LIQUID CRYSTAL DISPLAY (LCD)

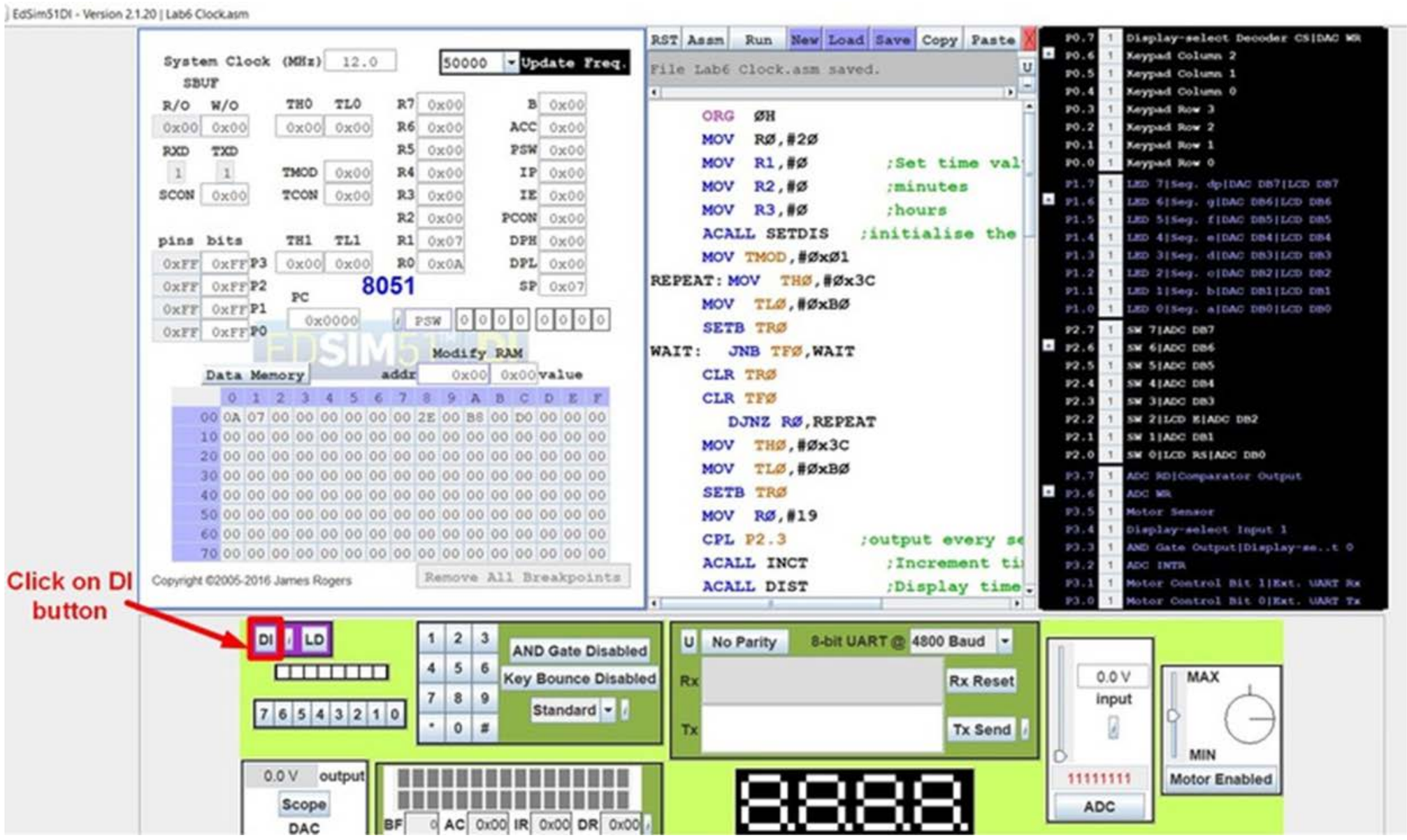
- LCDs provide a better user interface as they can display ASCII messages

- Pin Description for LCD
  - LCD modules usually have 14 pins.

