

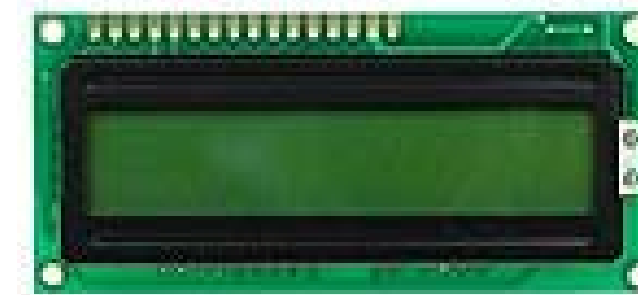
LCD module

Hitachi HD44780 controller
and compatible



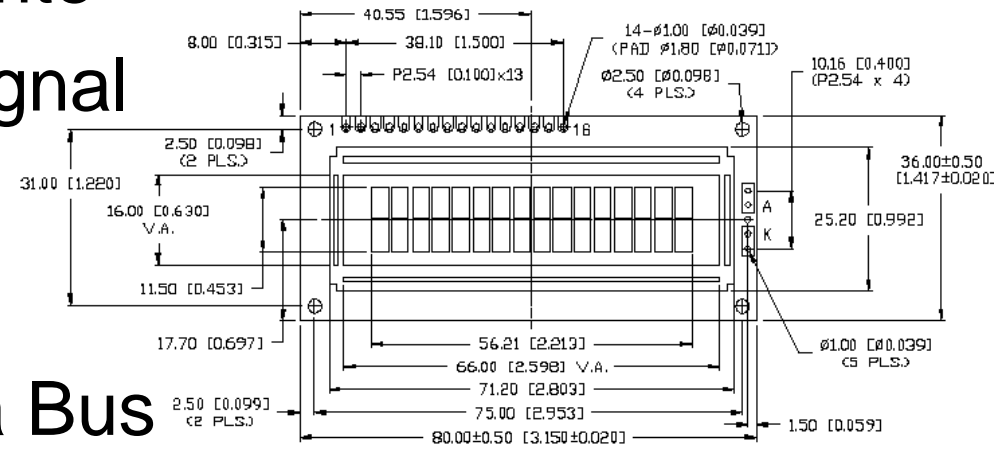
Main features

- 5x8 character dot matrix display
- 80x8-bit display RAM
- 64x8-bit character generator RAM
- 4-bit or 8-bit interface



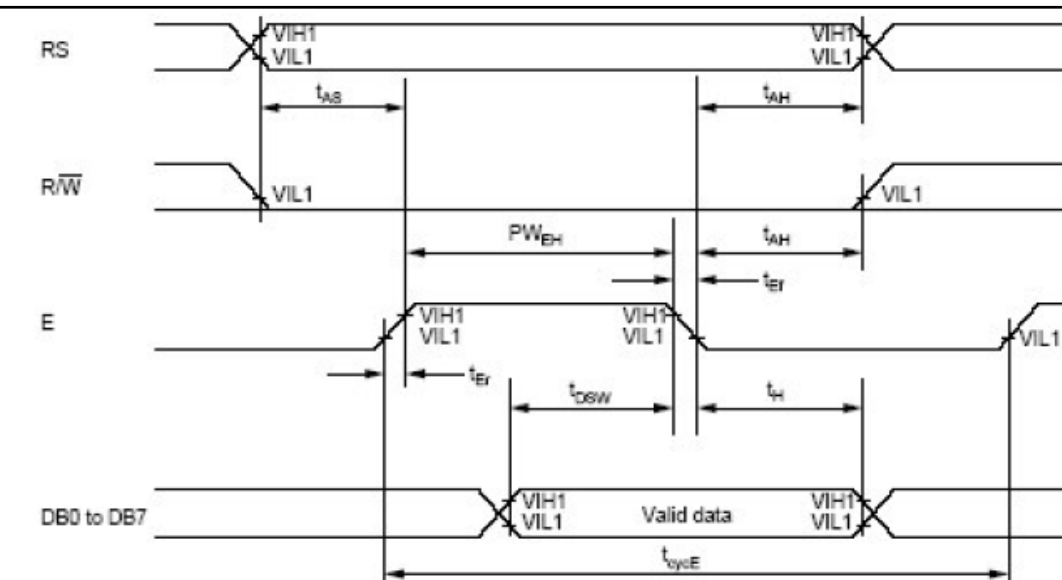
Interface

- 1 Vss GND
- 2 VDD Vcc (+5V ± 5%)
- 3 Vo Contrast Adjustment
- 4 RS Register Select
- 5 R/W Read / Write
- 6 E Enable signal



