Embedded System Interfacing

Lecture 3
Character LCD Interfacing

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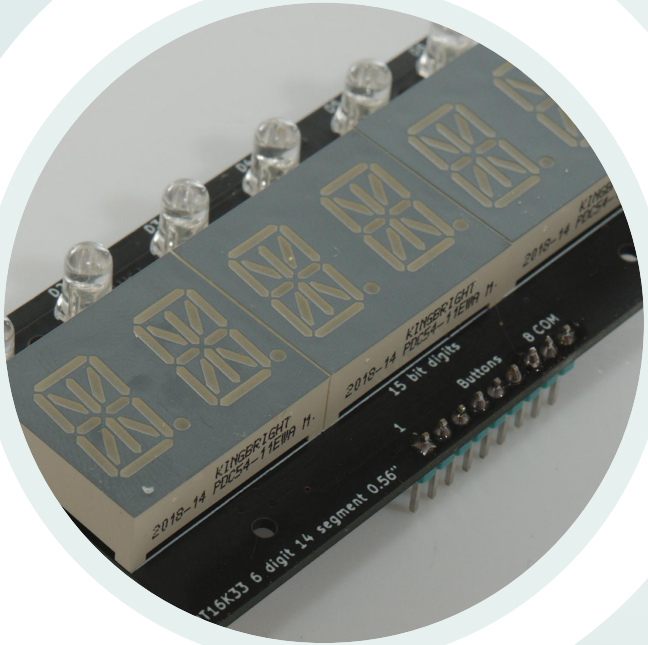
Display Types

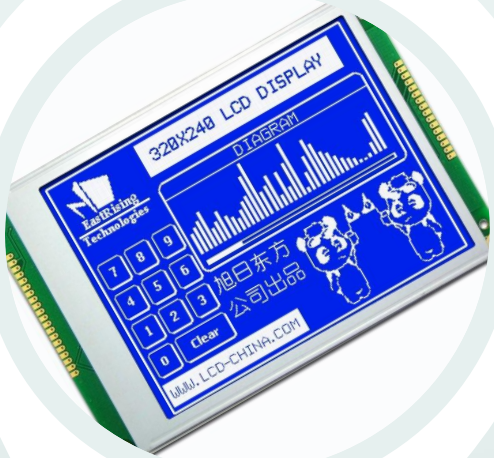
Segments Display



Character Display

Dot Matrix Display

Graphical Display



Colored Display

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Liquid Crystal Display

A bit of History

The American inventor J. Fergason created the first working liquid crystal display in 1970. Before that, such devices consumed too much energy, their operating life was limited, and the contrast of the image was on a low level. A new LCD monitor was introduced in 1971. Despite the fact that liquid crystals were discovered a long time ago, at first, they were applied for different purposes. Molecules of liquid crystals under the influence of electricity can change their orientation and, as a result, change the properties of the light beam passing through them. Based on this discovery and because of further research, it became possible to discover a connection between the increase of electric voltage and the change in the orientation of the crystal molecules to ensure the creation of the image. Firstly, liquid crystals found their application in the displays for calculators and quartz watches, and then they were utilized in monitors. Today, due to progress in this area, such screens have become very popular in desktop computers and many other devices.

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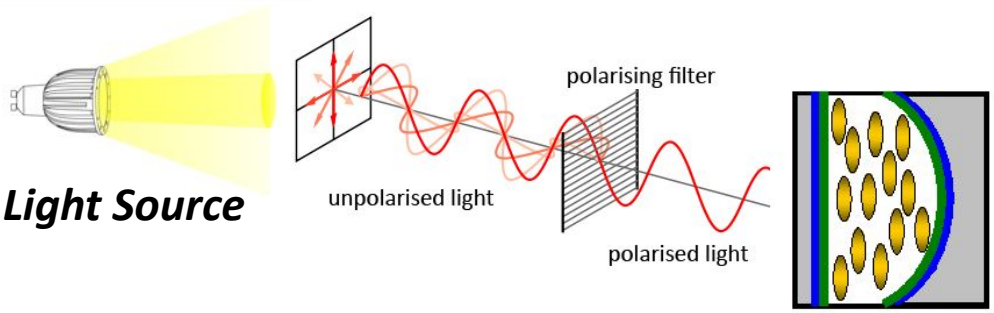
Liquid Crystal Display