Pin No.	Name	Function	Description
1	V_{SS}	Power	GND
2	V_{DD}	Power	+ 5 V
3	V_{EE}	Contrast adjust	0 – 5 V
4	RS	Register select	Signal to select data or command register of the LCD. RS = 0 select command register (for write); Busy flag, address counter (for read) RS = 1 select data register (for write)
5	R/W	Read / Write	Signal to read/write data from/to LCD. RW = 0 Write to LCD RW=1 read from LCD
6	E	Enable (Strobe)	High to low pulse is applied to this pin to enable LCD to accept (latch) data/ command present on its data lines D0-D7
7-14	D0-D7	Data lines D0 (Pin-7-LSB), D7 (Pin-14-MSB)	Bidirectional data lines used to send data/command to LCD; or read LCD internal registers, D7 is also used as a busy flag, D4 -D7 are used in the 4 bit operation

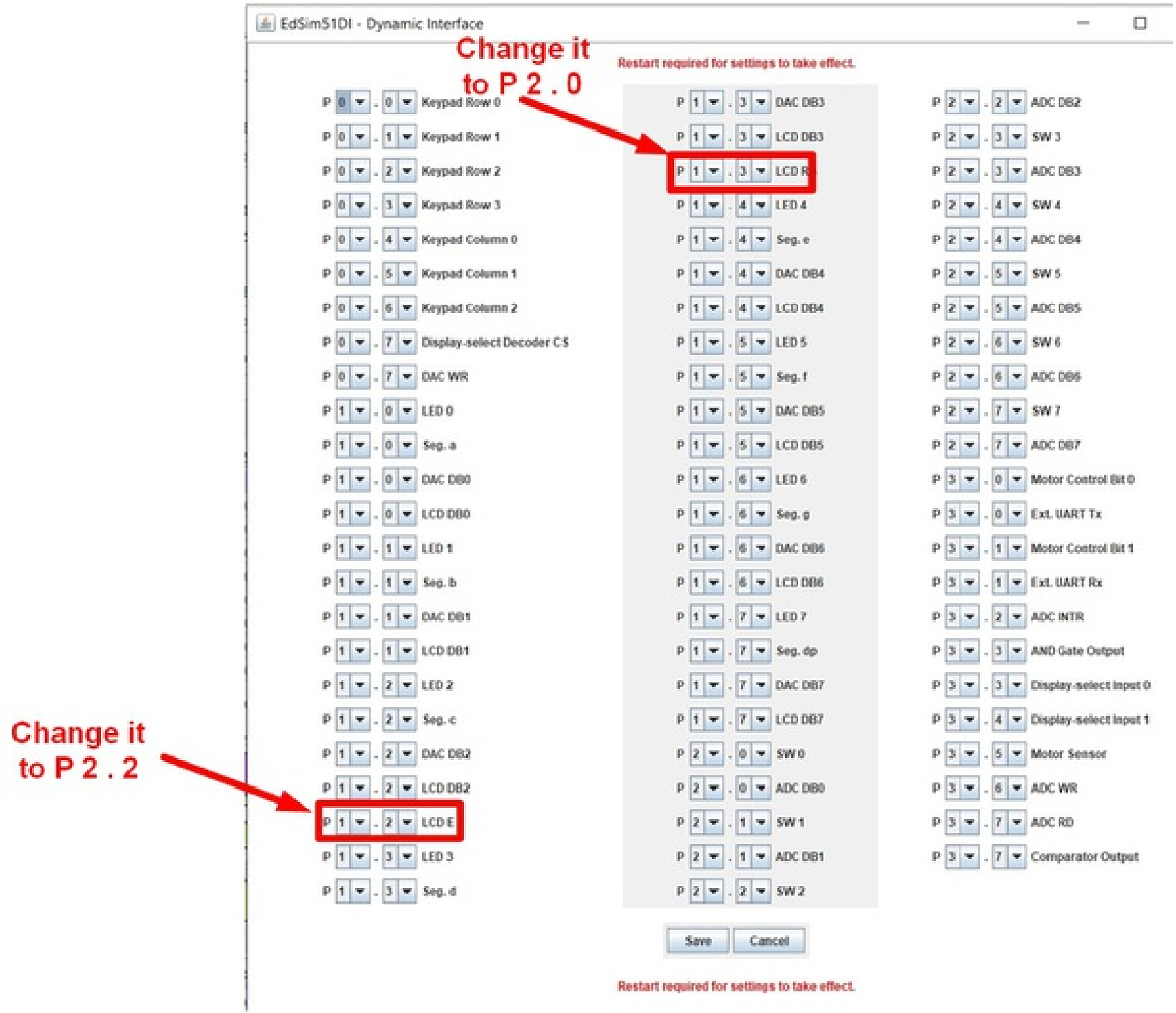
Using Simulator

- In the lab exercise, we used the LCD in 4-bit Mode.
- To use the simulator for the reset of labs, the LCD must be in 8-bit Mode.
- To change mode, RS and E should be remapped to other port pins, using the DI button at the top left of the peripheral panel.



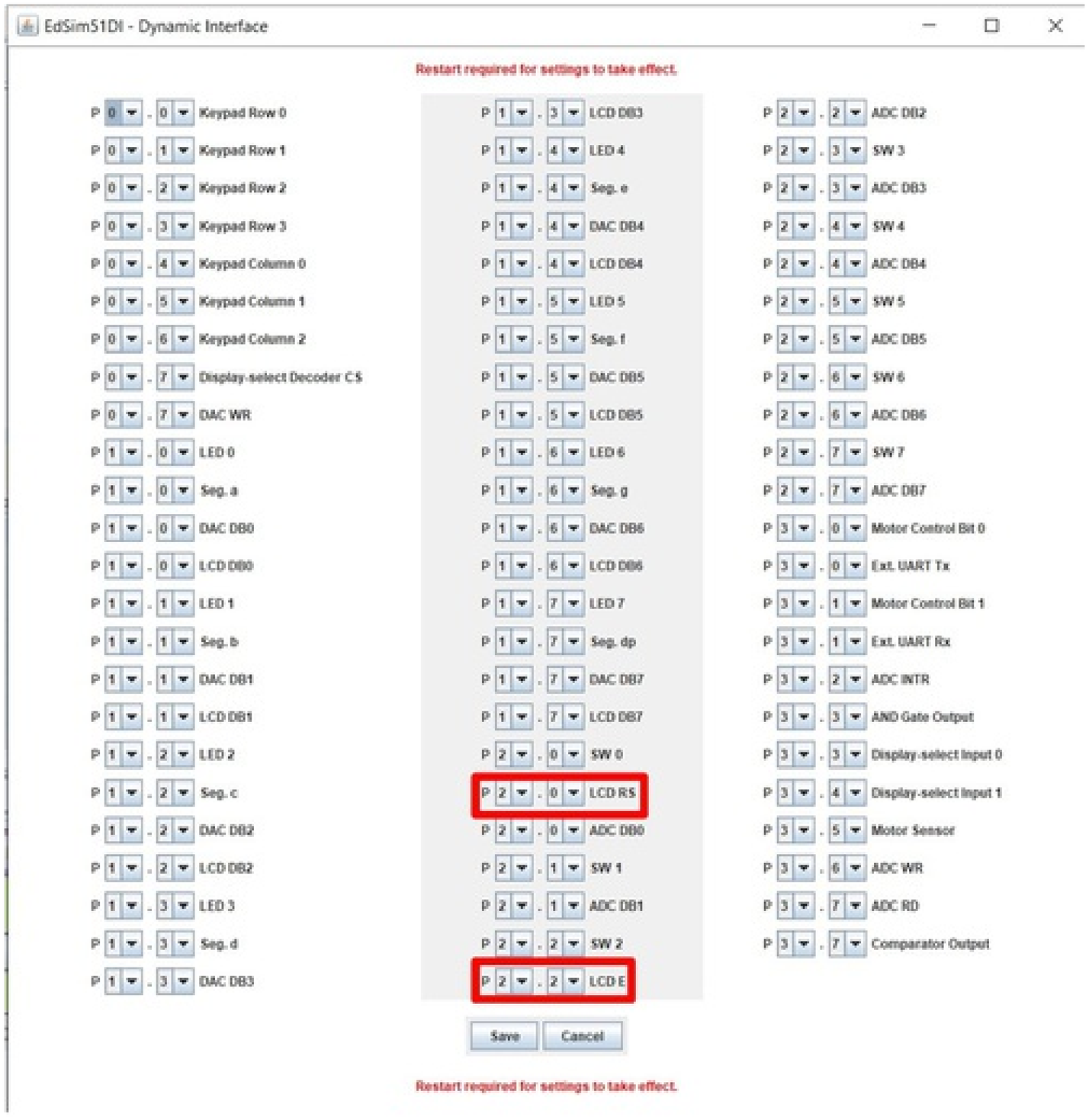
Using Simulator cont.

