Embedded Systems Interfacing

Lecture 3

Character LCD interfacing
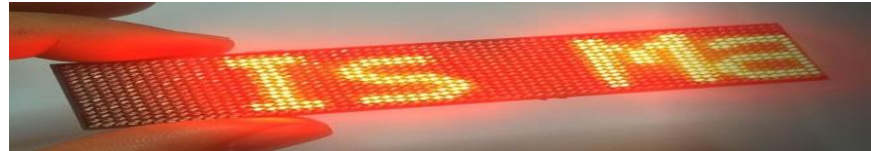
Display Types

Segments Display

7-segment   14-segment   16-segment

Dot matrix Display

Character Display

Graphical Display

Colored Display

Liquid Crystal Display

Light Source

unpolarised light

polarising filter

polarised light

Liquid Crystal
Vertical Position

No Passing Light

Black Screen

Light Source

unpolarised light

polarising filter

polarised light

Liquid Crystal
Horizontal Position

White Pixel
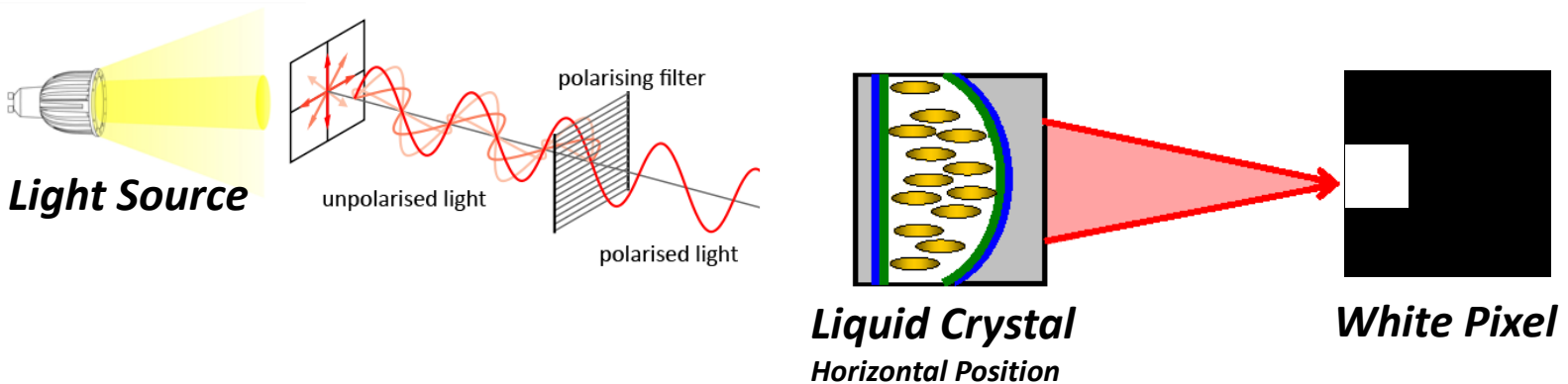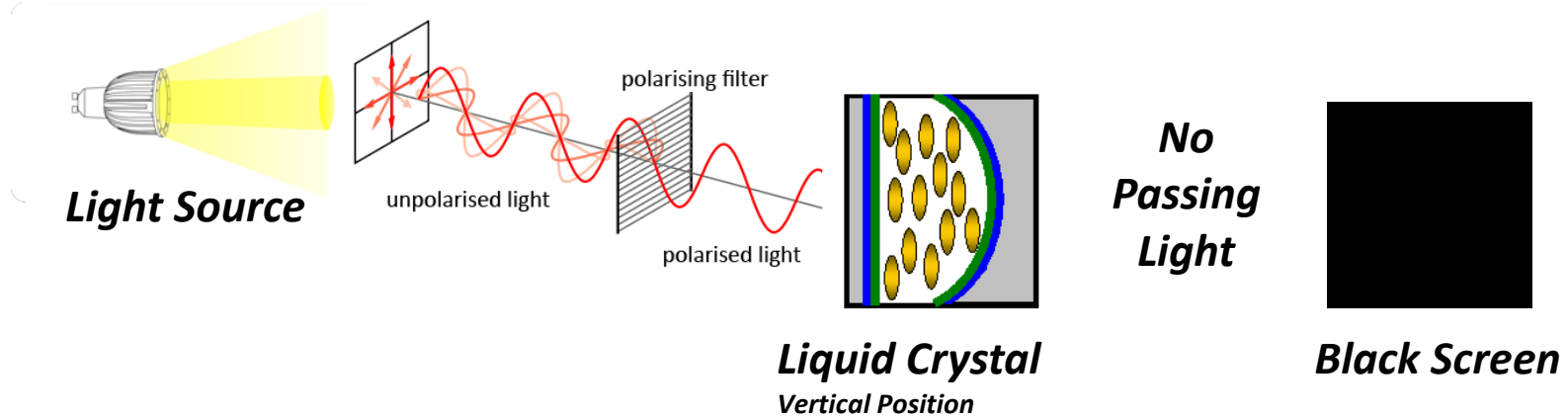
Character LCD Block diagram