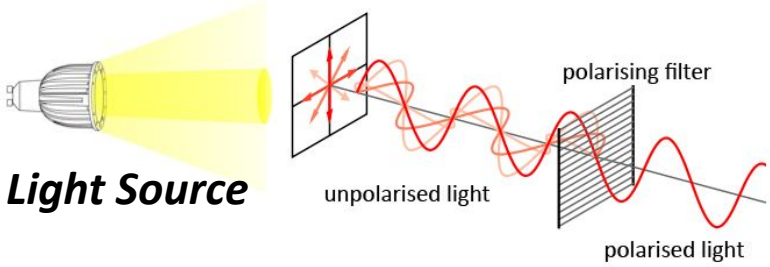


Light Source

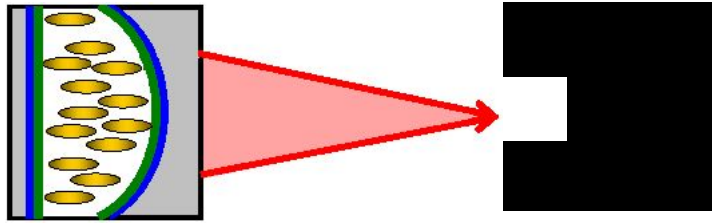
Liquid Crystal
Vertical Position

No Passing Light

Black Screen



Light Source



Liquid Crystal
Horizontal Position

White Pixel

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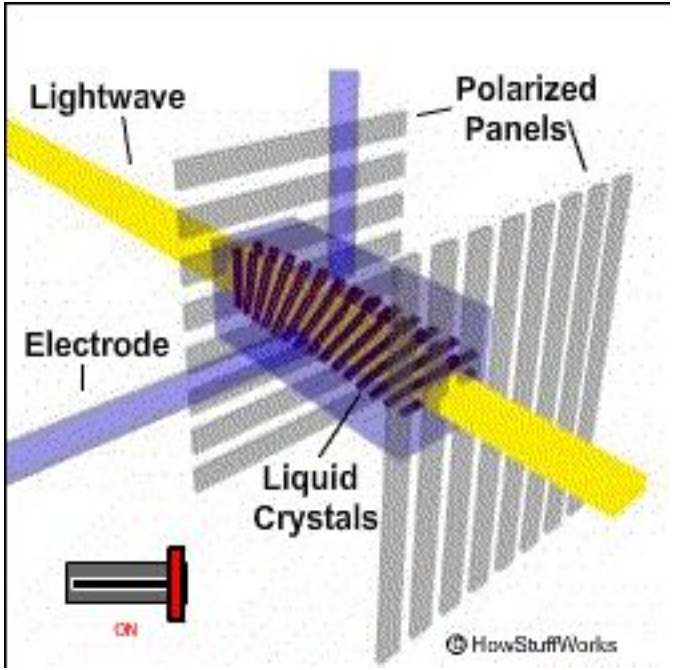
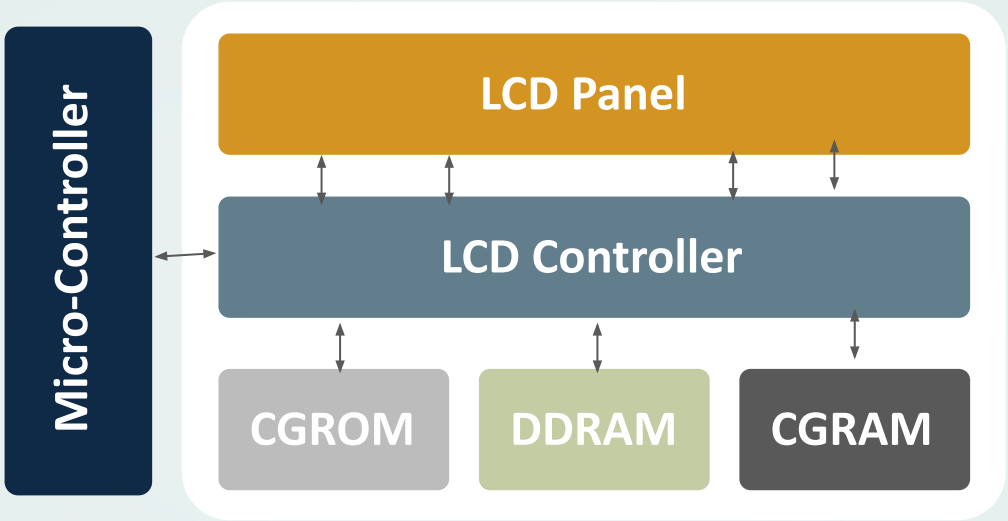
Liquid Crystal Display

LCD screens are an array of small segments called pixels, which can be manipulated for information displaying. Such displays have several layers, where two panels, made of glass material free of sodium and called substrate, play a crucial role. The substrate contains a thin layer of liquid crystals between them. The panels have flutes that direct the crystals, giving them a distinctive orientation. Flutes are parallel on each panel but are perpendicular between the two of them. Longitudinal flutes are obtained as a result of placing on the glass surface thin films of transparent plastic, which are then processed in a particular way. In contact with the flutes, the molecules are oriented identically in all the cells. The liquid crystal panel is illuminated by a light source, depending on where it is located, as the LCD panels operate on reflection or light transmission. The plane of polarization of the light beam is rotated by 90° as one panel passes. When an electric field appears, the molecules are partially aligned along it, and the angle of rotation of the plane of polarization of light becomes different from 90°. By producing screens using LCD monitor technology, the backlight of the monitor is used to output a color image so that light is generated at the back of the LCD monitors. It is necessary to be able to have a picture with good quality, even if it is dark. The color is obtained using three filters, which distinguish three principal components from the radiation of a white light source. By combining the three primary colors for each pixel of the screen, you can reproduce any color.



