AMS Lab exercise 3a
Graphic LCD Display

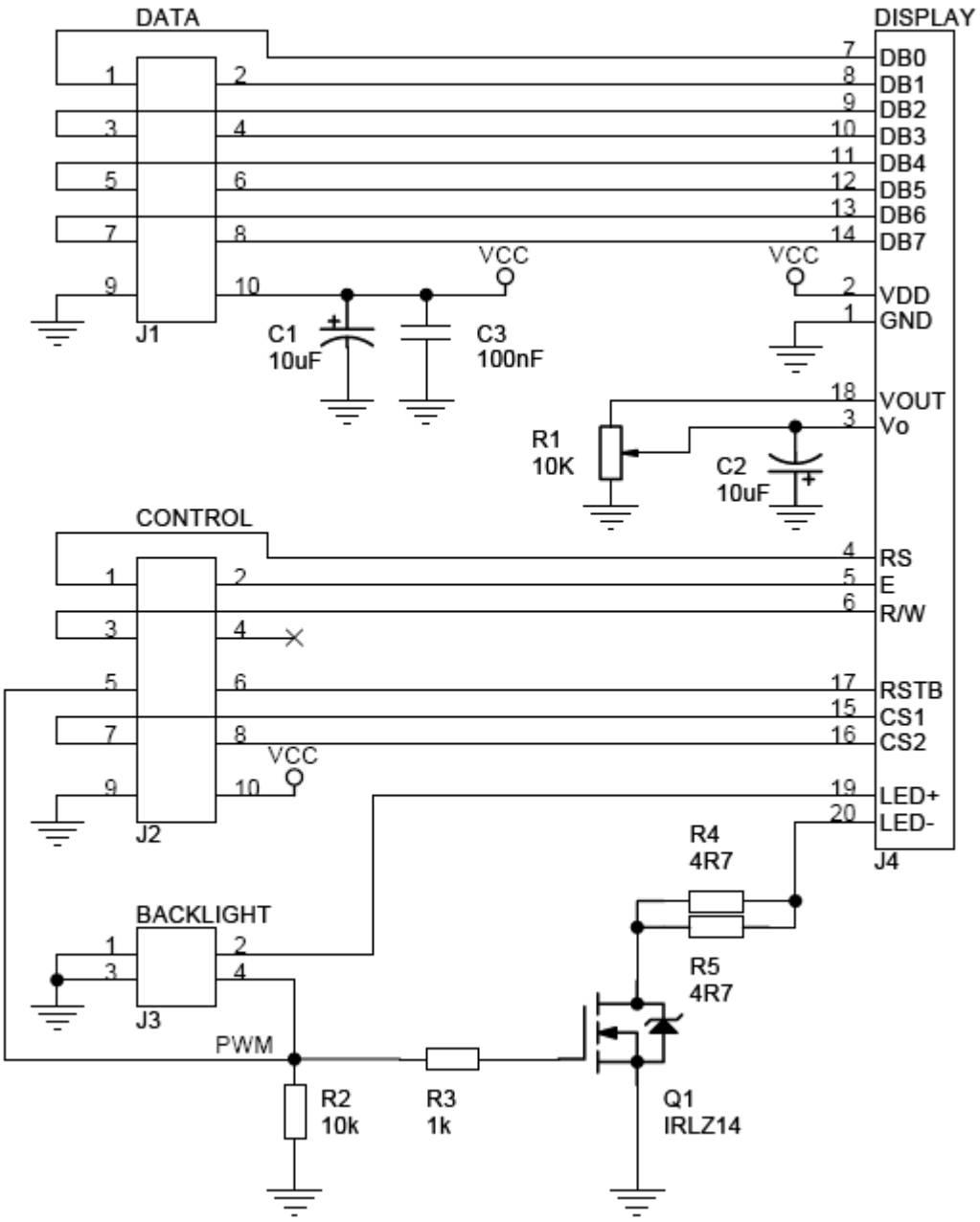
Purpose
To understand how to interface a typical graphic LCD display module.
A driver is to be implemented for a 128 x 64 dot graphic display module.

Literature
- Data sheet: Graphic LCD module DEM128064A.

The relevant documents can be downloaded from Blackboard.