LCD Panel

Microcontroller

LCD Controller
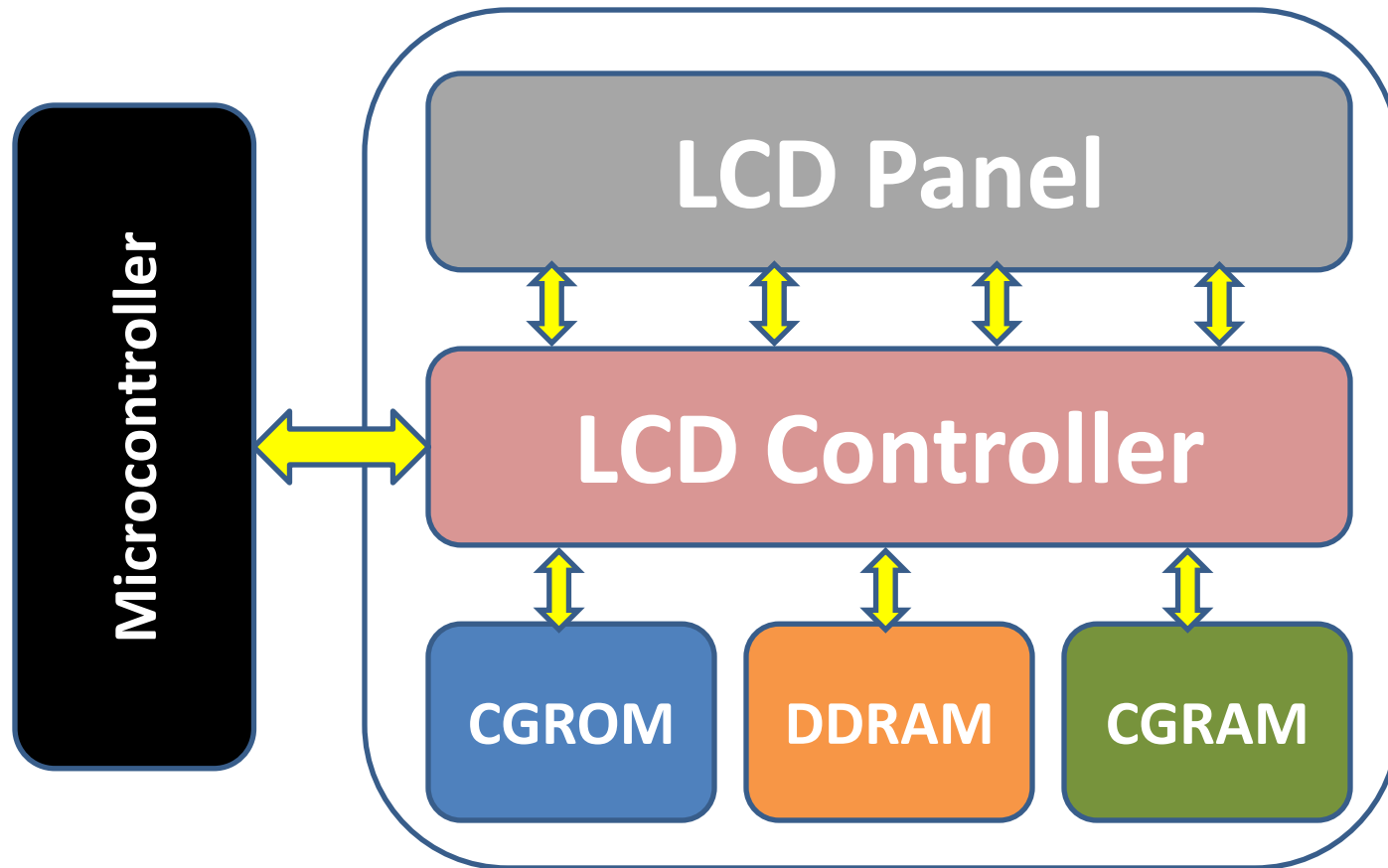
CGROM

DDRAM

CGRAM

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.