LCD Block Diagram

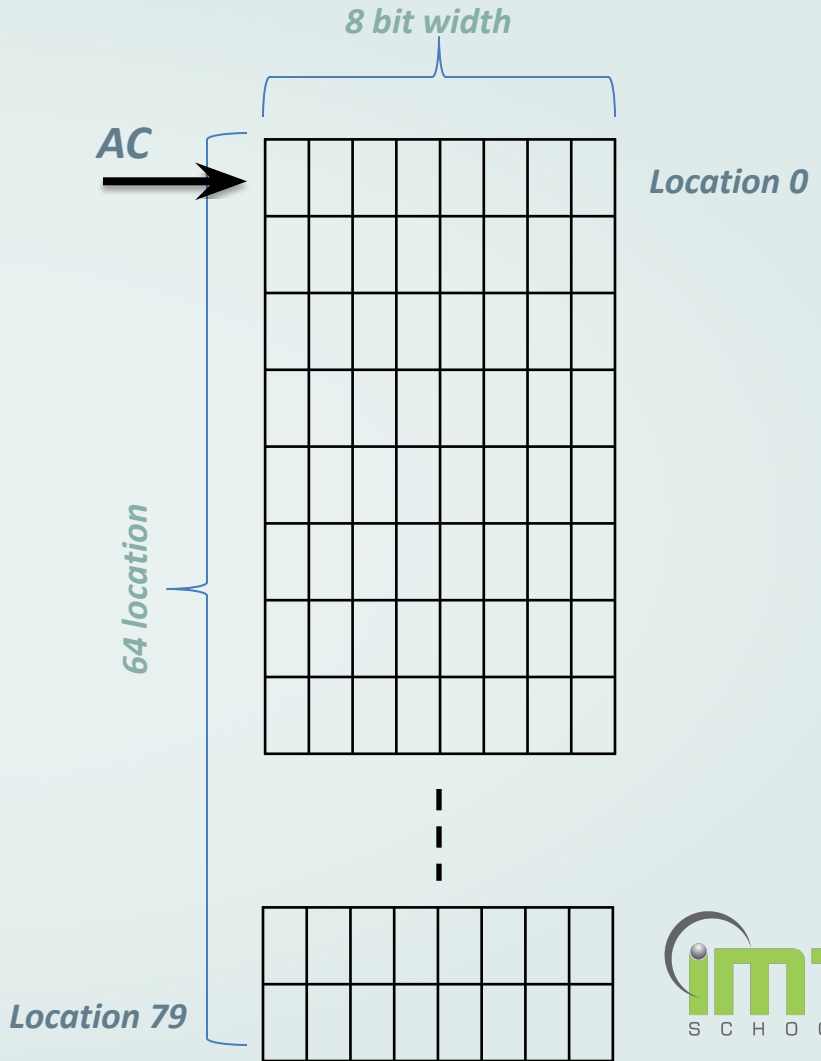


DDRAM: Display Data RAM
CGROM: Character Generator ROM
CGRAM: Character Generator RAM

Display Data Ram

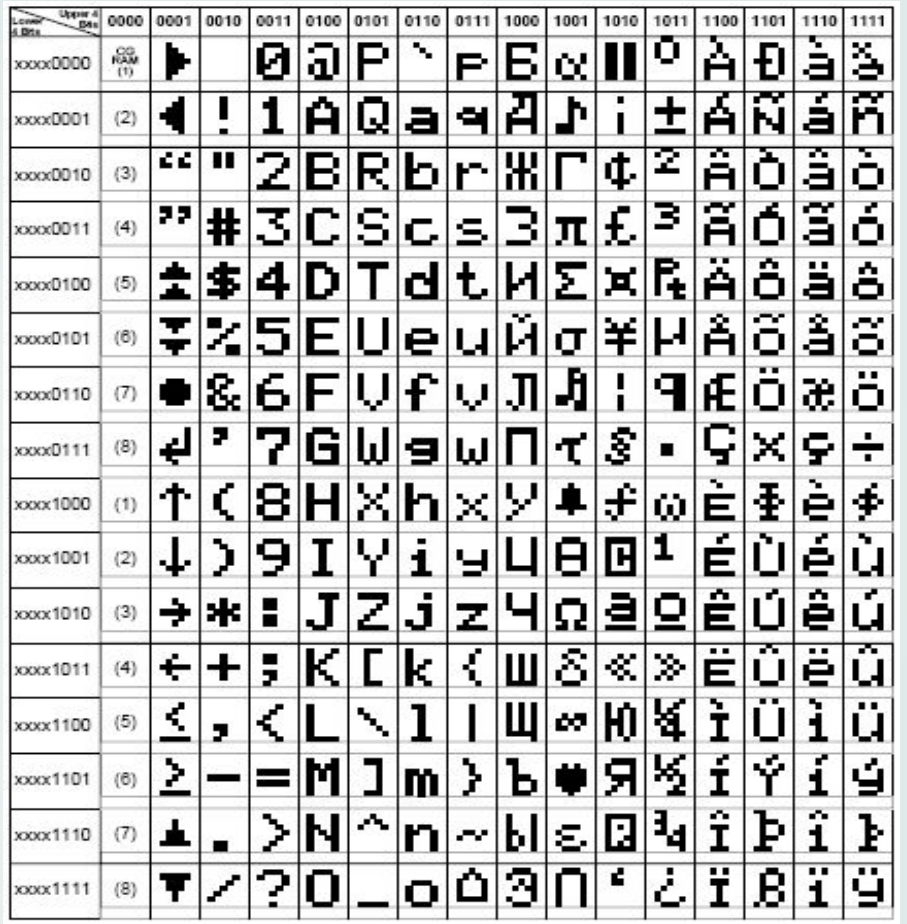
The Display Data RAM ***(DDRAM)*** stores the display data represented in 8-bit character code. ***Each location*** in the DDRAM corresponding to a ***character*** in the LCD panel. The DDARM capacity is 80 locations each is 8 bit. Unused locations can be used as General RAM.

