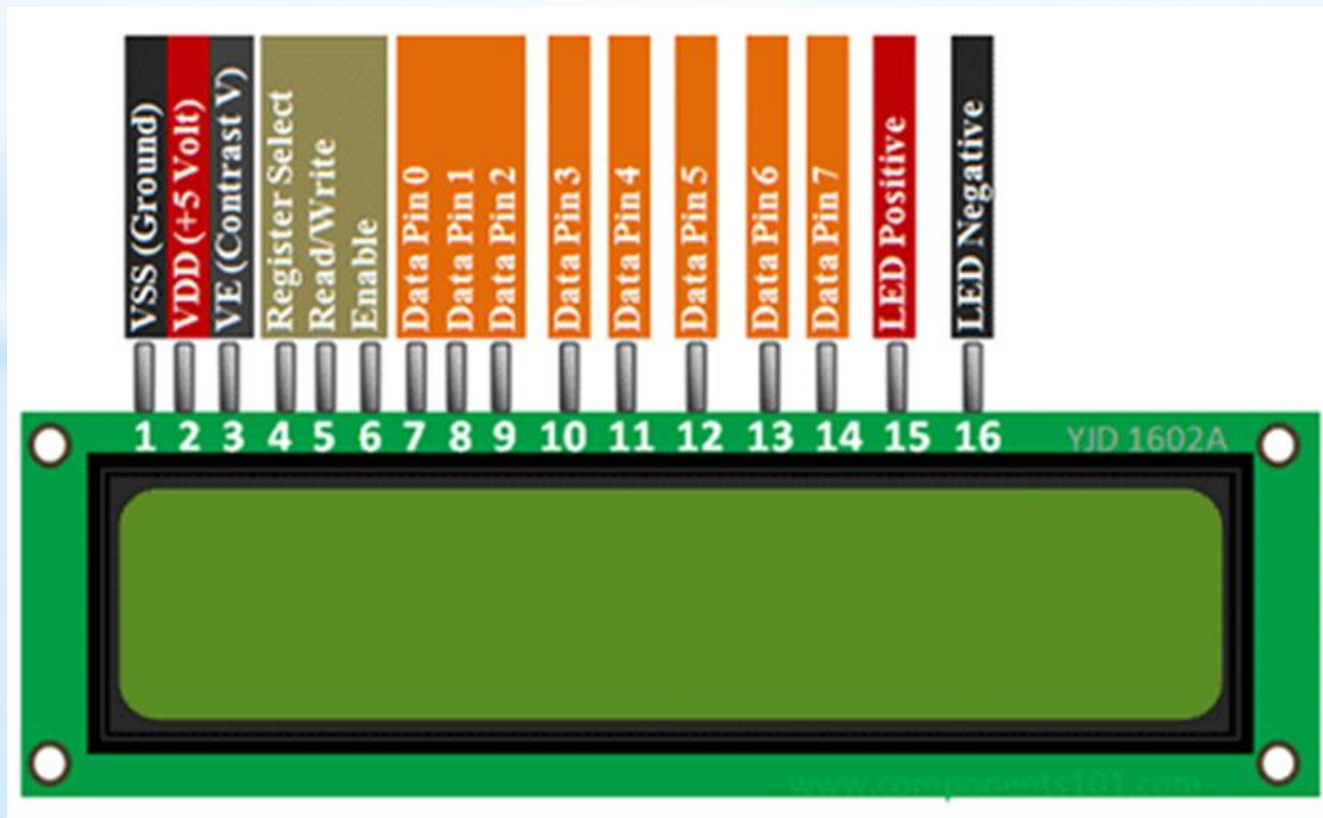
