



Embedded Systems Interfacing

Lecture 3

Character LCD interfacing

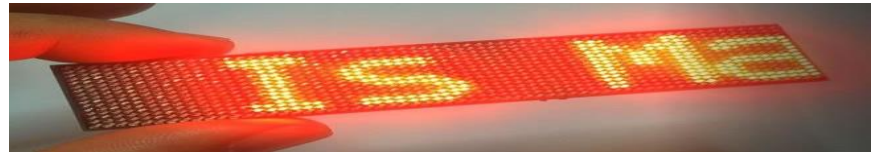
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Display Types

Segments Display



Dot matrix Display



Character Display



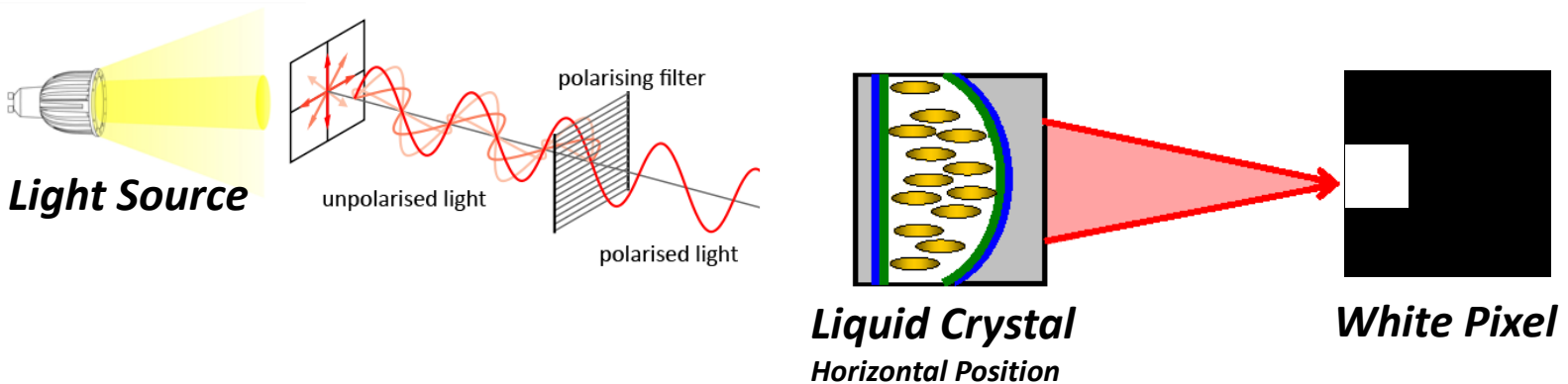
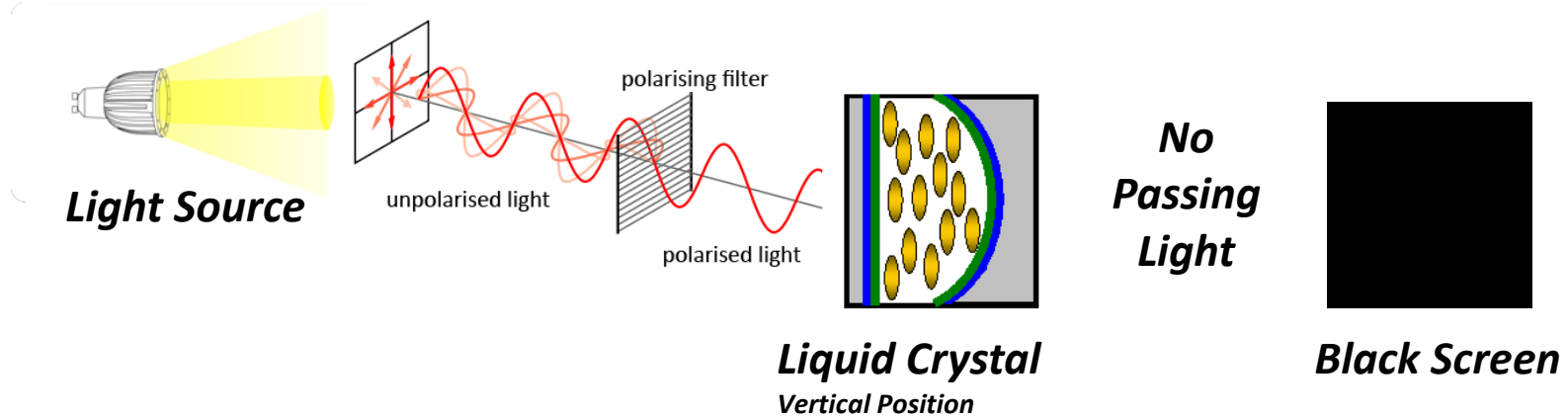
Graphical Display