The ***Address Counter*** (AC) points to the address to be written. The AC is auto incremented or decremented after each write operation.



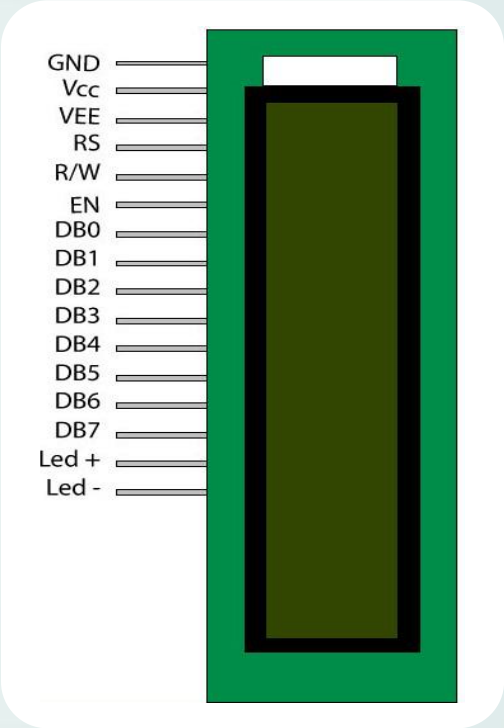
Character Generating Rom

CGROM saves a predefined patterns for characters. Each character has a ***8 bit*** address in the CGROM. When this address is written to the a certain location of DDRAM, the corresponding pattern from the CGROM is displayed on the corresponding character on the LCD panel.



16 * 2 LCD Pinout

Pin No.	Name	Description
1	VSS	GND
2	VCC	+5V
3	VEE	Contrast adjust
4	RS	0 = Command register 1 = Data register
5	R/W	0 = Write to LCD module 1 = Read from LCD module
6	EN	Enable
7	D0	Data bus line 0 (LSB)
8	D1	Data bus line 1
9	D2	Data bus line 2
10	D3	Data bus line 3
11	D4	Data bus line 4
12	D5	Data bus line 5
13	D6	Data bus line 6
14	D7	Data bus line 7 (MSB)