- Change the port P1.2 LCD E to P2.2 and the port P1.3 LCD RS to P2.0.



Using Simulator cont.

- Save the new settings and restart the program to see the changes.

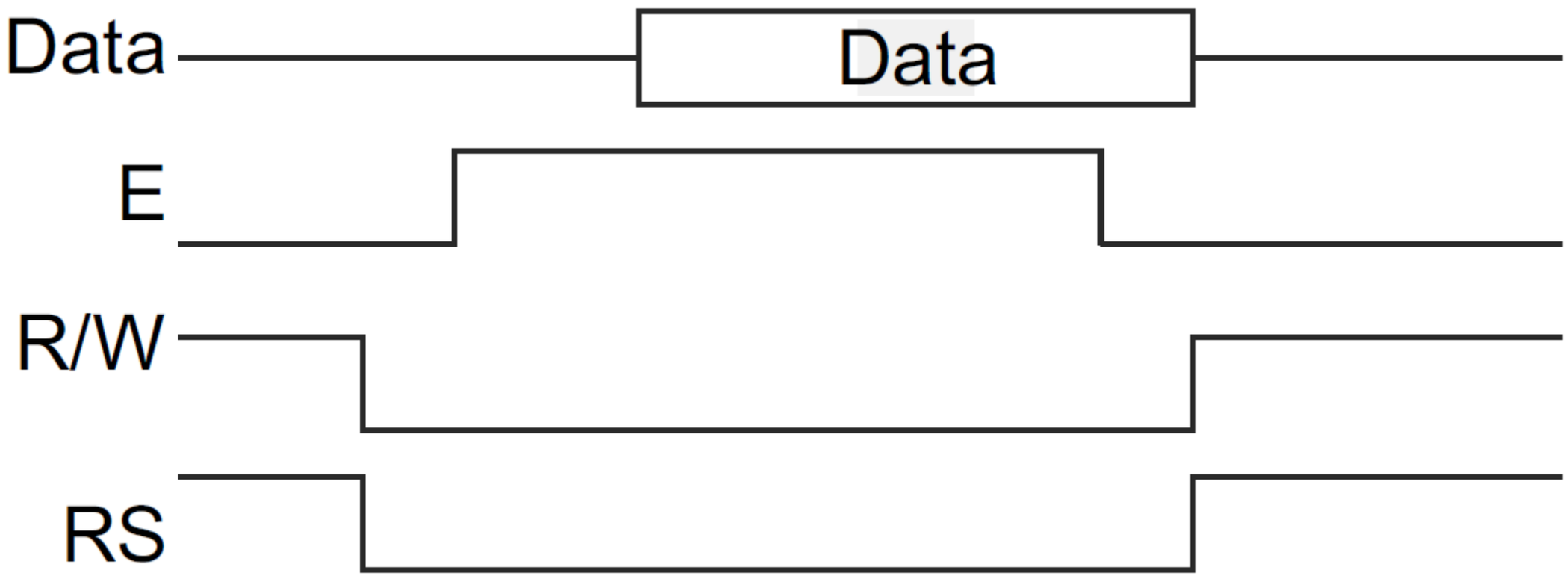


LCD commands

Command	RS	RW	D7	D6	D5	D4	D3	D2	D1	D0	Command Code (Hex)	Execution Time (Max.) f_{cp} = 250 kHz
Clear display	0	0	0	0	0	0	0	0	0	1	01	1.64 ms
Cursor home	0	0	0	0	0	0	0	0	1	x	02	1.64 ms
Entry mode set	0	0	0	0	0	0	0	1	I/D	S	04–Shift cursor left	40 µs
											06–Shift cursor right	
											05–Shift display right	
											07–Shift display left	
Display on/off control	0	0	0	0	0	0	1	D	U	B	08–Display off, Cursor off	40 µs
											0A–Display off, Cursor on	
											0C–Display on, Cursor off	
											0E–Display on, Cursor blink off	
											0F–Display on, Cursor blink	
Cursor/Display Shift	0	0	0	0	0	1	D/C	R/L	x	x	10–Shift cursor left	40 µs
											14–Shift cursor right	
											18–Shift display left	
											1C–Shift display right	
Function set	0	0	0	0	1	DL	N	F	x	x	28–2line,5X7matrix,4 line	40 µs
											38–2line,5X7matrix,8 line	40 µs
Set CGRAM address	0	0	0	1	CGRAM address							40 µs
Set DDRAM address	0	0	1	DDRAM address							80– Set cursor at beginning of line 1	40 µs
Read "BUSY" flag (BF)	0	1	BF	DDRAM address								40 µs
Write to CGRAM or DDRAM	1	0	D7	D6	D5	D4	D3	D2	D1	D0		40 µs
Read from CGRAM or DDRAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0		40 µs

I/D 1 = Increment (by 1)	0 = Decrement (by 1)	R/L 1 = Shift right	0 = Shift left
S 1 = Display shift on	0 = Display shift off	DL 1 = 8-bit interface	0 = 4-bit interface
D 1 = Display on	0 = Display off	N1= Display in two lines	0 = Display in one line
U 1 = Cursor on	0 = Cursor off	F 1 = Character format 5 × 10 dots	0 = 5×7 dots