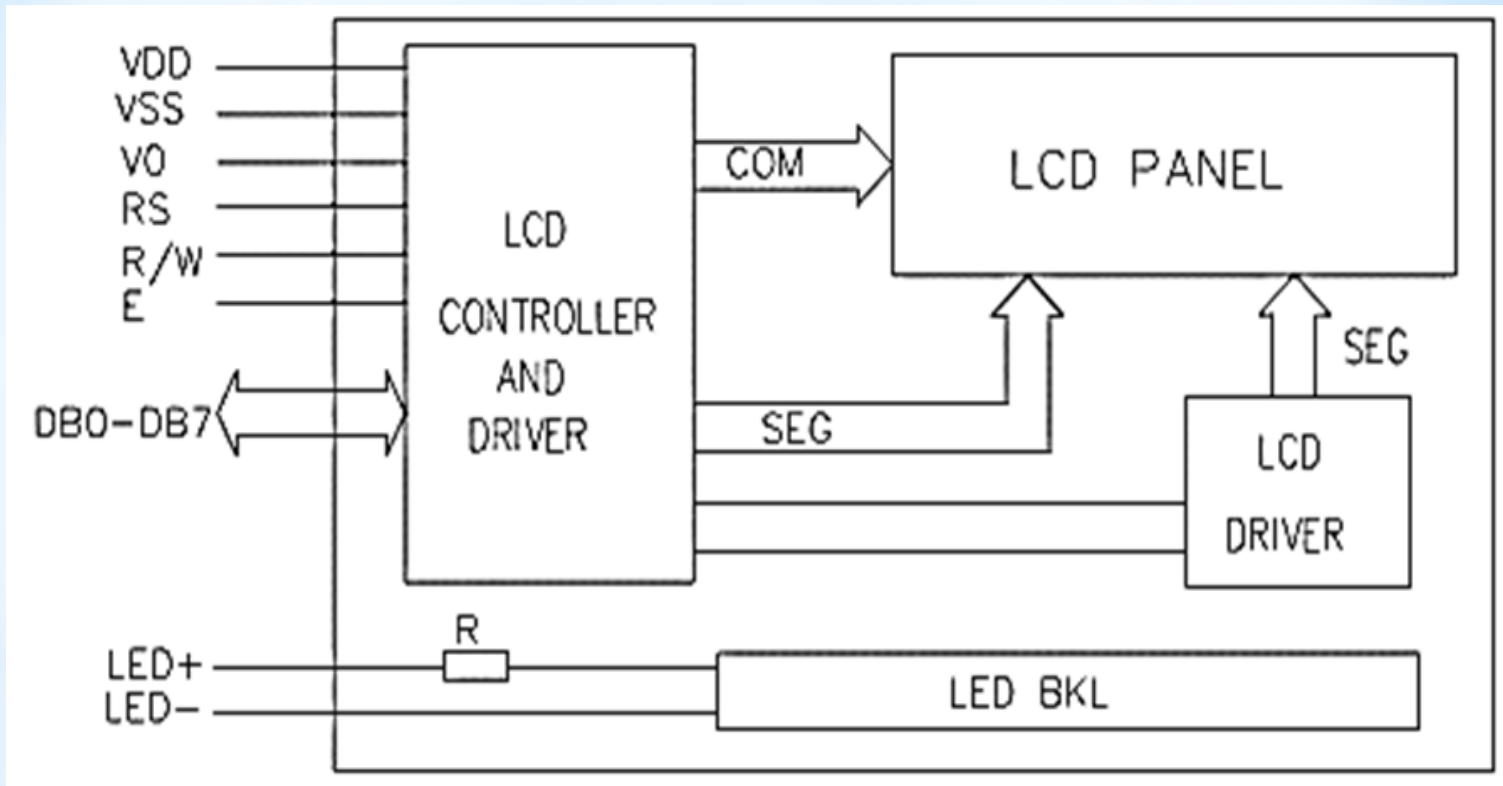