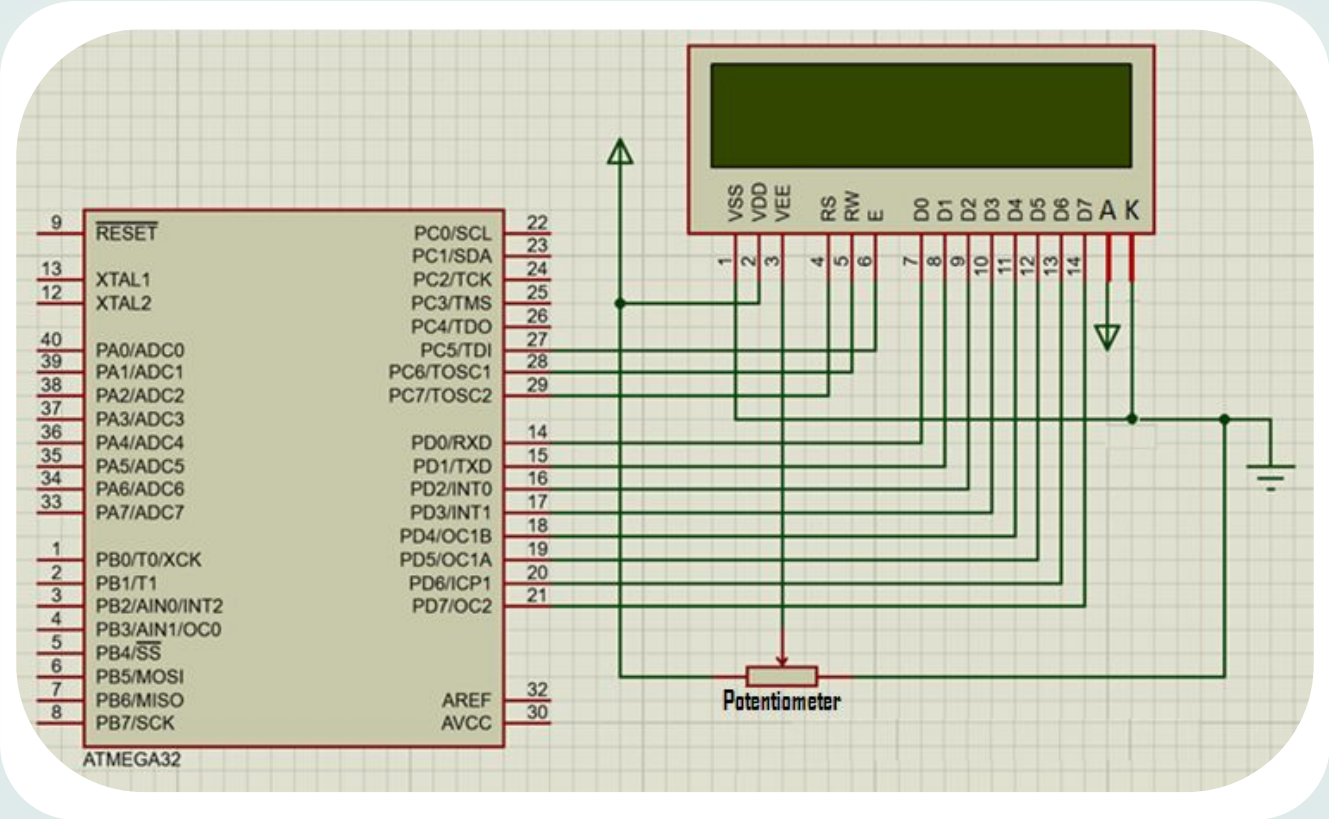


- Pins[RS,R/W,EN] Control Lines.
- Pins[D0:D7] Data Lines.

Watch out

Don't swap power pins to avoid damaging your LCD.

Hardware Connections



16 * 2 LCD DDRAM Map

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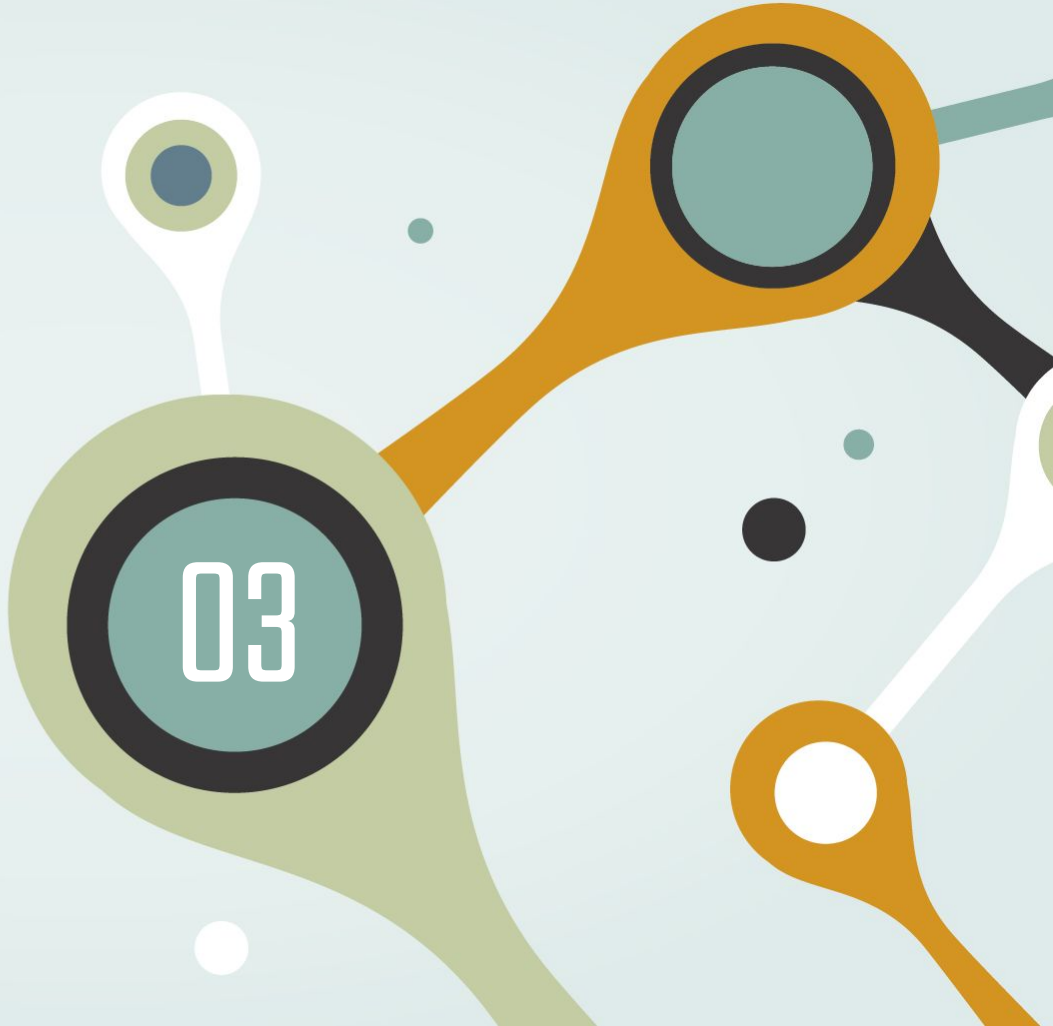
LCD Implementation

03



Software Implementation

Write command

- To send command to the LCD.

Initialization

- To initialize the LCD to be able to write on it.

Write Data

- To write a character on LCD.

Write Command Steps

Reset (RS&RW)pins.