Exercise
In this exercise, we will interface the DEM128064A 128x64 dot LCD module to the Mega32.

Available for the experiments is an evaluation board, making it easy to connect to the STK500 ports:



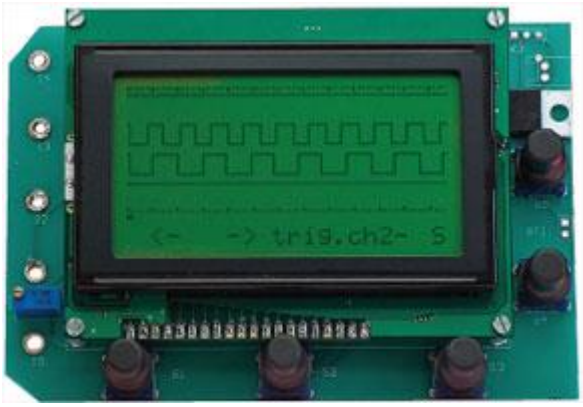
The "Data" connector is to be connected to one of the STK500 ports uses as the data bus for the display module (DB7 – DB0).
At the same time, the port supplies the display with the 5 volt power.

Also the "Control" connector is to be connected to one of the STK500 ports.
The Mega32 control port pins have the following connections to the display module:

Bit 7 (MSB)	CS2
Bit 6	CS1
Bit 5	RSTB
Bit 4	Backlight Control
Bit 3	(Not Connected)
Bit 2	R/W
Bit 1	E
Bit 0 (LSB)	RS

The driver circuit for the LED backlight will not be used in this exercise.
Important: If using the backlight, it is very important to use a separate (500 mA) 5 volt power supply. The STK500 board is <u>not</u> capable of supplying that much power!

Important: The LCD contrast voltage has to be adjusted using the potentiometer onboard.
Initially adjust the voltage, so that the dots just starts turning black.



Start studying the available data sheet (available at Blackboard):

- Data sheet: Graphic LCD module DEM128064A.
  This is the most important documentation (<u>very</u> poor English, but for some cases realistic ☺).

- Then implement a simple driver for the display module.

Test the driver by means of a test program (main() located in another file).

Start by implementing the basic, time-critical functions.
You might get inspired by the methods used in LAB3 ("Alphanumeric Display").

Then implement various "higher level" functions (such as drawing a line from one point to another).
Also functions for clearing the display and for turning a dot on or off is of cause relevant.

These are the demands for the basic bus timing:

Characteristic	Symbol	Min	Typ	Max	Unit
E Cycle	t_C	1000	-	-	ns
E Rise	t_R	-	-	25	ns
E Fall	t_F	-	-	25	ns
E High Level Width	t_{WH}	450	-	-	ns
E-Low Level Width	t_{WL}	450	-	-	ns
Address Set –Up Time	t_{ASU}	140	-	-	ns
Address Hold Time	t_{AH}	10	-	-	ns
Data Delay Time	t_D	-	-	320	ns
Data Set –Up Time	t_{DSU}	200	-	-	ns
Data Hold Time (Write)	t_{DHW}	10	-	-	ns
Data Hold Time (Read)	t_{DHR}	20	-	-	ns