2x16 LCD DISPLAY



- * Διαθέτει οθόνη με 2 σειρές των 16 χαρακτήρων.
- * Κάθε χαρακτήρας έχει διαστάσεις 5x8 pixel
- * 204 χαρακτήρες είναι αποθηκευμένοι στη μνήμη του display .
- * Ένας ενσωματωμένος μικροελεγκτής δέχεται εντολές από εξωτερική συσκευή και διαχειρίζεται την λειτουργία της LCD οθόνης.



Διάγραμμα LCD display

12. Standard character pattern

Upper 4bit Lower 4bit	LLLL	LLLH	LLHL	LLHH	LHLL	LHLH	LHHL	LHHH	HLLL	HLLH	HLHL	HLHH	HHLL	HHLH	HHHL	HHHH
LLLL	CG RAM (1)			0	1	2	3	4	5	6	7	8	9	A	B	C
LLLH	(2)	!	"	#	\$	%	&	'	()	*	+	,	-	.	/
LLHL	(3)	"	#	\$	%	&	'	(	)	*	+	,	-	.	/	0
LLHH	(4)	#	\$	%	&	'	(	)	*	+	,	-	.	/	0	1
LHLL	(5)	\$	%	&	'	(	)	*	+	,	-	.	/	0	1	2
LHLH	(6)	%	&	'	(	)	*	+	,	-	.	/	0	1	2	3
LHHL	(7)	&	'	(	)	*	+	,	-	.	/	0	1	2	3	4
LHHH	(8)	'	(	)	*	+	,	-	.	/	0	1	2	3	4	5
HLLL	(1)	(	)	*	+	,	-	.	/	0	1	2	3	4	5	6
HLLH	(2)	)	*	+	,	-	.	/	0	1	2	3	4	5	6	7
HLHL	(3)	*	+	,	-	.	/	0	1	2	3	4	5	6	7	8
HLHH	(4)	+	,	-	.	/	0	1	2	3	4	5	6	7	8	9
HHLL	(5)	,	-	.	/	0	1	2	3	4	5	6	7	8	9	A
HHLH	(6)	-	.	/	0	1	2	3	4	5	6	7	8	9	A	B
HHHL	(7)	.	/	0	1	2	3	4	5	6	7	8	9	A	B	C
HHHH	(8)	/	0	1	2	3	4	5	6	7	8	9	A	B	C	D

Ενσωματωμένοι χαρακτήρες

CGROM

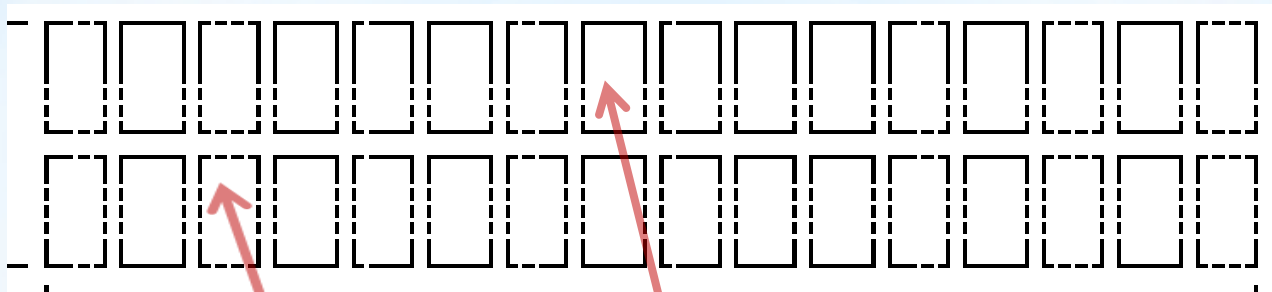
Character Generator ROM

Για παράδειγμα:
η διεύθυνση

01000001 (LHLLLLLH)
περιέχει το σχήμα A

CGRAM

Character Generator RAM
Μπορούν να αποθηκευτούν
8 σχήματα



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

Μνήμη Δεδομένων Οθόνης

Display Data RAM (DDRAM)