Send command through data port.

Set the (E) pin for a period defined in datasheet (1ms is working) then reset it.

Instruction	Code RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Description	Execution Time (max) (when f_{cp} or f_{osc} is 270 kHz)
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	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 µs
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 µs
Cursor or display shift	0	0	0	0	0	1	S/C	R/L	—	—	Moves cursor and shifts display without changing DDRAM contents.	37 µs
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 µs
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 µs
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 µs
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 µs
Write data to CG or DDRAM	1	0	Write data								Writes data into DDRAM or CGRAM.	37 µs t_{ADD} = 4 µs*
Read data from CG or DDRAM	1	1	Read data								Reads data from DDRAM or CGRAM.	37 µs t_{ADD} = 4 µs*
	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 × 10 dots, F = 0: 5 × 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_{cp} or f_{OSC} is 250 kHz, $37\ \mu s \times \frac{270}{250} = 40\ \mu s$

Note: — indicates no effect.

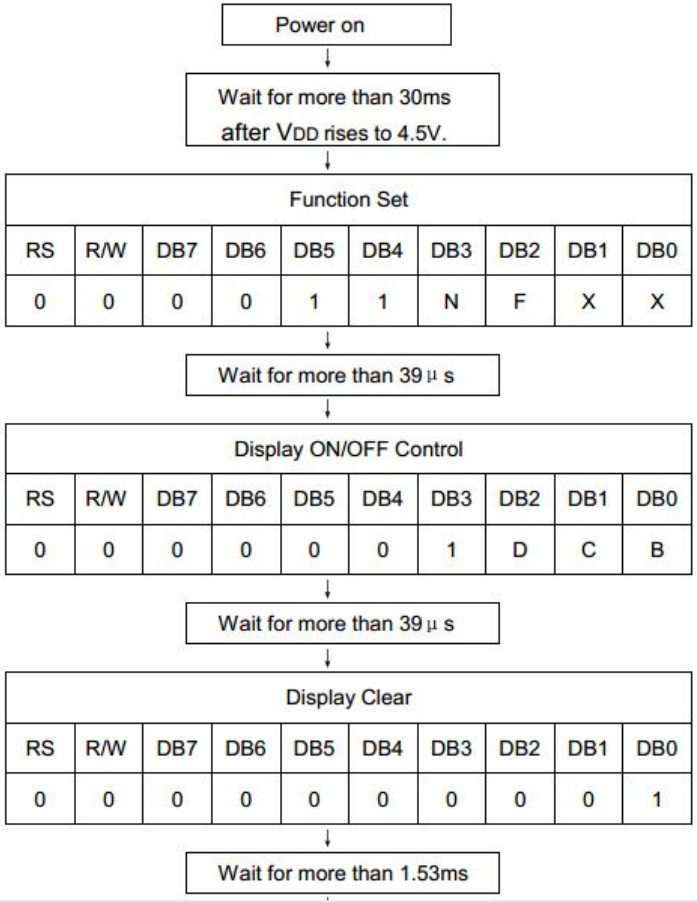
Write Data Steps

Set RS and Reset RW pins.

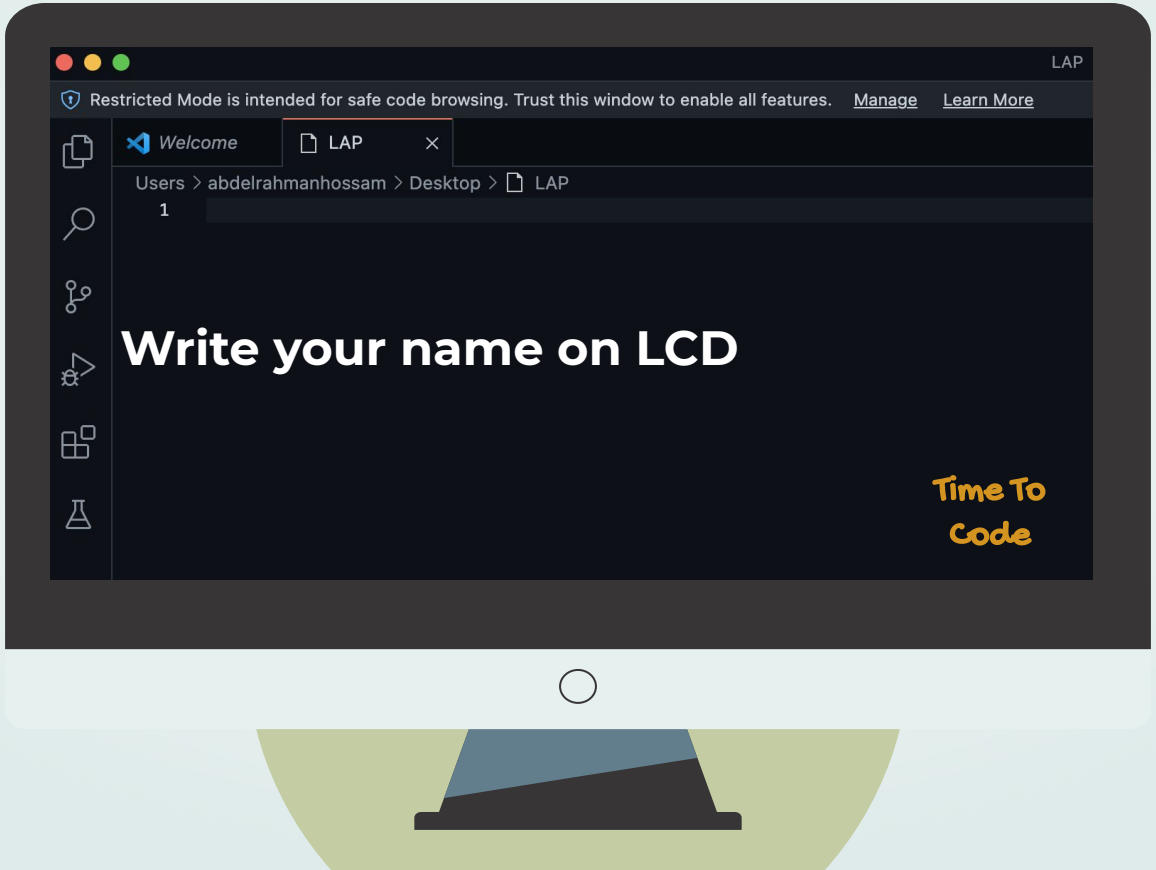
Send command through data port.