7-14 DB0-DB7 Data Bus

Timing



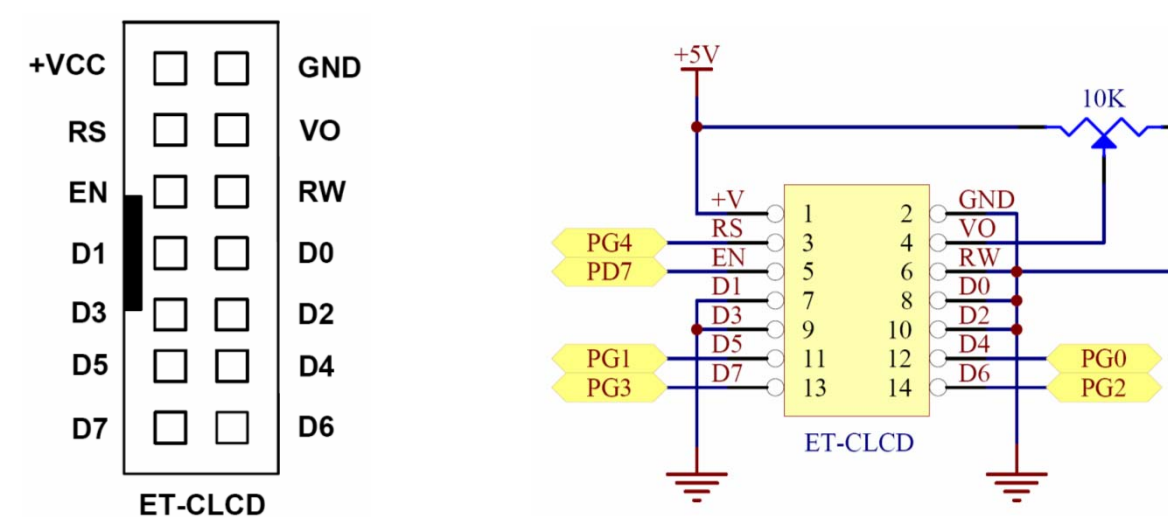
Item	min @ 2.7-4.5V	min @ 4.5-5.5V	description
PW _{EH}	450 ns	230 ns	E hold
t _{cycE}	1000 ns	500 ns	E cycle
t _{AB}	60 ns	40 ns	address setup
t _{AH}	20 ns	10 ns	address hold
t _{DBW}	195 ns	80 ns	data setup (write)
t _H	10 ns	10 ns	data hold (write)
t _{DHR}	5 ns	5 ns	data hold (read)

Quick guide for standard write

1. Set RS and data
2. Set E
3. Wait at least PW_{EH}
4. Clear E
5. Wait t_{cycE}

(initialization is different!!)

ET-LCD port on ET-BASE AVR



ET-CLCD pin	1	2	3	4	5	6	7	8	9	10	11	12	13	14
signal	GND	+Vcc	Vo	RS	R/W	EN	D0	D1	D2	D3	D4	D5	D6	D7
AVR pin	GND	+Vcc	(LCD ADJ)	PG4	GND	PD7	GND	GND	GND	GND	PG0	PG1	PG2	PG3

4-bit interface

- bus lines DB0-DB3 disabled
- 4 high order bits followed by 4 low order bits



Display addressing

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



Instruction Set

1. Designate functions (display format, data length etc.)
2. Set internal RAM address
3. Data transfer
4. Miscellaneous functions



Instruction	Code										Description	Execution Time (max) (when f_{op} 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.	1.64 ms
Return home	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*

1 tclock tick @ 16MHz = 62.5 ns
 1 μ s = 1000ns/(62.5ns/instr) = 16 instructions
 37 μ s = 592 instructions



Instructions - Legend

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_{op} or f_{osc} is 250 kHz,
 37μ s $\times \frac{270}{250} = 40 \mu$ s