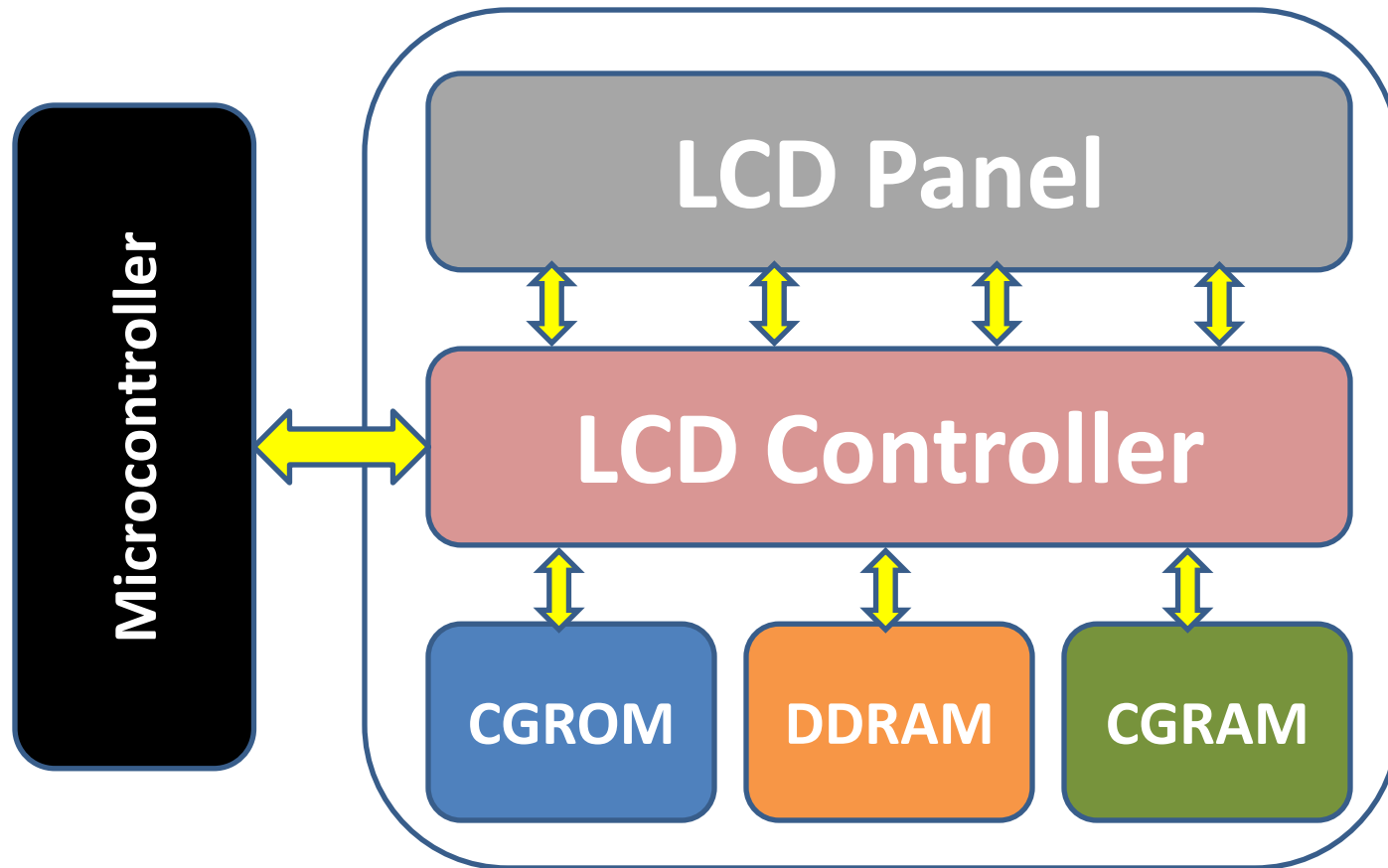
Colored Display



Liquid Crystal Display



Character LCD Block diagram



DDRAM: Display Data RAM

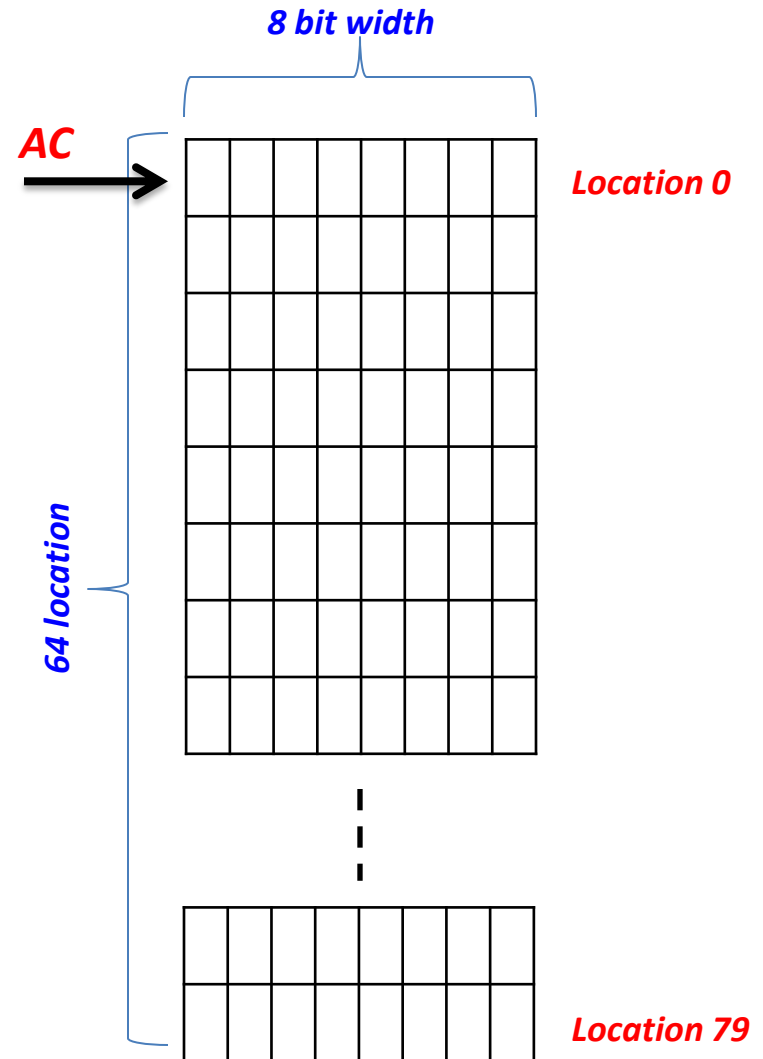
CGROM: Character Generator ROM

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.



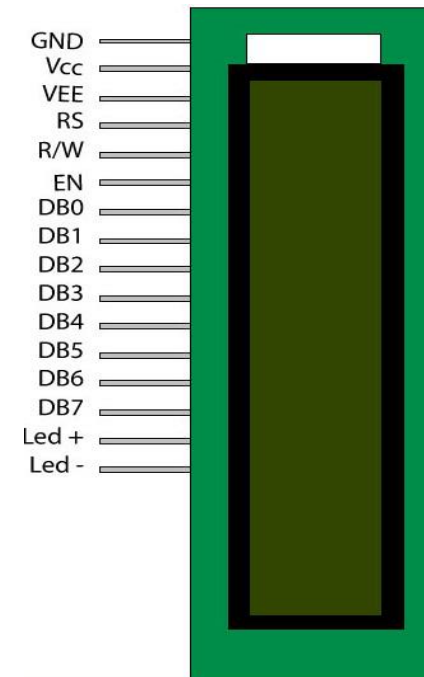
Character Generator ROM

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.