Pin no.	Symbol	External connection	Function
1	V _{SS}	Power supply	Signal ground for LCM
2	V _{DD}		Power supply for logic for LCM
3	V ₀		Contrast adjust
4	RS	MPU	Register select signal
5	R/W	MPU	Read/write select signal
6	E	MPU	Operation (data read/write) enable signal
7~10	DB0~DB3	MPU	Four low order bi-directional three-state data bus lines. Used for data transfer between the MPU and the LCM. These four are not used during 4-bit operation.
11~14	DB4~DB7	MPU	Four high order bi-directional three-state data bus lines. Used for data transfer between the MPU
15	LED+	LED BKL power supply	Power supply for BKL
16	LED-		Power supply for BKL

Σήματα
ελέγχου

Γραμμές
Δεδομένων

Διεπαφές

11.9 Instruction Table

Instruction	Instruction code										Description	Execution time (fosc=270 KHZ)
	RS	R/M	DB ₇	DB ₆	DB ₅	DB ₄	DB ₃	DB ₂	DB ₁	DB ₀		
Clear Display	0	0	0	0	0	0	0	0	0	1	Write "20H" to DDRA and set DDRAM address to "00H" from AC	1.53ms
Return Home	0	0	0	0	0	0	0	0	0	-	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 blinking of entire display	39us
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.	
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.	39us
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: 5x11/5x8)	39us
Set CGRAM Address	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM address in address Counter.	39us
Set DDRAM Address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address Counter.	39us
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.	0us
Write data to Address	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM).	43us
Read data From RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM (DDRAM/CGRAM).	43us

ΣΕΤ
Εντολών

10. Timing Characteristics

Write cycle ($T_a=25^\circ\text{C}$, $V_{DD}=3.3\text{V}$)

Parameter	Symbol	Test pin	Min.	Typ.	Max.	Unit
Enable cycle time	t_c	E	500	-	-	ns
Enable pulse width	t_w		300	-	-	
Enable rise/fall time	t_r, t_f		-	-	25	
RS; R/W setup time	t_{su1}	RS; R/W RS; R/W	100	-	-	
RS; R/W address hold time	t_{h1}		10	-	-	
Read data output delay	t_{su2}	DB0-DB7	60	-	-	
Read data hold time	t_{h2}		10	-	-	

