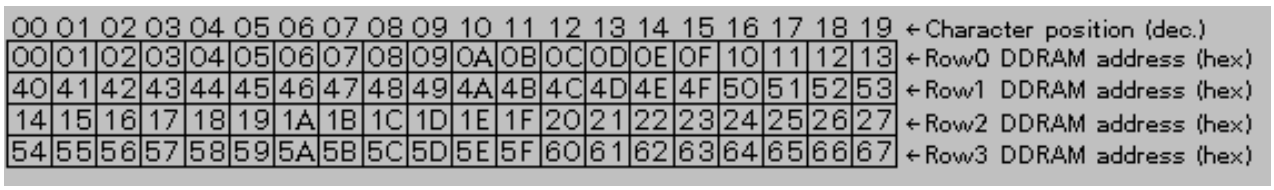
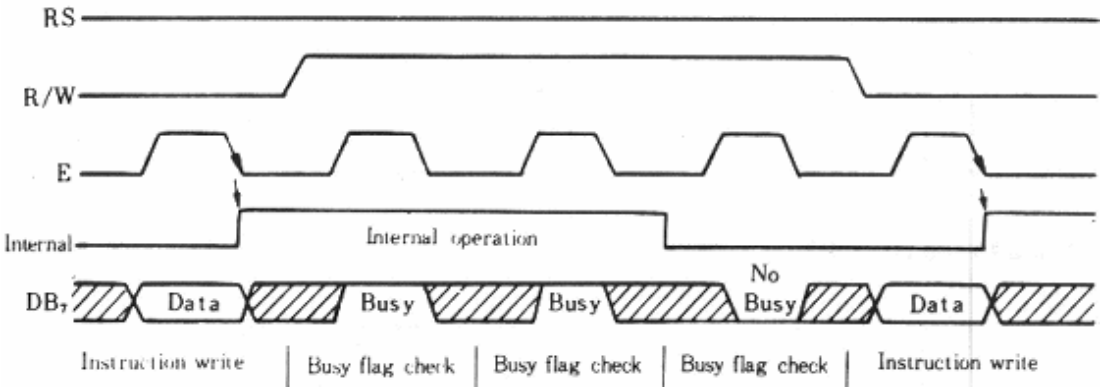


Table 2.7. DDRAM address usage for a 4-line LCD		
Display size	Visible	
	Character positions	DDRAM addresses
4*16	00..15	00h..0Fh + 40h..4Fh + 14h..23h + 54h..63h
4*20	00..19	00h..13h + 40h..53h + 14h..27h + 54h..67h
4*40	(00..39) on 1st controller and (00..39) on 2nd controller	(00h..27h + 40h..67h) on 1st controller and (00h..27h + 40h..67h) on 2nd controller

2.4. Interfacing

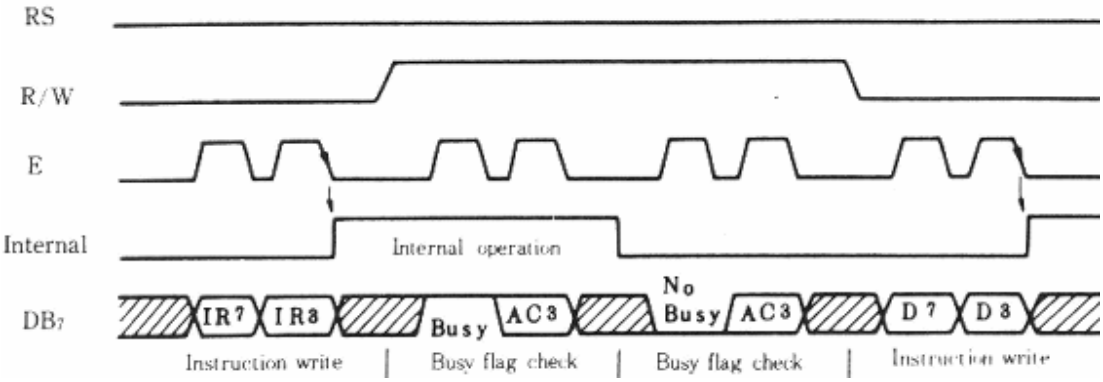
2.4.1. 8-bit interface

Example of busy flag testing using an 8-bit interface.

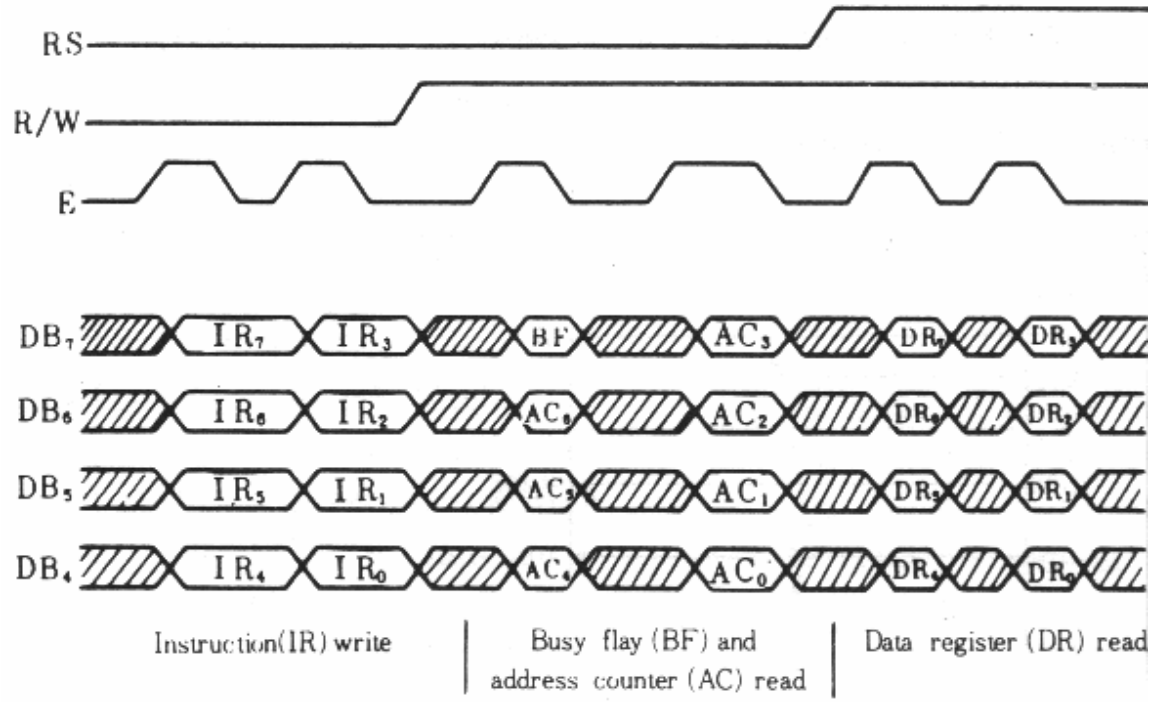


2.4.2. 4-bit interface

Example of busy flag testing using a 4-bit interface.



Example of data transfer using a 4-bit interface.



2.5. Character set

Characterset for 5x7 dot font (to be completed..)