Lower 4 Bits	Upper 4 Bits	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
xxxx0000	CG RAM (1)	▶		0	@	P	`	P	B	α	||	°	À	Ð	á	ÿ	
xxxx0001	(2)	◀	!	1	A	Q	a	q	A	J	i	±	Á	Ñ	ä	ÿ	
xxxx0010	(3)	“	"	2	B	R	b	r	Ж	Г	¢	²	Â	Ò	å	ö	
xxxx0011	(4)	”	#	3	C	S	c	s	З	π	£	³	Ã	Ó	æ	ó	
xxxx0100	(5)	⬆	\$	4	D	T	d	t	И	Σ	¥	₣	Ä	Ô	ç	ô	
xxxx0101	(6)	⬇	%	5	E	U	e	u	Й	σ	¥	₣	Å	Ö	ä	ö	
xxxx0110	(7)	⬅	&	6	F	V	f	v	Ј	Ј	! 9	Æ	Ö	æ	ö		
xxxx0111	(8)	↶	'	7	G	W	w	Π	τ	§	•	Ç	×	ç	÷		
xxxx1000	(1)	↑	(	8	H	X	h	x	У	⬆	ƒ	ω	È	⬆	⬆	
xxxx1001	(2)	↓	)	9	I	Y	i	y	Ч	θ	¹	É	Ù	é	ù	
xxxx1010	(3)	➔	*	:	J	Z	j	z	Ч	Ω	Ω	Ê	Ú	ê	ú		
xxxx1011	(4)	⬅	+	;	K	[k	<	Ш	δ	⊗	⊗	Ë	Û	ë	Ü	
xxxx1100	(5)	⬅	,	<	L	\	l	|	Ш	∞	∞	İ	Ü	ı	ü		
xxxx1101	(6)	⬆	-	=	M	]m	>	b	⬆	⬆	⬆	İ	Ÿ	ı	ı	
xxxx1110	(7)	⬆	.	>	N	^n	~	b	⬆	⬆	⬆	İ	Ÿ	ı	ı		
xxxx1111	(8)	⬆	/	?	O	_	o	⬆	⬆	⬆	⬆	İ	Ÿ	ı	ı		

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)