AC

8 bit width

64 location
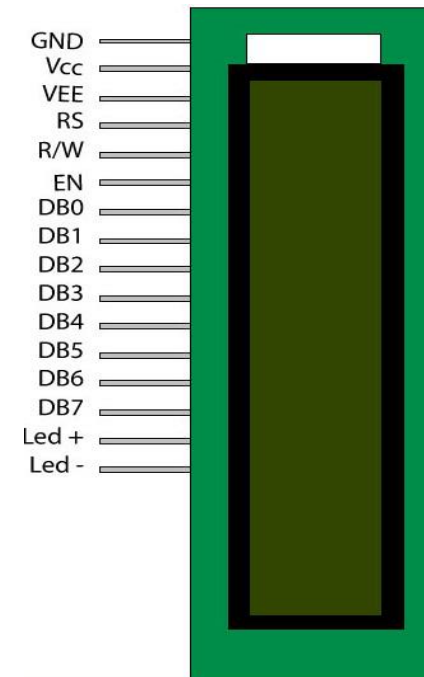
Location 0
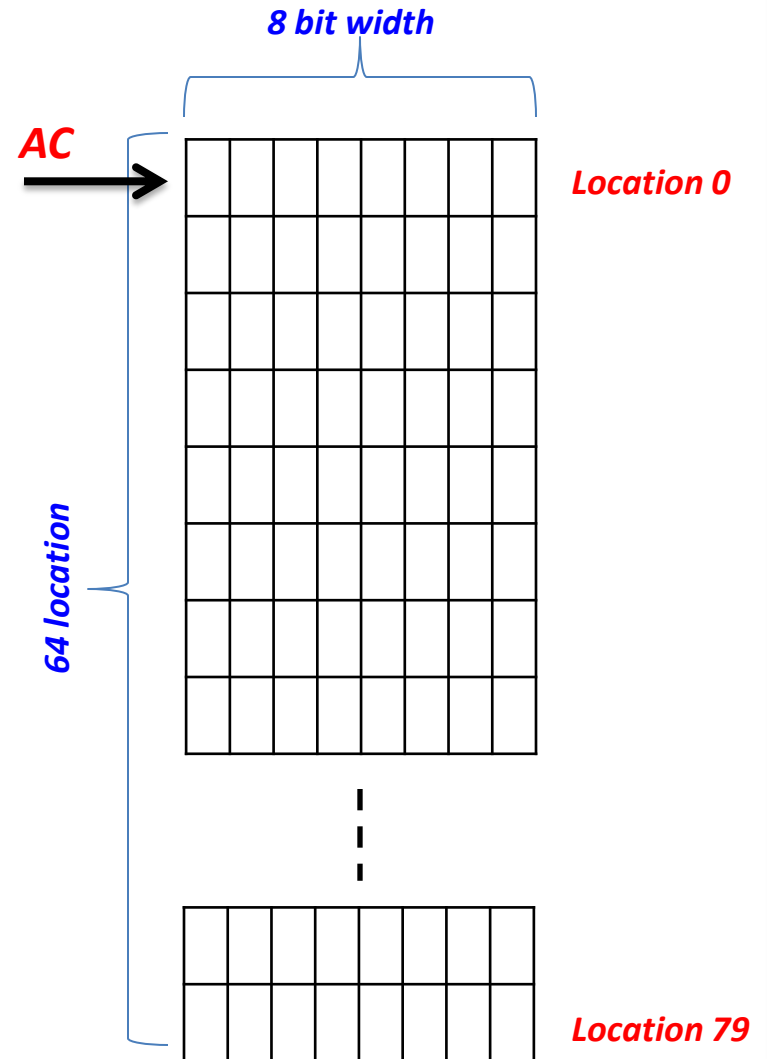
Location 79

Character Generator 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.