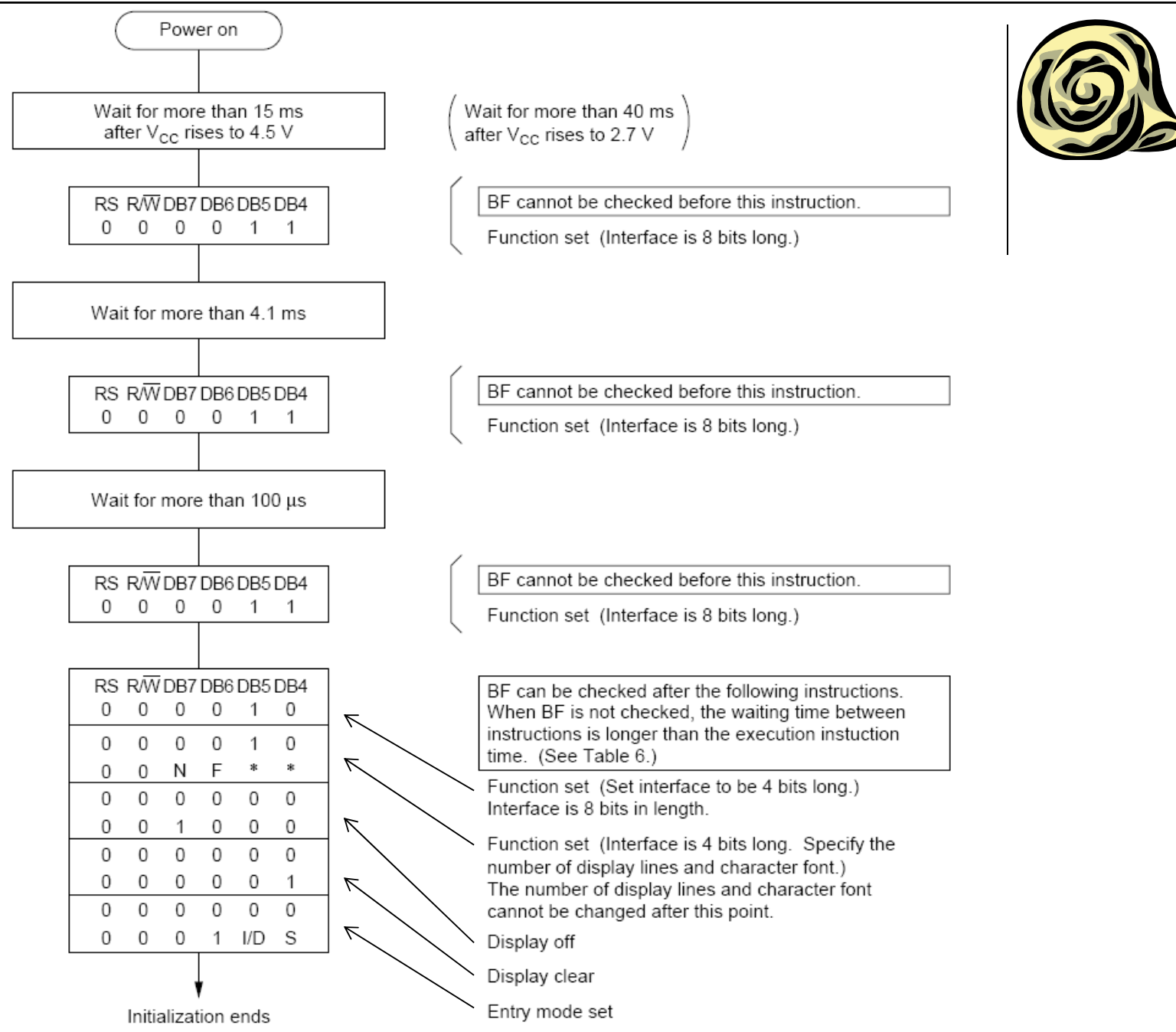


Internal Reset Procedure

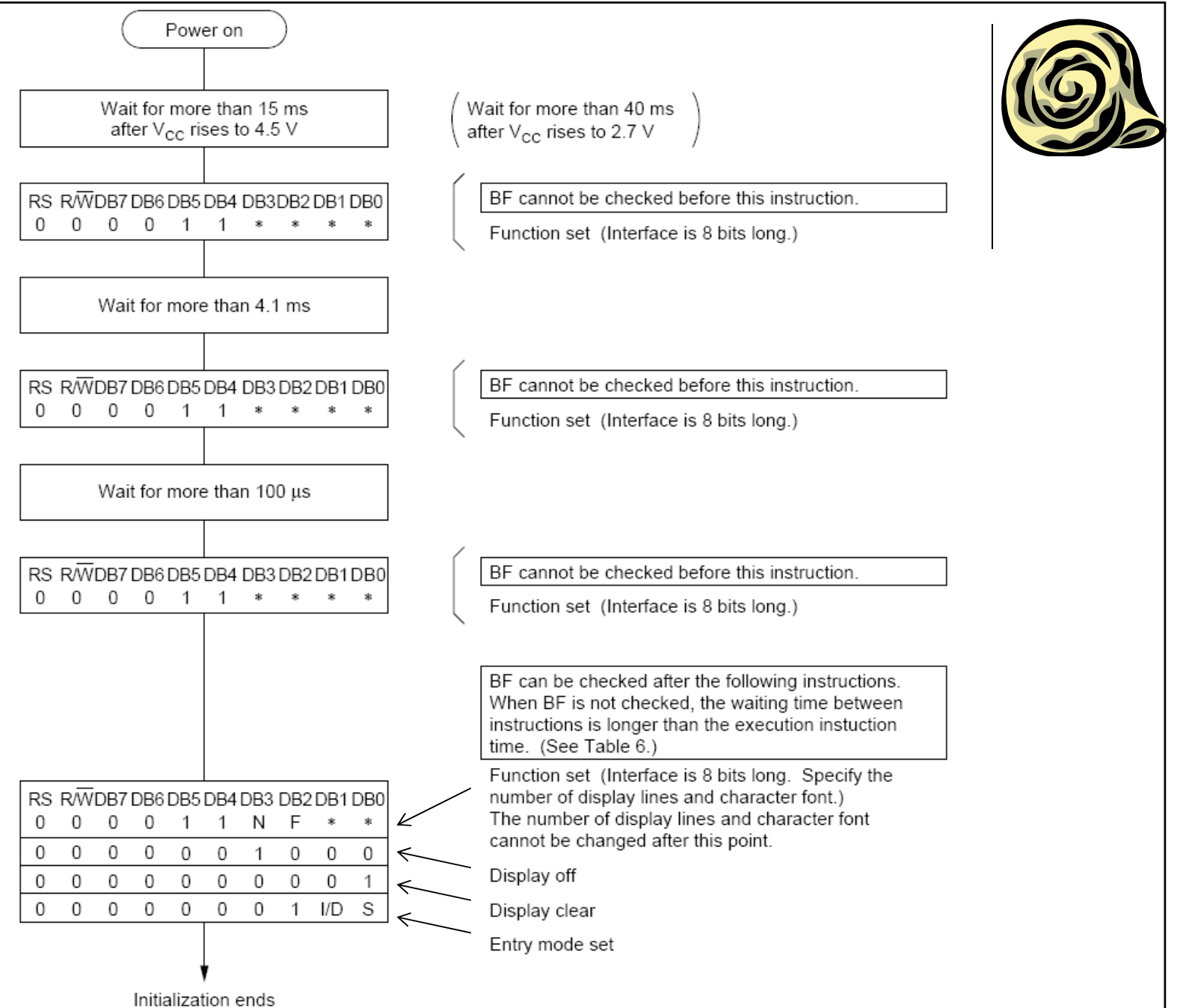
1. Display clear
2. Function set:
 DL = 1; 8-bit interface data
 N = 0; 1-line display
 F = 0; 5 x 8 dot character font
3. Display on/off control:
 D = 0; Display off
 C = 0; Cursor off
 B = 0; Blinking off
4. Entry mode set:
 I/D = 1; Increment by 1
 S = 0; No shift



Initializing by Instruction 4-bit interface



Initializing by Instruction 8-bit interface



Homework

- Make a small library for controlling the LCD
 - lcd_init
 - lcd_putc
 - later lcd_gotoxy, lcd_puts
 - put it in a separate source file
 - later make it C compatible
- Print *Hello world* on the LCD