B 1 = Cursor blink on	0 = Cursor blink off	D/C 1 = Display shift	0 = Cursor shift

LCD timing



Display message ‘HI’

➢ Initialize the LCD by sending a set of commands to it

1. Configure data bus as 4-bit or 8-bit mode
2. Select character font, (i.e.) dots/character
3. Configure display and cursor type, i.e. display ON or not, cursor blinking or not
4. Configure display and cursor movement, i.e. left shift or right shift or shift off
5. Configure display position
6. Clear display

- (The commands are sent by making RS = 0 and R/W = 0, and high to low pulse on E pin, a delay should be provided between two commands to ensure that the LCD has executed the previous command.)

- Send ASCII values of the characters to be displayed one character at a time with a delay between them.
- (Data characters are sent to the LCD by making RS = 1 and R/W=0, and high to low pulse on E pin, with a delay between two consecutive data characters).

Example

- Write an assembly-language program to generate a square wave on P1.1 with an ON time (high time) of 1 ms. Assume the crystal frequency is 11.0592 MHz.
- Hint: Count to be loaded in to TH and TL = FC66H.

```
MOV TMOD, #10H          ; configure Timer 1in Mode 1
REPEAT:
MOV TL1, #66H           ; load count in TH1–TL1
MOV TH1, #0FCH          ;
SETB P1.1               ; set P1.1 high to get ON part of
                        ; square wave
SETB TR1                ; start Timer 1
HERE: JNB TF1, HERE     ; wait until timer overflows
CLR P1.1                ; clear P1.1 to get OFF part of square wave
CLR TR1                 ; stop timer
CLR TF1                 ; clear overflow flag
SJMP REPEAT             ; reload timer registers and repeat
```