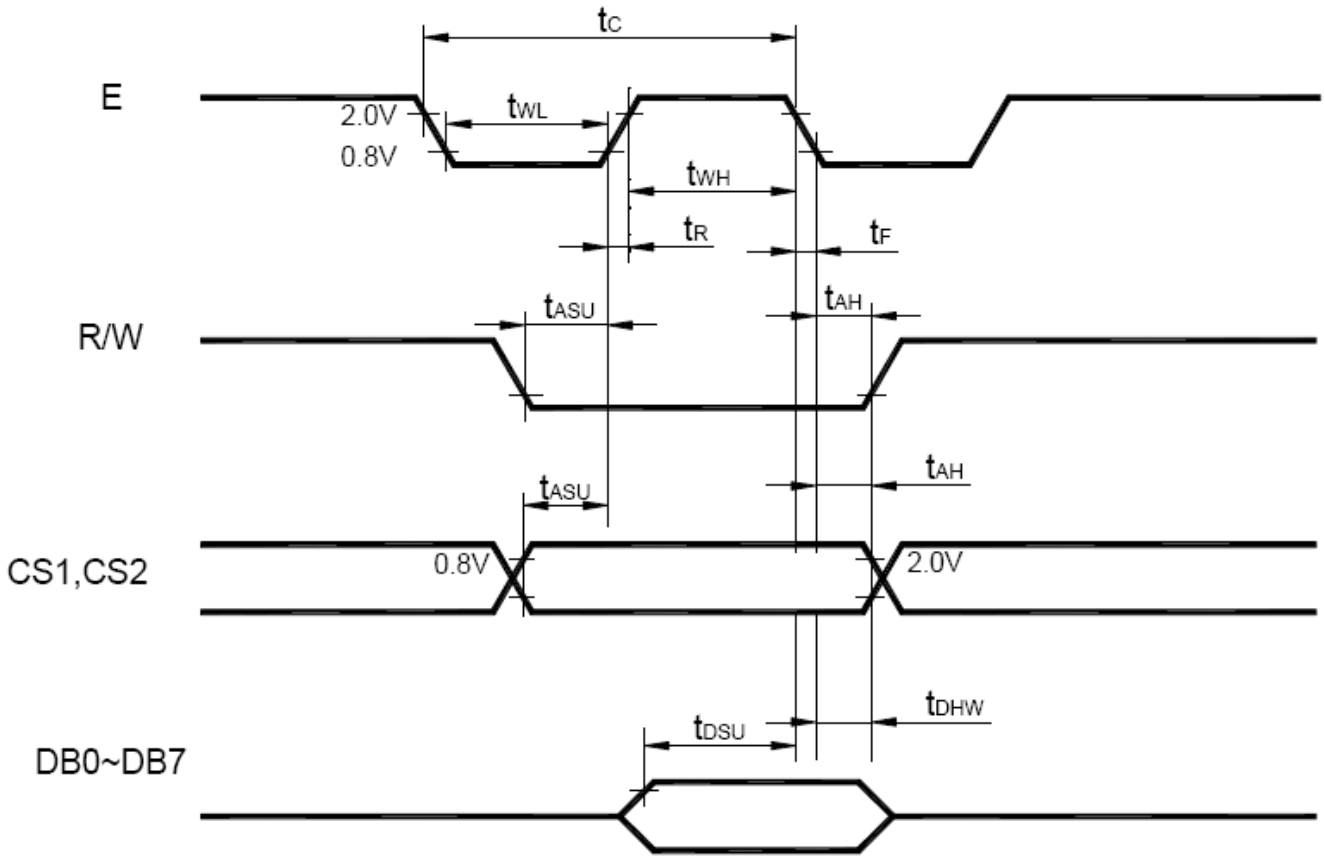


Figure 5.0 MPU write timing

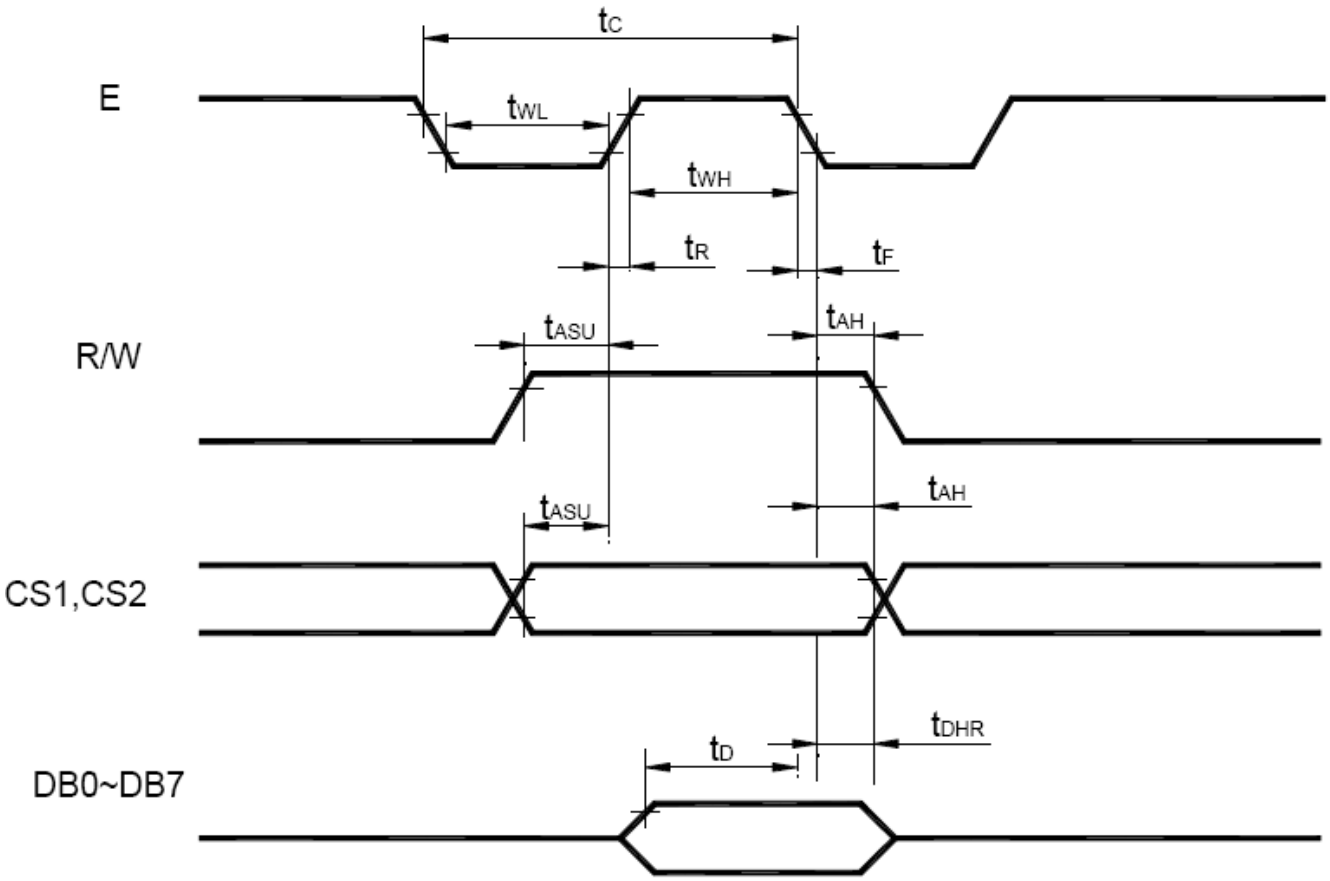


Figure 6.0 MPU Read timing

Controlling RS and R/W:

RS	R/W	Function
L	L	Instruction
