STEPS TO PROGRAMMING THE LCD

1) Create OUTPUT ports in the Entity Declaration, and SIGNALS in the Architecture body of the circuit for these variables:

RS (data/Instruction_code mode)(1-bit), R/W (read/write), E(enable), LCD_ON, LCD_BON(backlight), and an 8-bit databus.

Example code :

```
Entity foo IS
        port (RS, RW,LCD_ON,LCD_BON : OUTPUT STD_LOGIC;
              data_bus              : OUTPUT STD_LOGIC_VECTOR (7 DOWNTO 0));
END foo;

ARCHITECTURE arc OF foo IS

        SIGNAL RS_sig, RW_sig       : STD_LOGIC;
        SIGNAL data_sig             :STD_LOGIC_VECTOR (7 DOWNTO 0);

BEGIN

        RS <= RS_sig;
        RW <= RW_sig;
        data_bus <= data_sig;
        .
        .
        .
END arc;
```

7.Interface Pin Function

Pin No.	Symbol	Level	Description
1	V_{SS}	0V	Ground
2	V_{DD}	5.0V	Supply Voltage for logic
3	VO	(Variable)	Operating voltage for LCD
4	RS	H/L	H:DATA, L:Instruction code
5	R/W	H/L	H:Read(MPU→Module)L:Write(MPU→Module)
6	E	H,H→L	Chip enable signal
7	DB0	H/L	Data bit 0
8	DB1	H/L	Data bit 1
9	DB2	H/L	Data bit 2
10	DB3	H/L	Data bit 3
11	DB4	H/L	Data bit 4
12	DB5	H/L	Data bit 5
13	DB6	H/L	Data bit 6
14	DB7	H/L	Data bit 7
15	A	—	Power supply for LED backlight (+)
16	K	—	Power supply for LED backlight (-)

Refer to the table below for pin assignments.

G_LSPEED	PIN_G6	
Signal Name	FPGA Pin No.	Description
LCD_DATA[0]	PIN_J1	LCD Data[0]
LCD_DATA[1]	PIN_J2	LCD Data[1]
LCD_DATA[2]	PIN_H1	LCD Data[2]
LCD_DATA[3]	PIN_H2	LCD Data[3]
LCD_DATA[4]	PIN_J4	LCD Data[4]
LCD_DATA[5]	PIN_J3	LCD Data[5]
LCD_DATA[6]	PIN_H4	LCD Data[6]
LCD_DATA[7]	PIN_H3	LCD Data[7]
LCD_RW	PIN_K4	LCD Read/Write Select, 0 = Write, 1 = Read
LCD_EN	PIN_K3	LCD Enable
LCD_RS	PIN_K1	LCD Command/Data Select, 0 = Command, 1 = Data
LCD_ON	PIN_L4	LCD Power ON/OFF
LCD_BLON	PIN_K2	LCD Back Light ON/OFF
Signal Name	FPGA Pin No.	Description
	PIN_AD24	

2) Initialize LCM

First we scan through the Instruction code table to learn what each instruction code is assigned to do.

R S	R/W	Operation
0	0	IR write as an internal operation (display clear, etc.)
0	1	Read busy flag (DB7) and address counter (DB0 to DB7)
1	0	Write data to DDRAM or CGRAM (DR to DDRAM or CGRAM)
1	1	Read data from DDRAM or CGRAM (DDRAM or CGRAM to DR)

(When the busy flag is 1, the next instruction will not be accepted.)