Set the (E) pin for a period defined in datasheet (1ms is working) then reset it.

Initialization Steps



LAb 1



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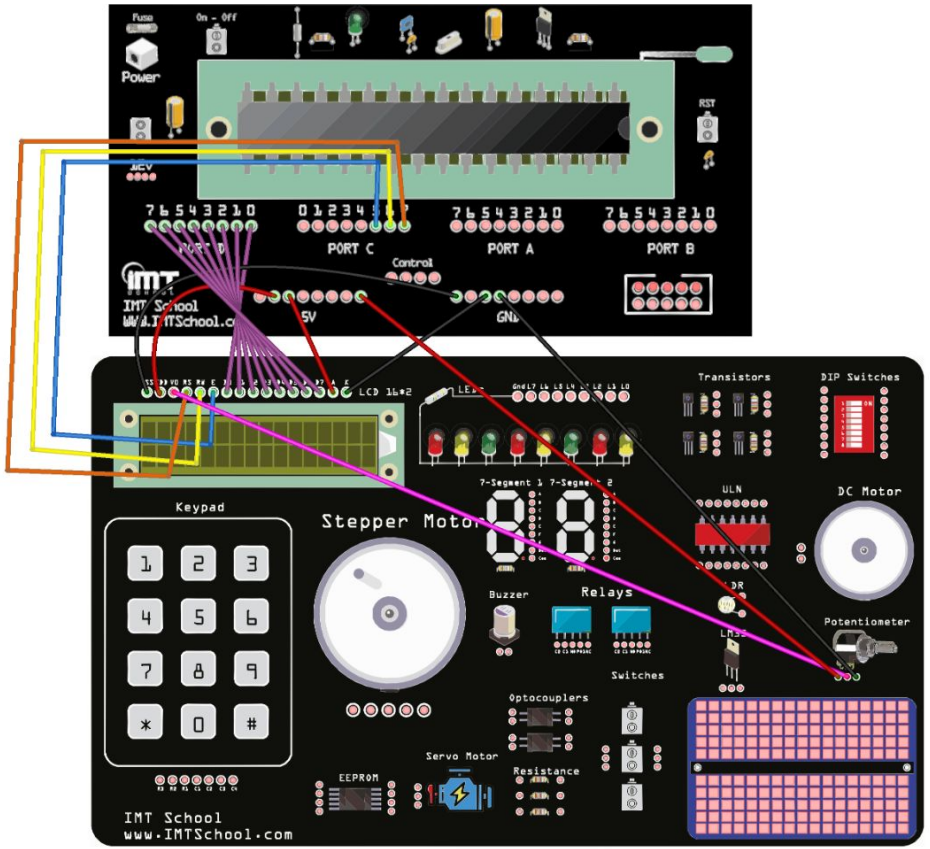
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Power
RST
JCV
PORT D
PORT C
PORT A
PORT B
Control
5V
GND
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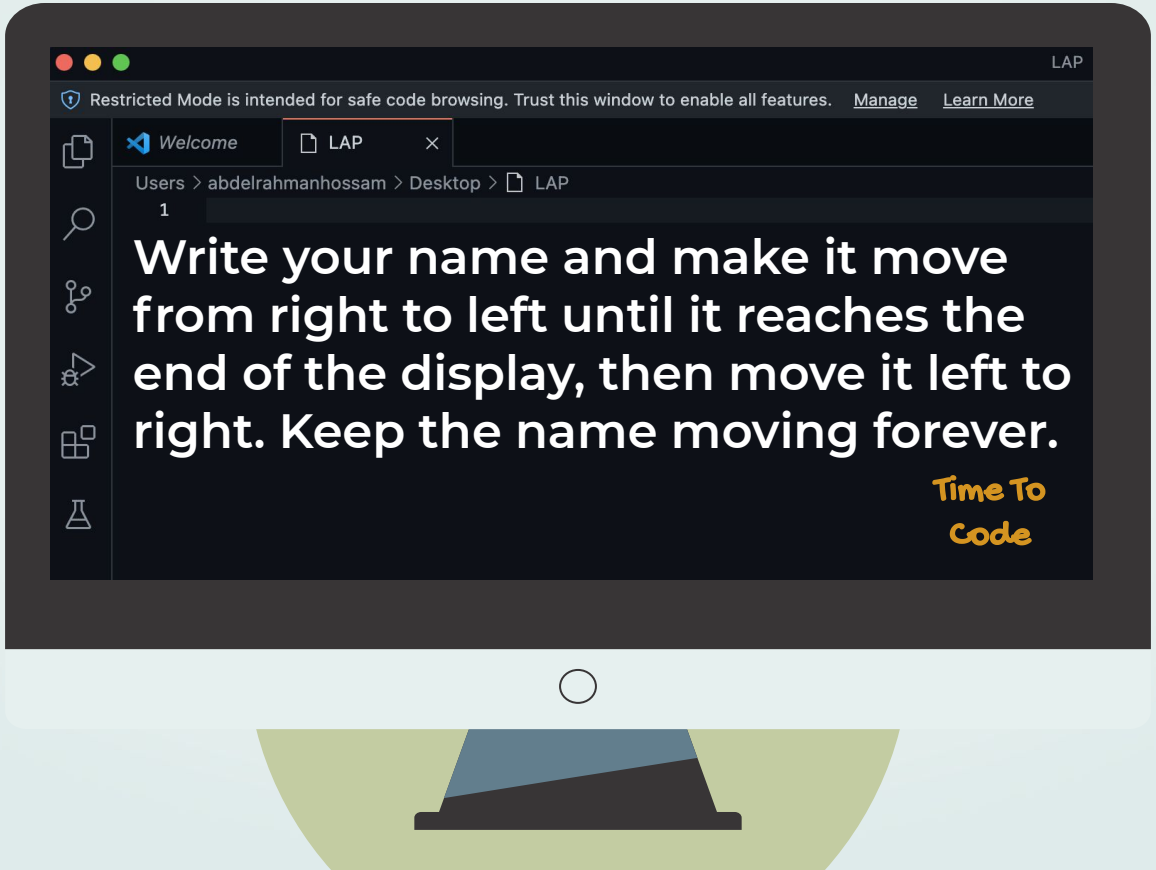
LAb 2