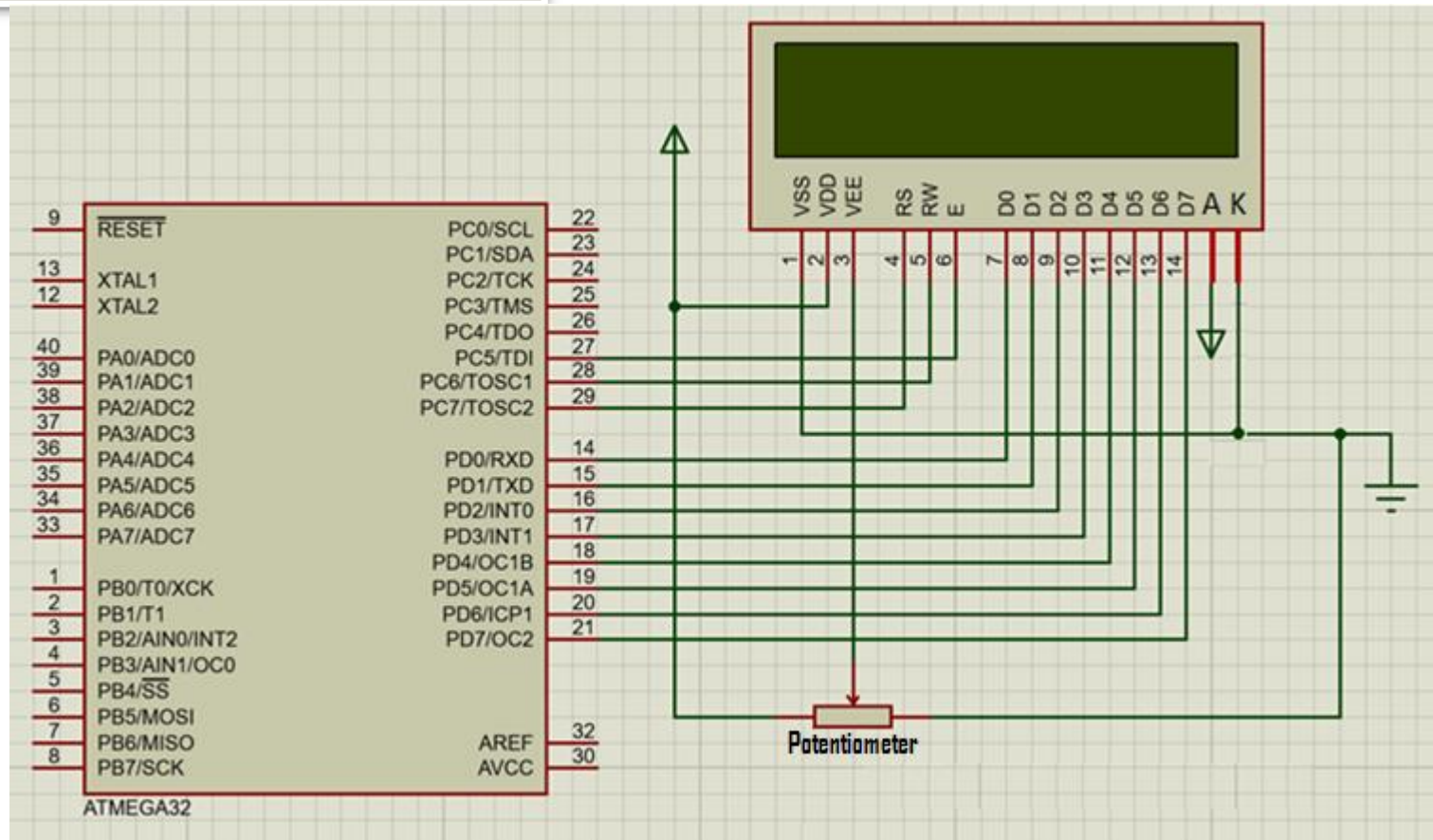
Take Care:

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

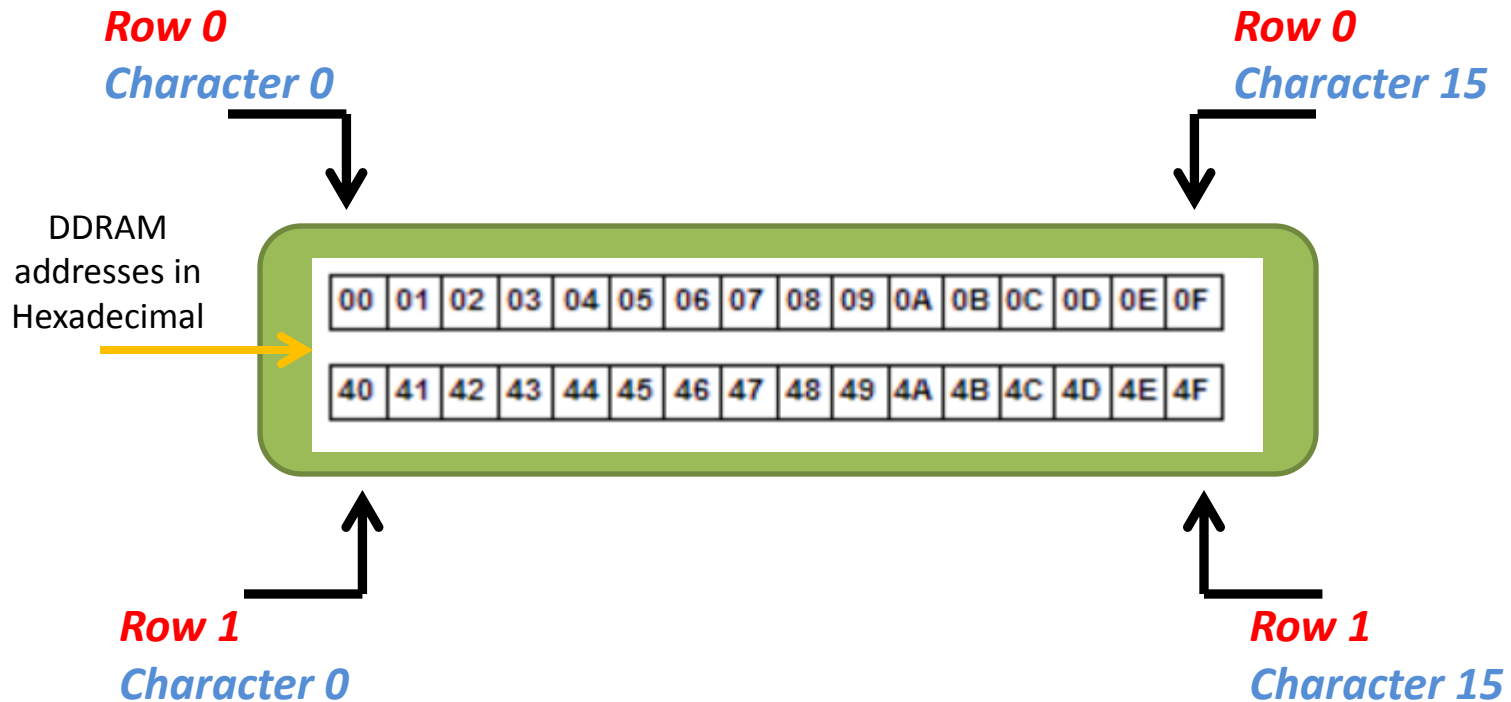
- Pins[RS,R/W,EN] → Control Lines.
- Pins[D0:D7] → Data Lines.

Hardware connection

2x16 LCD Schematic :



16X2 LCD DDRAM Map



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	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.		
Return home	0	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	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	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	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	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 $t_{ADD} = 4 \mu s^*$	
Read data from CG or DDRAM	1	1	Read data								Reads data from DDRAM or CGRAM.	37 μ s $t_{ADD} = 4 \mu s^*$	
	I/D = 1:	Increment								DDRAM: Display data RAM	Execution time changes when frequency changes Example: When f_{op} or f_{osc} is 250 kHz, $37 \mu s \times \frac{270}{250} = 40 \mu s$		
	I/D = 0:	Decrement								CGRAM: Character generator RAM			
	S = 1:	Accompanies display shift								ACG: CGRAM address			
	S/C = 1:	Display shift								ADD: DDRAM address			
	S/C = 0:	Cursor move								(corresponds to cursor address)			
	R/L = 1:	Shift to the right								AC: Address counter used for both DD and CGRAM addresses			
	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 \times 10 dots, F = 0: 5 \times 8 dots											
	BF = 1:	Internally operating											
	BF = 0:	Instructions acceptable											

Note: — indicates no effect.