INSTRUCTION CODE TABLE

Instruction	Instruction Code										Description	Execution time (fosc=270Khz)
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Clear Display	0	0	0	0	0	0	0	0	0	1	Write "00H" to DDRAM and set DDRAM address to "00H" from AC	1.53ms
Return Home	0	0	0	0	0	0	0	0	1	–	Set DDRAM address to "00H" from AC and return cursor to its original position if shifted. The contents of DDRAM are not changed.	1.53ms
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	SH	Assign cursor moving direction and enable the shift of entire display.	39μs
Display ON/OFF Control	0	0	0	0	0	0	1	D	C	B	Set display (D), cursor (C), and blinking of cursor (B) on/off control bit.	39μs
Cursor or Display Shift	0	0	0	0	0	1	S/C	R/L	–	–	Set cursor moving and display shift control bit, and the direction, without changing of DDRAM data.	39μs
Function Set	0	0	0	0	1	DL	N	F	–	–	Set interface data length (DL:8-bit/4-bit), numbers of display line (N:2-line/1-line)and, display font type (F:5× 11 dots/5× 8 dots)	39μs
Set CGRAM Address	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM address in address counter.	39μs
Set DDRAM Address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address counter.	39μs
Read Busy Flag and Address	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Whether during internal operation or not can be known by reading BF. The contents of address counter can also be read.	0μs
Write Data to RAM	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM).	43μs
Read Data from RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM (DDRAM/CGRAM).	43μs

＊ "—" : don't care

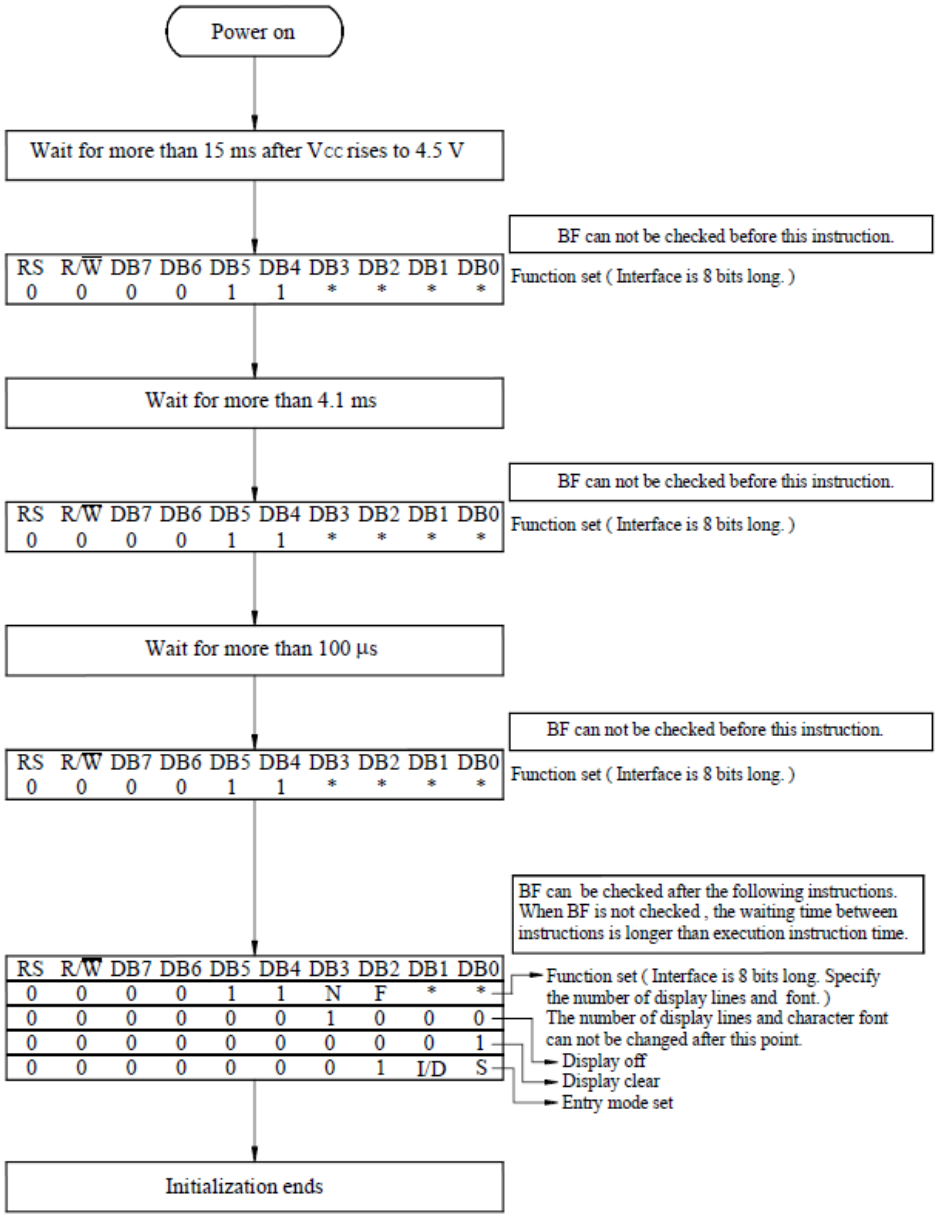
Some examples on how to use above functions:

- Function set : To set a 4-bit data length, a 2 line space (using both top and bottom lines of lcd screen) and a 5x11 dot font type :
  RS <= ‘0’;
  RW <= ‘0’;
data_bus <= “001011**”

Notice how DB4 = 1, if DB4 = 0 then the data_length = 8-bits

Entry Mode Set():
I\D = increment/decrement (1/0)
SH = shift enable (1 = enable, 0 = disable)

Now, we go ahead to initialize the LCD using the steps given in the diagram below. Note that the initialization is done only once at the beginning of the program. Also note that the function set() (display lines/space and font type) cannot be changed after initialization.



8-Bit Ineterface

＊ ”—” : don’t care

To initialize LCD follow instructions in the diagram above.

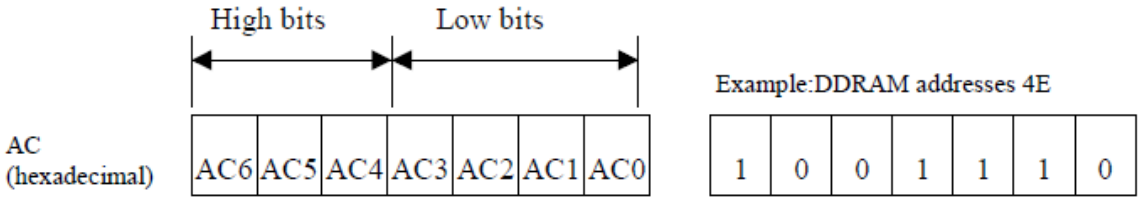
3) Continue with desired instructions:

To display a character refer to the table below:
Example: to display B,
RS_sig <= ‘1’;
RW_sig <= ‘0’;
data_sig <= “01000010”; (HEX 42)

Upper 4 bit / Lower 4 bit	LLLL	LLLH	LLHL	LLHH	LHLL	LHLH	LHHL	LHHH	HLLL	HLLH	HLHL	HLHH	HHLL	HHLH	HHHL	HHHH
LLLL	CG RAM (1)															
LLLH	(2)															
LLHL	(3)															
LLHH	(4)															
LHLL	(5)															
LHLH	(6)															
LHHL	(7)															
LHHH	(8)															
HLLL	(1)															
HLLH	(2)															
HLHL	(3)															
HLHH	(4)															
HHLL	(5)															
HHLH	(6)															
HHHL	(7)															
HHHH	(8)															

To Jump to a specific position on the screen, set the DDRAM address:

Example: To set DDRAM address 4E,
RS_sig <= ‘0’
RW_sig <= ‘0’
Data_sig <= “11001110”; (most sig. bit remains high when setting DDRAM address)



DDRAM Address

Display position DDRAM address

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F

2-Line by 16-Character Display

source: lcd_datasheet from altera de2 CD

Each instruction must be Enabled (Hold for at least minimum execution time), and then Disabled.
i.e Data_sig <= “x....x”
E <= ‘1’
wait for (t >= min execution time)
E <= ‘0’;

Source: All information found in this guideline can be found in the lcd_datasheet pdf file on the altera de2 CD.