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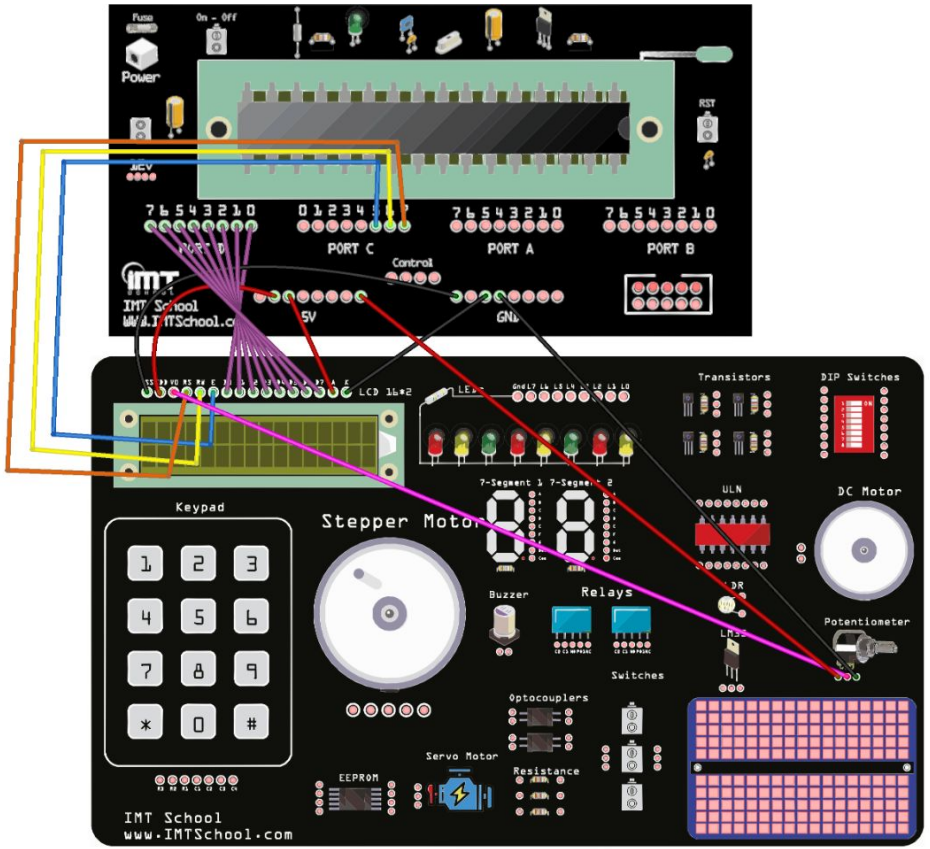
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The End

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Assignments

Talk is cheap
show me the Code

- Linus Torvalds

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Assignment 1

Write your name moving in sinusoidal wave on the LCD

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