Write mode timing diagram

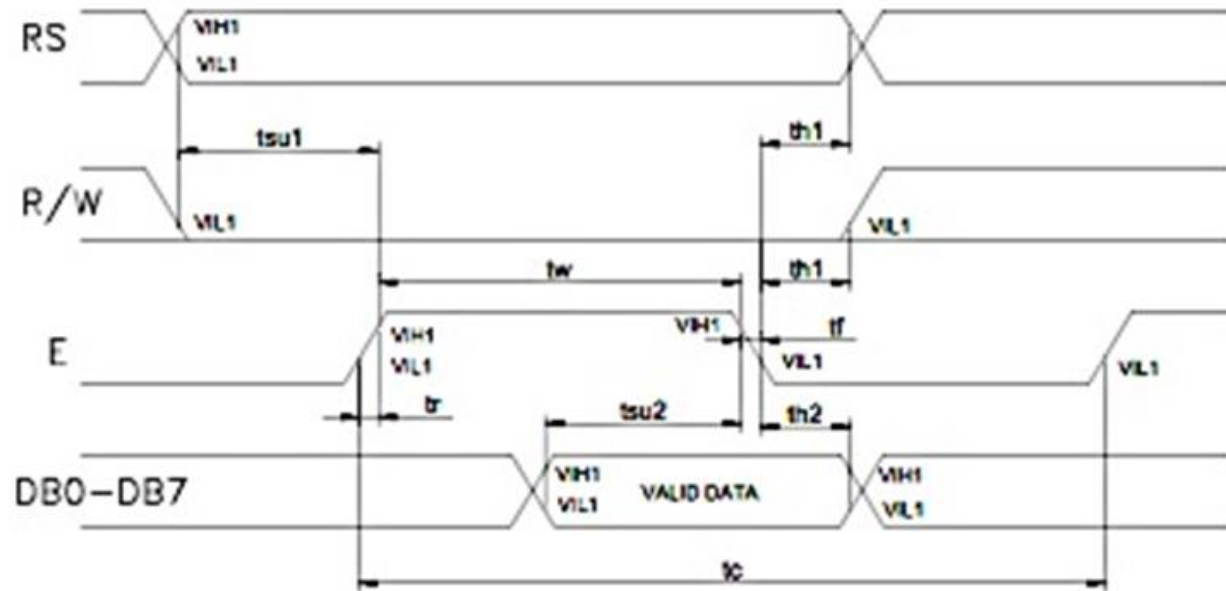
a) RS=0,1

b) R/W=0,1

c) E=1

d) DATA

e) E=0



Μορφή σημάτων εξωτερικών εντολών

Παράδειγμα εντολών

Για να ορίσουμε την θέση στην οθόνη που θα εμφανιστεί ο χαρακτήρας

Set RS ->0

Set R/W->0

Set E->1

Set DB7-DB0-> 10000111 (Θέση οθόνης 07)

Set E->0 Ολοκληρώνεται η εντολή

Για να ορίσουμε ποιος χαρακτήρας θα εμφανιστεί.