16X2 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)

GND
Vcc
VEE
RS
R/W
EN
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
Led +
Led -

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

Take Care:

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

Hardware connection

2x16 LCD Schematic :

16x2 LCD DDRAM Map

Row 0
Character 0

Row 0
Character 15

DDRAM
addresses in
Hexadecimal

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

Row 1
Character 0

Row 1
Character 15

IMT
SCHOOL
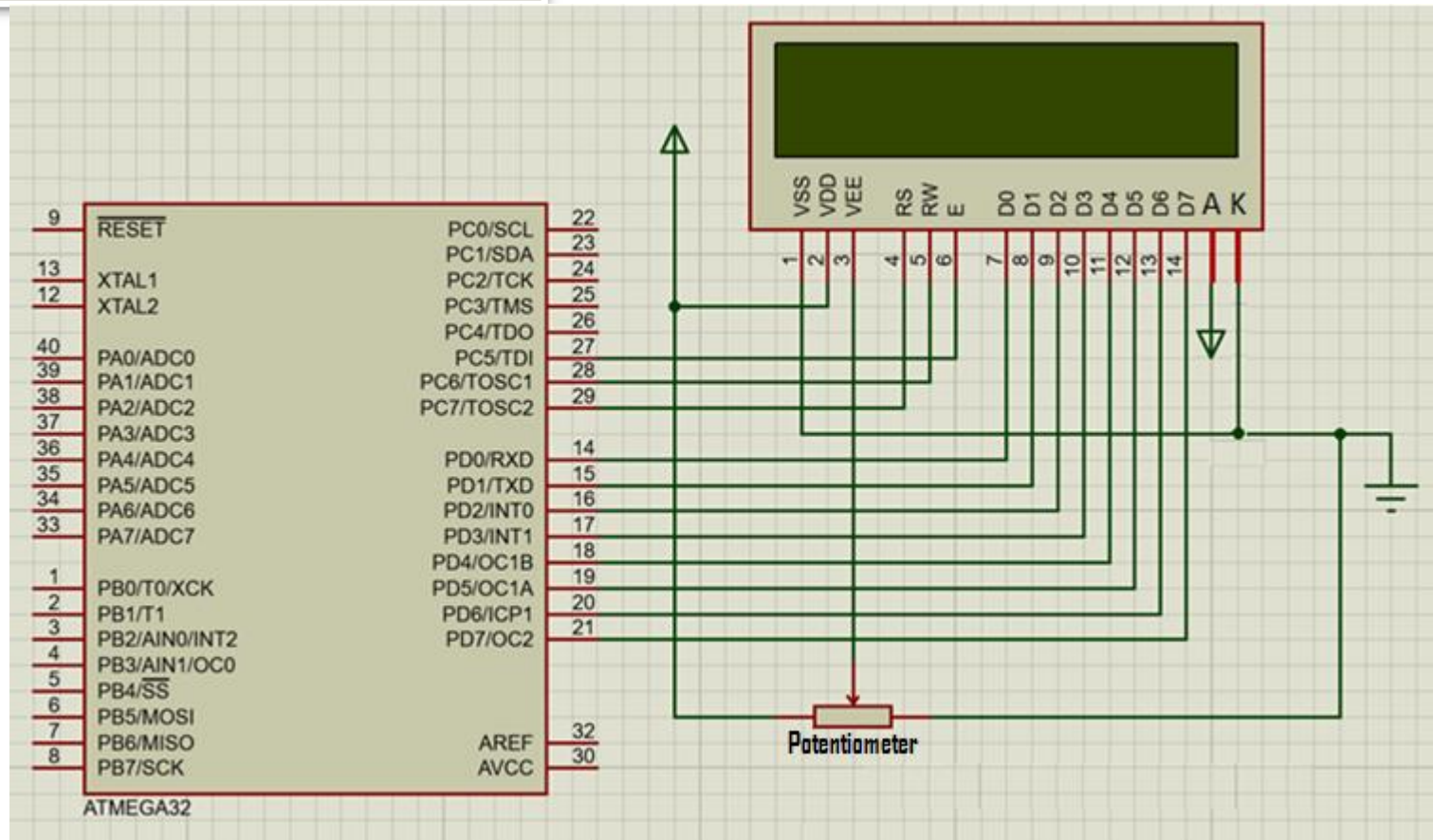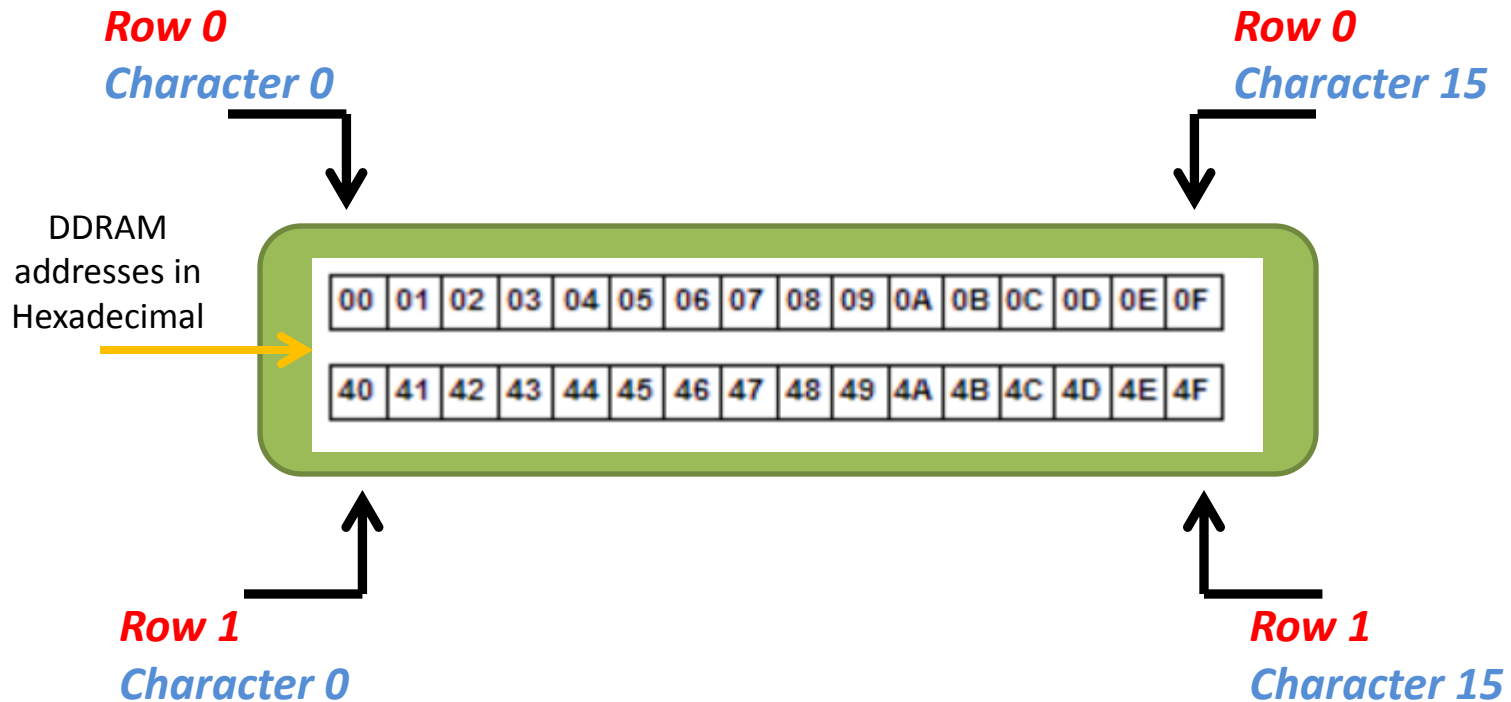
Software Implementation