	H	Status read (busy check)
H	L	Data write (from input read register to display data RAM
	H	Data read (from display data RAM to output register)

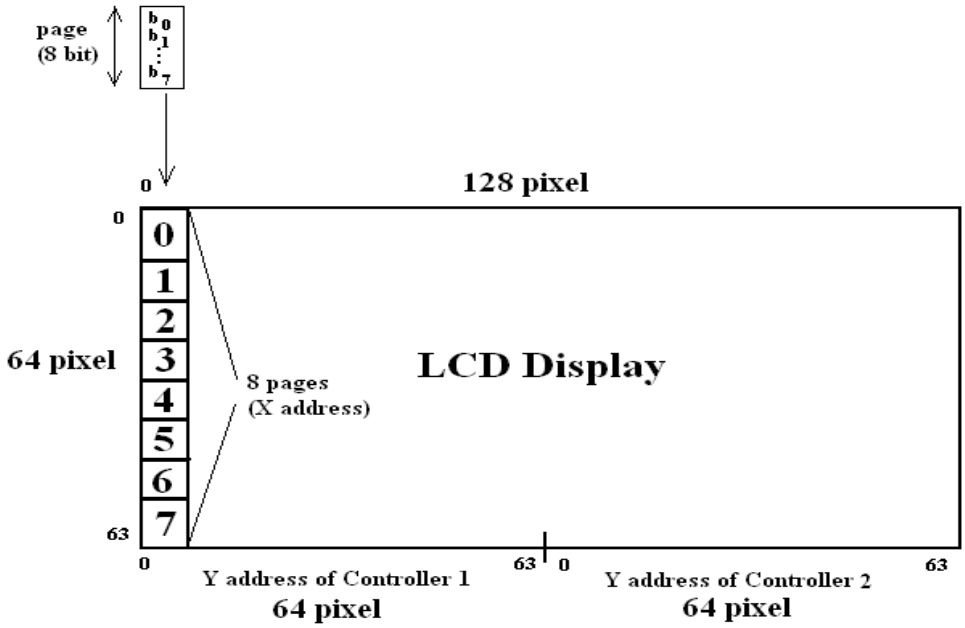
The instructions available:

Instruction	RS	R/W	DB7	DB 6	DB5	DB4	DB3	DB2	DB1	DB0	Function
Display ON/OFF	L	L	L	L	H	H	H	H	H	L/H	Controls the display on or off. Internal status and display RAM data is not affected. L: OFF, H: ON
Set Address (Y address)	L	L	L	H	Y address (0 ~ 63)						Sets the Y address in the Y address counter.
Set Page (X address)	L	L	H	L	H	H	H	Page (0 ~ 7)			Sets the X address At the X address counter
Display Start line (Z address)	L	L	H	H	Display start line (0 ~ 63)						Indicates the display data RAM displayed at the top of the screen.
Status Read	L	H	BUSY	L	ON/OFF	RESET	L	L	L	L	Read status BUSY L: Ready H: In operation On/Off L: display ON H: Display OFF RESET L: Normal H: Reset
Write Display Data	H	L	Write Date								Writes data (DB0:7) into display data RAM . After writing instruction, Y address is increased by 1 automatically.
Read Display data	H	H	Read Date								Reads data (DB0:7) From display data RAM to the data bus.

Consult the DM128064 data sheet for a detailed explanation.
Unfortunately, the data sheet is written in very bad English, but that's life ☺.

To supplement the (sometimes poor) information in the data sheet, some hints are given at the following pages.

Hint 1
There might be some confusion for the definitions of the X address and the Y address.
This figure should help a bit:



Notice that the "x addresses" are in the physical vertical display orientation, and the "y addresses" are in the physical "y direction".

The "x address" is analogous with the "page number", and "page 0" is at the display uppermost, left corner.

Also notice that the display is controlled by 2 LCD chips: One controlling the leftmost half and the other one controlling the rightmost half. Only one controller is allowed to be chip selected at a time.

Hint 2
The chips selects for the 2 LCD controllers are CS1 and CS2 respectively.
It is not clear from the data sheets, whether they are active low or active high controlled.
Both CS1 and CS1 are active HIGH ("CS1 = 1" will select the chip controlling the leftmost half).

Hint 3
According to the data sheets, it is necessary to wait for the display to become ready before writing it (data or commands). The method described is to read the BUSY flag until it becomes low.
However, numerous experiments show that the BUSY flag never gets low (always read as 1).
Also, the experiments shows, that in practice, we don't have to wait for the display to get "not busy".
Therefore, do not implement this method. The display can be read or written immediately.

Hint 4
Before writing data to the display or reading data from the display, the "page address" and the "Y address" has to be written. There is no "auto-increment" for the "page address", but the Y address is "auto-incremented" after each read or write.

Hint 5
When reading the display data, be aware that you have to do a dummy read before reading the actual display data. This addresses (page and Y) have to be set before the dummy read, but not between the dummy read and the actual read.

Hint 6
Unless you want to implement scrolling of the LCD display, you don't have to use the "Display Start Line" command.

Hint 7
Bus timing:
The "E" control signal: I recommend, this signal is held low, when not reading or writing the display. Only set it high when needed (minimum the tWH time in the timing diagrams).
The RS control signal: This is not shown in any of the timing diagrams. It always has to be set to the wanted level, before setting E high or activating the chip select).
The R/W control signal: Set this up before setting E high or activating the chip select). "R/W = 0" for writing, "R/W = 1" for reading.
The CS1 and CS1 control signals: Always remember to enabled only one CS at a time (before setting "E = 1").
The data bus: Obviously, the data bus port has to be set up as an output port when writing and to an input port when reading (modify the Data Direction Register).

Hint 8
A skeleton for the driver (c file and h file) is available at Blackboard.
You are free to use this and/or create you own (maybe more advanced) functions.