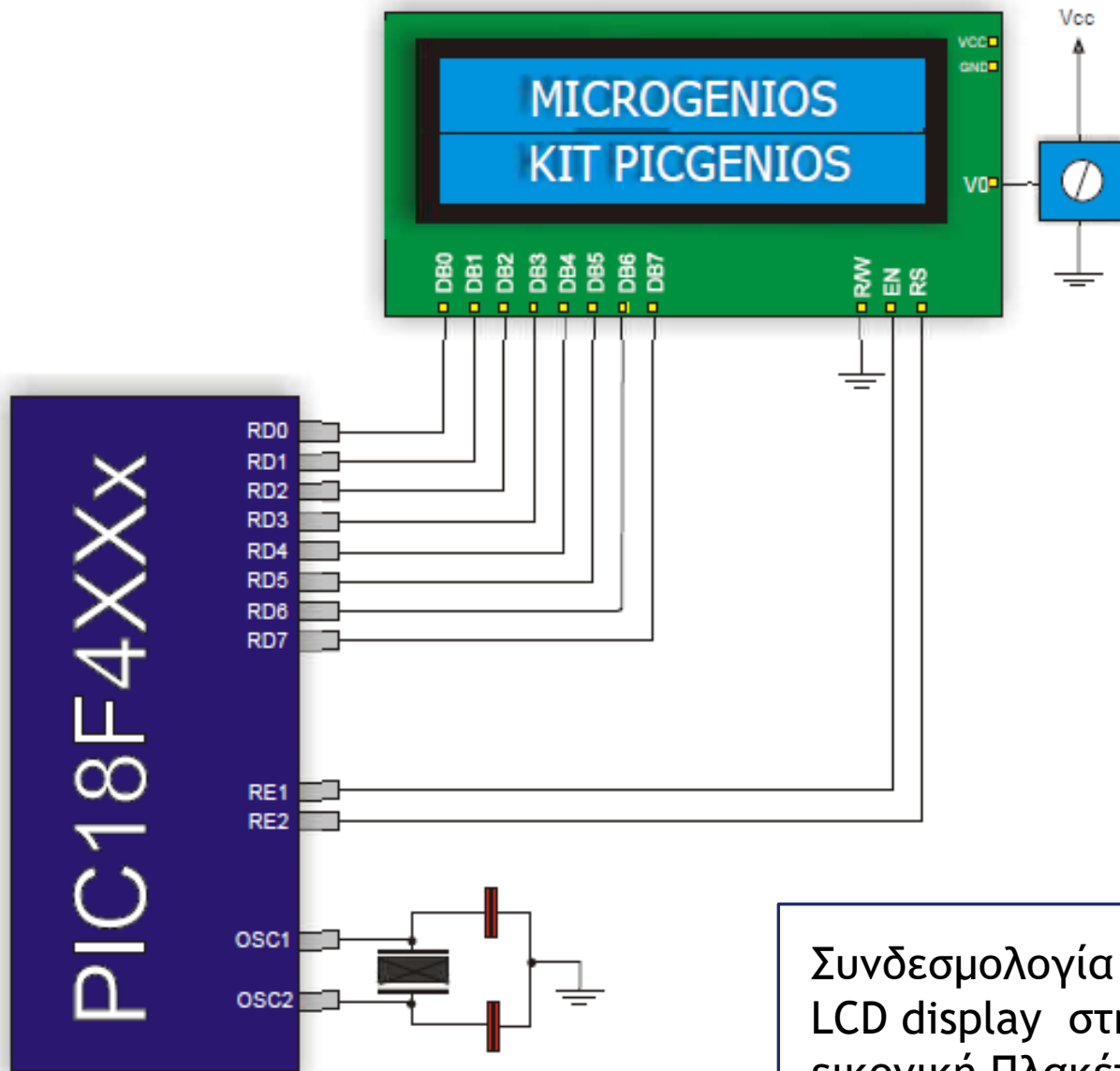
Set RS ->1

Set R/W->0

Set E->1

Set DB7-DB0-> 01000001 Διεύθυνση μνήμης CGROM

Set E->0 Ολοκληρώνεται η εντολή



Συνδεσμολογία LCD display στην εικονική Πλακέτα.

Παράδειγμα κώδικα σε MICROC

Εντολές για την εμφάνιση του χαρακτήρα «Κ» στην 2 σειρά και 9 θέση.

```
TRISE.F1 =0;
```

```
TRISE.F2 =0;
```

```
TRISD=0x00;
```

```
PORTE.F1 = 0;
```

```
.....//Αρχικοποίηση του LCD display.
```

```
//Ορίζουμε την θέση στην οθόνη
```

```
PORTE.F2 = 0;          //RS ->0
```

```
                        //R/W->0 (είναι γειωμένο)
```

```
PORTE.F1 = 1;          //E->1
```

```
PORTD = 0xC7;          //Set DB7-DB0-> 11000111 (Θέση οθόνης 0x47)
```

```
PORTE.F1= 0;           //Set E->0 Ολοκληρώνεται η εντολή
```

```
//Για να ορίσουμε ποιος χαρακτήρας θα εμφανιστεί.
```

```
PORTE.F2 = 1;          // Set RS ->1
```

```
                        //Set R/W->0
```

```
PORTE.F1 = 1;          //Set E->1
```

```
PORTD =0x4B;           // Set DB7-DB0-> 01001011 Διεύθυνση μνήμης CGROM
```

```
                        // PORTD = 'K'; ASCII του K είναι 0x4B.
```

```
PORTE.F1 = 0;          //Set E->0 Ολοκληρώνεται η εντολή
```

Παράδειγμα κώδικα αρχικοποίησης LCD

```
//Manual control of LCD Display without using MliroC libraries
```

```
PORTE.F1 = 0; //SET ENABLE TO 0  
delay_ms(100);
```

```
PORTE.F2 = 0; //RS ->0
```

```
PORTE.F1 = 1; //E->1
```

```
PORTD = 0b00110000; //set 8 bit mode 2 lines 5x8 ROM
```

```
PORTE.F1=0; //E->0
```

```
delay_ms(100);
```

```
PORTE.F2 = 0; //RS->0
```

```
PORTE.F1=1; //E->1
```

```
PORTD = 0b00110000; //set 8 bit mode 2 lines 5x8 ROM
```

```
PORTE.F1=0; /E->0
```

```
delay_ms(100);
```

```
PORTE.F2 = 0; //RS->0
```

```
PORTE.F1=1; //E->1
```

```
PORTD = 0b00001100; // display ON/OFF
```

```
PORTE.F1=0; //E->0
```

```
delay_ms(100);
```

```
PORTE.F2 = 0; //RS->0
```

```
PORTE.F1=1; //E->1
```

```
PORTD = 0b00001100; // Set Entry Mode
```

```
PORTE.F1=0; //E->0
```

```
delay_ms(100);
```

```
PORTE.F2 = 0; //RS->0
```

```
PORTE.F1=1; //E->1
```

```
PORTD = 0b00000001; //clear display
```

```
PORTE.F1=0; //E->0
```

```
delay_ms(100);
```