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.

16x2 LCD Commands

Instruction	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Description	Execution Time (max) (when f_{op} or f_{osc} is 270 kHz)
						Code						
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,
$37 \text{ μs} \times \frac{270}{250} = 40 \text{ μs}$

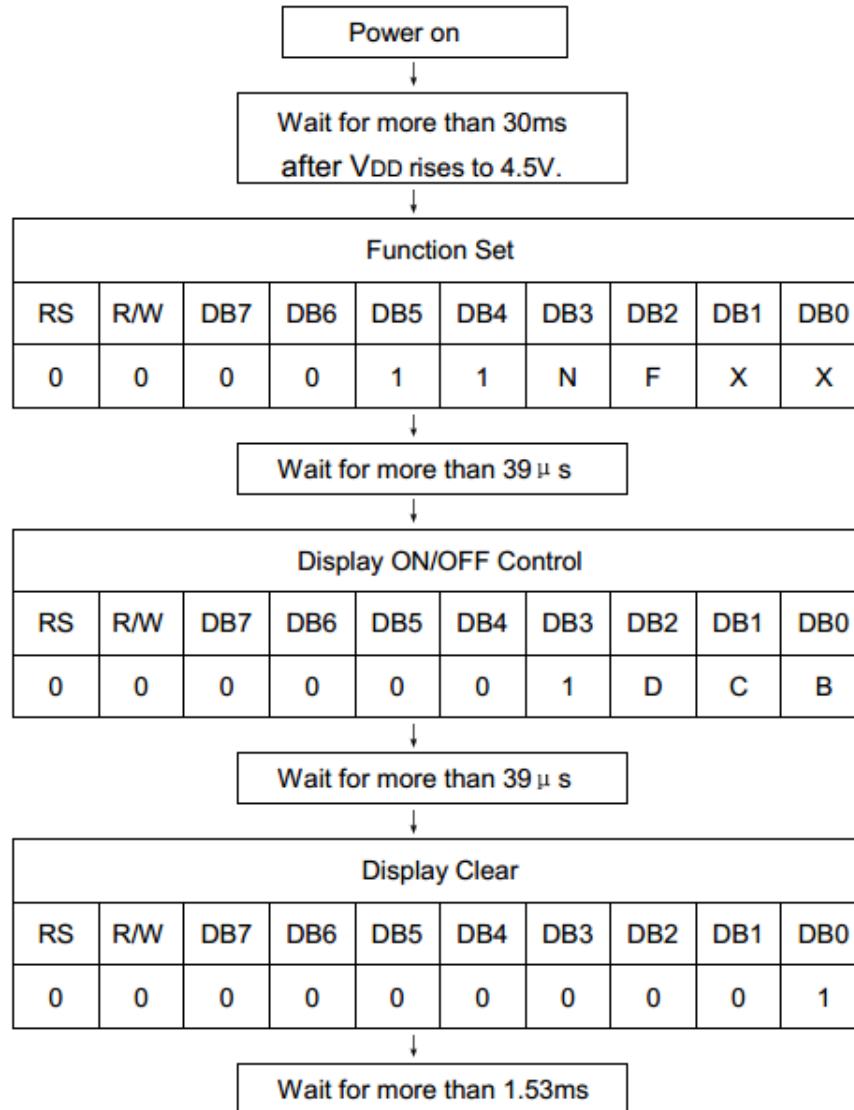Note: — indicates no effect.

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.
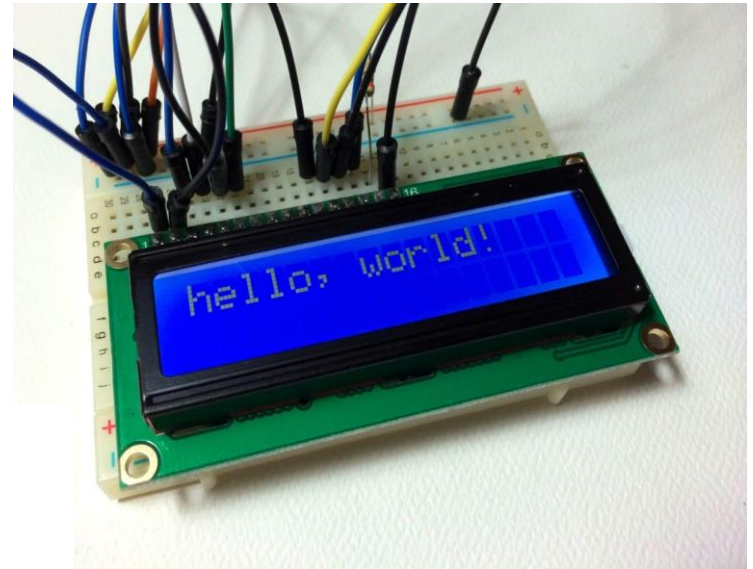
Initialization Steps

Power on

↓

Wait for more than 30ms after V_{DD} rises to 4.5V.

↓

Function Set

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	1	N	F	X	X

↓

Wait for more than 39 μs

↓

Display ON/OFF Control

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	1	D	C	B

↓

Wait for more than 39 μs

↓

Display Clear

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	0	0	0	1

↓

Wait for more than 1.53ms

Description :

Write your name on LCD.

Description :

Write your name and make it move from right to left until it reaches the end of the display, then move it left to right. Keep the name moving forever.

Any questions … ?

Write your name moving in sinusoidal wave on the LCD

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