Display Special Characters on LCD

A LCD is an arrangement of various 5x8 segment displays arranged in specific number of rows and columns so as to display more than one character at a time. A 16x2 LCD consists of 32 5x8 segment displays arranged in 2 rows and 16 columns allowing us to display 32 characters.

For writing program first let us know memory mapping in a LCD.

MEMORY MAPPING:

The memory of the LCD divided into three parts:-

- DDRAM (Display Data RAM):-
  - ✓ DDRAM is the memory which holds only those characters which are currently on the screen means if there is a message is currently being displayed on the screen then it has to be on the DDRAM
    Example if you want to display "hi" on the screen then you have to load pattern of h from the CGROM TO DDRAM then do the same for 'i'.
  - ✓ DDRAM memory address starts from 0x80 to 0x8F in first row and 0xC0 to 0xCF in second row.
- CGROM (Character Generator ROM):-
  - ✓ This is the memory address where all the predefined patterns are stored.
  - ✓ The ROM used by HD44780 is EPROM this memory varies from manufacture to manufacture.
  - ✓ The patterns are drawn in this memory area during the time of manufacturing.
  - ✓ The patterns are stored such that their memory address is equivalent to their ASCII code.
  - ✓ As an example character 'b' has ASCII value as 0x62 (01100010) then at memory location 0x62 the pattern for 'b' is stored.

EPROM Address												Data					
A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0	O4	O3	O2	O1	LSB O0	
								0	0	0	0	1	0	0	0	0	
								0	0	0	1	1	0	0	0	0	
								0	0	1	0	1	0	1	1	0	
								0	0	1	1	1	1	0	0	1	
								0	1	0	0	1	0	0	0	1	
								0	1	0	1	1	0	0	0	1	
								0	1	1	0	1	1	1	1	0	
0	1	1	0	0	0	1	0	0	1	1	1	0	0	0	0	0	← Cursor position
								1	0	0	0	0	0	0	0	0	
								1	0	0	1	0	0	0	0	0	
								1	0	1	0	0	0	0	0	0	
								1	0	1	1	0	0	0	0	0	
								1	1	0	0	0	0	0	0	0	
								1	1	0	1	0	0	0	0	0	
								1	1	1	0	0	0	0	0	0	
								1	1	1	1	0	0	0	0	0	

Character code — Line position

Figure 1: Relation between ASCII Value and Character Pattern

- CGRAM (Character Generator RAM):-
  - ✓ This area of LCD's memory is used when the user wants to display his own special character or show animation on the LCD. Like: heart, smiley etc.

Below table contains the hex value for individual characters which are present in LCD controller. So, to make a special character, i.e. characters which are not available in the table can be made by programming individual pixels.

Figure 2: CGRAM & CGROM Locations for Different Character

Now to design our own special characters we have to store it in CGRAM. There are 8 symbol locations where a custom character can be stored as shown in the following table. These locations will have a particular bitmap layout corresponding to the custom character.

When the controller receives an ASCII code in the range that's mapped to the CGRAM, it uses the bit patterns stored there to display a pattern on the LCD. The concept here lies in the fact one can write to the CGRAM, thereby defining one's own graphic symbols. Each byte of CGRAM is mapped to a five-bit vertical column of pixels, and LCD characters are typically eight rows high, so 64 bytes of CGRAM is enough to define eight custom characters. These characters correspond to ASCII codes 0 through 7.

An example to display arrow sign is given below:

To display an arrow sign, the bitmap values are mapped to a base address location, say 64 (ASCII code 0).

In CGRAM 8 locations are available where user can store their own character patterns.

The symbol locations with their base addresses are given below:

ASCII Code	Base Address
0	64
1	72
2	80
3	88
4	96
5	104
6	112
7	120

Figure 3: Available Addresses in CGRAM

This is achieved by first sending the address location (64) to LCD command register. Next, the bitmap values (0, 4, 2, 31, 2, 4, 0, 0) are sent to the LCD data register. Now the arrow sign gets stored at the first address. Now whenever this symbol is to be displayed, its location needs to be sent to the command register of LCD.

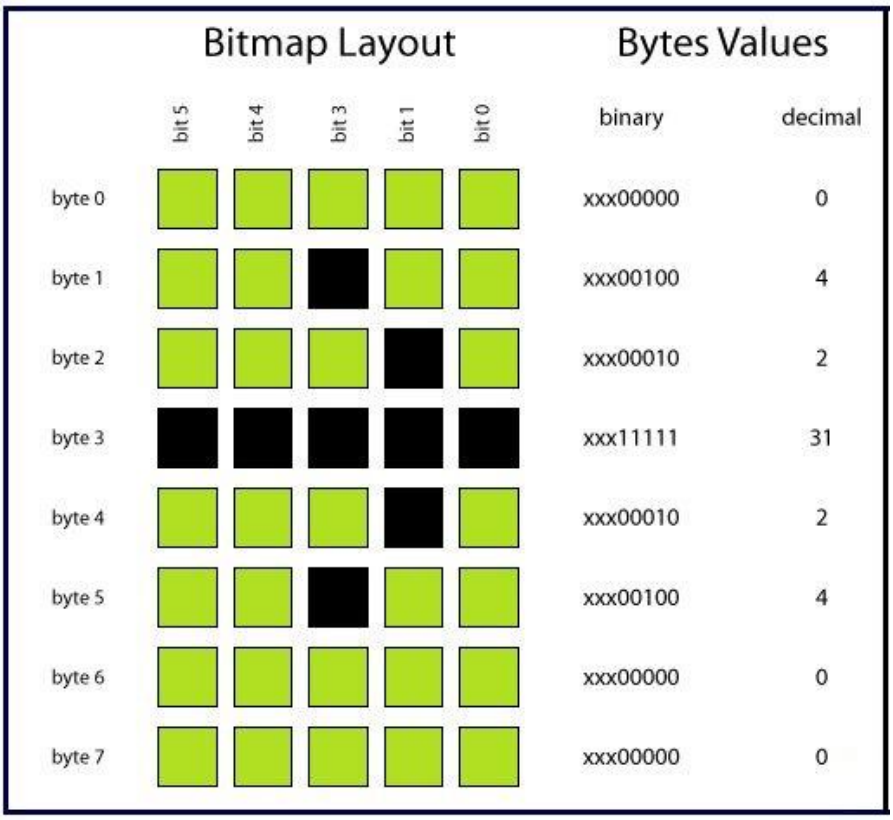

Figure 4: Example of Arrow Pattern in 5x8 Pixels

In order to draw pattern of this shape, following algorithm is used:

1. Initialize the LCD
2. Clear LCD screen
3. Store this shape in CGRAM by giving appropriate commands
4. Set the cursor on the desired location where you want to display character
5. Display it on the screen by giving appropriate command.