

Department of Engineering Technology and Industrial Distribution ESET 349 Microcontroller Architecture

Lab 6 – Interfacing 16x2 LCD display to STM32F401RE

Objectives

1. Understand the 16x2 display's functioning, which uses the HD44780U LCD controller.
2. Write an assembly language program to interface an STM32F401RE with the LCD.

Your Tasks

1. Read and understand the functioning of the display, as presented in Pages 1 - 4.
2. Complete the starter program shared on Canvas using the instructions on Page 4.

Overview

A 16x2 LCD is a 32-digit LCD screen which can display 2-line messages of 16 characters in each line. Each digit is a 5x8 pixel matrix, which displays a single ASCII character.

This display unit has a built-in controller (Hitachi HD44780U). Any program to display characters must follow the protocols governed by the controller. Fig. 1 shows the display and its 16 pins for interfacing with the STM32F401RE microcontroller. Fig. 2 shows the functionalities of individual pins. Note RS, RW, and EN in Fig. 2.

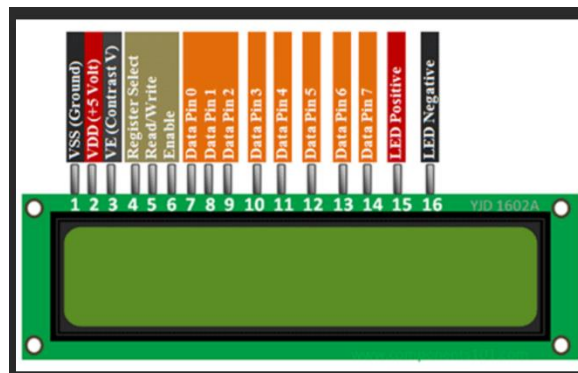


Figure 1. A 16x2 LCD display and its pins



Figure 2. Functions of individual pins of 16x2 LCD display unit

There are three control pins on the LCD: RS (register select), RW (read/write), and EN (enable). The data pins (D0-D7) connect to both the Command Register and the Data Register.

- RW decides if the LCD controller is operating in the read or the write mode. Since you will be writing commands and data to the LCD using an STM32 in this lab, the RW pin remains 0 throughout your exercises.
- RS determines if the byte at the data pins (D0-D7) will be written to the Command Register or to the Data Register.
- The EN pin is latched at the falling edge (described below in Fig. 3), which means that it must go from high to low in order to send the information (both commands and data) to the LCD.

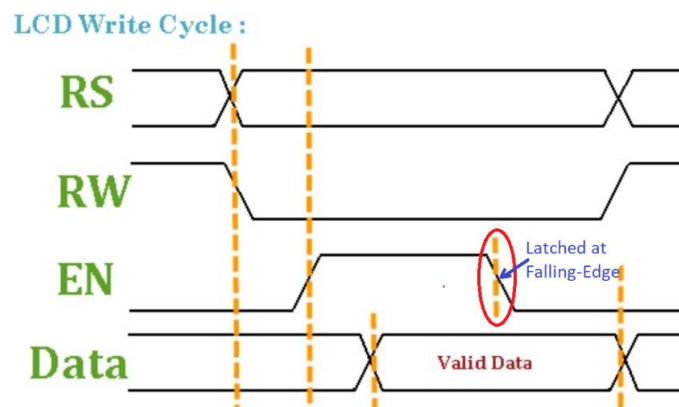


Figure 3. Timing diagram of the EN pin. Note how the falling edge of the EN pin is carried out **after** the other pins have been set to their desired values.

The objective of this lab is to write a program to send a short message for display on 16x2 LCD display. The display can accommodate a maximum of 32 characters in two lines. The characters

are sent to the Data Register of the LCD one at a time. Before sending a message, the LCD must be set up as desired by sending some control commands.

Control Commands

Table 1 shows some control commands. One control command is sent to the Command Register at a time. Note that not all these commands need to be used.

Table 1: List of control commands

Control Command (hex)	Description
01	Clear the display screen
02	Return Cursor home
06	Increment Cursor (automatically shift cursor one place to right)
0E	Turn ON Display and Cursor
0F	Display ON, Cursor blinking
80	Force cursor to beginning of the 1 st line
C0	Force cursor to beginning of the 2 nd line
38	2 lines and 5x8 character matrix (8-bit data, D7-D0)
28	2 lines and 5x8 character matrix (4-bit data, D7-D4)

Example

Tables 2 and 3 below show pin states as well as control and data commands to be written to the LCD controller **in sequence** for displaying two characters on the LCD. You may follow a similar approach to the steps below while writing your assembly program.

Table 2: Example command input

Command Code, hex	D7-D0	RS	RW	EN (Latched at 0 input)
38	Send 0x38 to LCD			
		0	0	1
Delay. Let all get settled.				
		0	0	0
0E	Send 0x0E to LCD			
		0	0	1
Delay. Let all get settled.				
		0	0	0
01	Send 0x01 to LCD			
		0	0	1
Delay. Let all get settled.				
		0	0	0
06	Send 0x06 to LCD			

		0	0	1
Delay. Let all get settled.				
		0	0	0

Table 3: Example character input (sample characters – ‘D’ and ‘B’)

Character Code, hex	D7-D0	RS	RW	EN (Latched at 0 input)
‘D’ ~ 0x44	Send 0x44 to LCD			
		1	0	1
Delay. Let all get settled.				
		1	0	0
‘B’ ~ 0x42	Send 0x42 to LCD			
		1	0	1
Delay. Let all get settled.				
		1	0	0

If Tables 2 and 3 are followed in sequence, the LCD will display:

D B _ _ _ _ _ _ _ _
_ _ _ _ _ _ _ _

Instructions for Your Task using the Starter Program

1. Make the following connections for the shared starter program.

Port A: Control

Pin PA5 - RS

Pin PA6 - RW

Pin PA7 - EN

Port C: Data

Connect Pins PC0 - PC7 on the STM32 to D0 - D7 on the LCD respectively.

2. Complete the LCDDData function (refer the LCDCommand function and Table 3).
3. Add the missing instructions within the LCDInit function.
4. Add the necessary instructions in __main to display the words “SUCCESS” on the first line and “FAILURE” on the second line as shown below.

S U C C E S S _ _ _ _ _ _ _ _
_ _ _ _ _ _ _ _ F A I L U R E _ _