Βιβλιοθήκη MicroC για LCD display

* `Lcd8_Config(&PORTC,&PORTD,0,1,2,6,5,4,3,7,1,2,0);`

* `Lcd8_Cmd(LCD_CLEAR);`

`LCD_FIRST_ROW`

Move cursor to 1st row

`LCD_CLEAR`

Clear display

`LCD_RETURN_HOME`

Return cursor to home position

`LCD_CURSOR_OFF`

Turn off cursor

`LCD_UNDERLINE_ON`

Underline cursor on

`LCD_BLINK_CURSOR_ON`

Blink cursor on

`LCD_MOVE_CURSOR_LEFT`

Move cursor left without changing DDRAM

`LCD_MOVE_CURSOR_RIGHT`

Move cursor right without changing DDRAM

`LCD_TURN_ON`

Turn LCD display on

`LCD_TURN_OFF`

Turn LCD display off

`LCD_SHIFT_LEFT`

Shift display left

`LCD_SHIFT_RIGHT`

Shift display right

* `Lcd8_Out(1, 3, "Hello!");`

* `Lcd8_Out_Cp("Here!");`

* `Lcd8_Chr(2, 3, 'i');`

* `Lcd8_Chr_Cp('e');`

Βιβλιοθήκη MicroC PRO για LCD display

* LCD_Init();

* LCD_Cmd(LCD_CLEAR);

LCD_FIRST_ROW

Move cursor to 1st row

LCD_CLEAR

Clear display

LCD_RETURN_HOME

Return cursor to home position

LCD_CURSOR_OFF

Turn off cursor

LCD_UNDERLINE_ON

Underline cursor on

LCD_BLINK_CURSOR_ON

Blink cursor on

LCD_MOVE_CURSOR_LEFT

Move cursor left without changing DDRAM

LCD_MOVE_CURSOR_RIGHT

Move cursor right without changing DDRAM

LCD_TURN_ON

Turn LCD display on

LCD_TURN_OFF

Turn LCD display off

LCD_SHIFT_LEFT

Shift display left

LCD_SHIFT_RIGHT

Shift display right

* LCD_Out(1, 3, "Hello!");

* LCD_Out_Cp("Here!");

* LCD_Chr(2, 3, 'i');

* LCD_Chr_Cp('e');

Παράδειγμα χρήσης βιβλιοθήκης Lcd για τη λειτουργία του LCD Display (MIKROC PRO).

```
sbit LCD_RS at RE2_bit;  
sbit LCD_EN at RE1_bit;  
sbit LCD_D4 at RD4_bit;  
sbit LCD_D5 at RD5_bit;  
sbit LCD_D6 at RD6_bit;  
sbit LCD_D7 at Rd7_bit;
```

```
sbit LCD_RS_Direction at TRISE2_bit;  
sbit LCD_EN_Direction at TRISE1_bit;  
sbit LCD_D4_Direction at TRISD4_bit;  
sbit LCD_D5_Direction at TRISD5_bit;  
sbit LCD_D6_Direction at TRISD6_bit;  
sbit LCD_D7_Direction at TRISD7_bit;
```

```
char *text = "MyTextHere";  
void main() {  
    // Initialize LCD as defined above  
    LCD_Init();  
    LCD_Cmd(LCD_CURSOR_OFF); // Turn off cursor  
    LCD_Out(1, 4, text); // Print text on LCD  
}
```