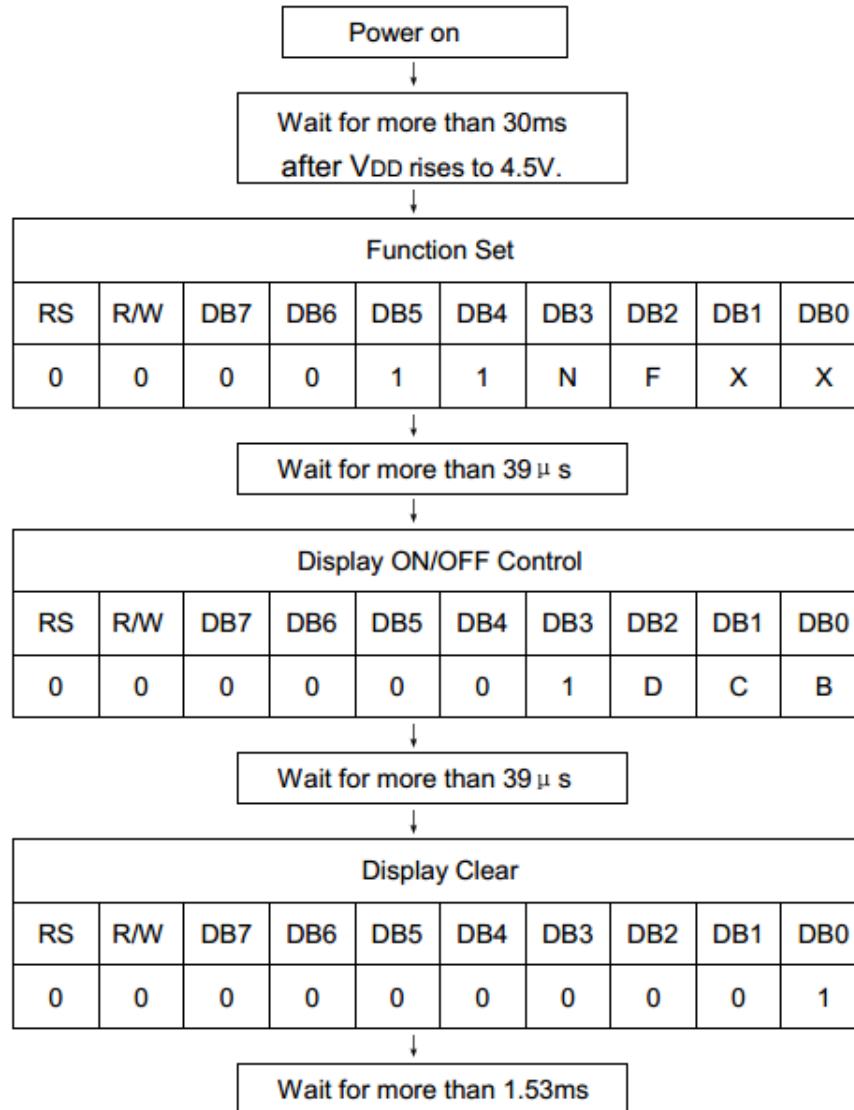
Write Data Steps

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.

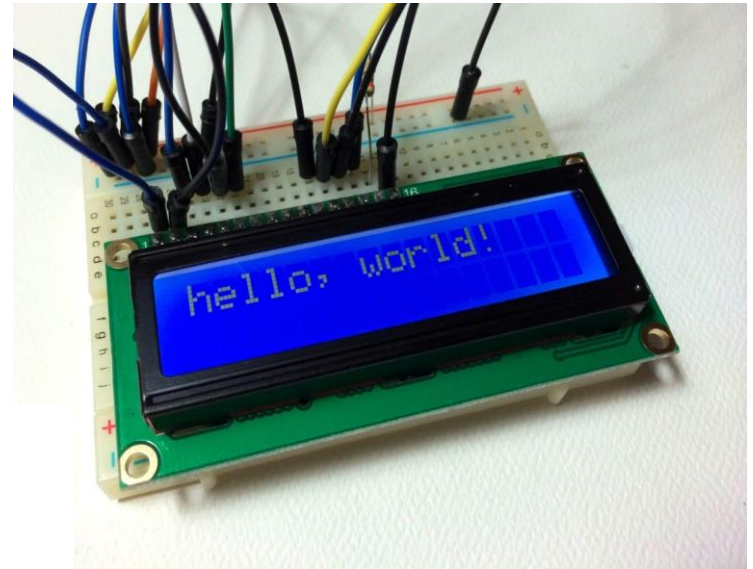
Initialization Steps



Lab 1

Description :

Write your name on LCD.



Lab 2

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.



The End ...



Assignment

Write your name moving in sinusoidal wave on the LCD





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