

Development of Hardware Control on Dot Matrix Liquid Crystal Display

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Abstract – This paper proposes a new method of display control based on CPLD, using logical gate functions. It allows easy creating an external block with desired characters of the alphanumerics, upper or lower case, symbols. Assignment of symbols is set in binary code, which has to be written in memory of the display's controller.

Keywords – Logic gate functions, Dot matrix, Control, LCD, CPLD, Xilinx.

I. INTRODUCTION

LCD is a display device used to display information. Its applications starts from simple clocks and reaches to machine's control units or railway's monitor boards and so on. A special controller converts instructions into signals, which switch on or off lights in the matrix.

There are many LCD dot matrix modules containing the corresponding LCD driver and controller, e.g. "KS0066U" (40SEG DRIVER & CONTROLLER FOR DOT MATRIX LCD) designed by Samsung or "HD44780U" (Dot Matrix Liquid Crystal Display Controller/Driver) designed by Hitachi. These both are compatible. [1, 2]

The display consists of a dot matrix of lights, which are organized by lines and columns. The controller defines which single dot to turn on or off. Every single dot has coordinates C_n (Common 1-16) and S_n (Segment 1-40). The combinations of dots, which formed figures, letters, and symbols, are saved in library called character generator.

Every single character can be summoned by a binary code according to manufacturer's arranged table. The internal memory contains three character generators:

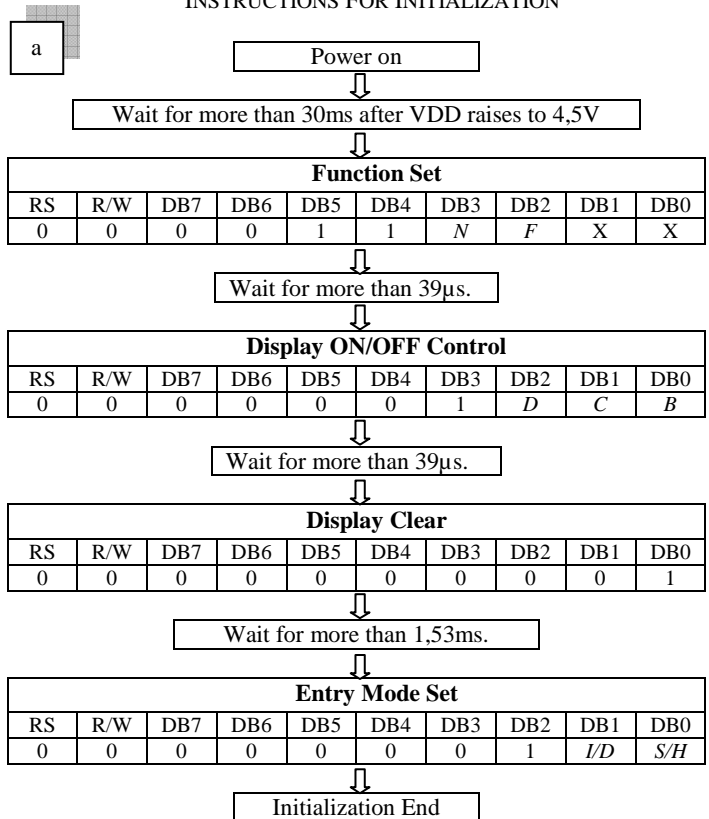
1. CGROM (Character Generator ROM): 10,080 bits (204 characters 5x8 dots) & (32 characters 5x11 dots);
2. CGRAM (Character Generator RAM): 64x8 bits (8 characters 5x8 dots);
3. DDRAM (Display Data RAM): 80x8 bits (80 characters max.);

The Special character pattern is directly programmable by the Character Generator RAM and owing to a mask option, customer can program character pattern in his own.

The principle of managing a display like this is the same for different manufacturers. The strategy is based on few

commands of initialization, followed by instructions to choose mode and data for visualization, Table 1, a. All codes are accompanies by a strobing frequency which is the clock frequency for data bus transfer. [1]

TABLE I
INSTRUCTIONS FOR INITIALIZATION



LEGEND OF CHARACTERS

N	0	1-line mode	F	0	Display off
	1	2-line mode		1	Display on
D	0	Display off	C	0	Cursor off
	1	Display on		1	Cursor on
B	0	Blink off	I/D	0	Decrement mode
	1	Blink on		1	Increment mode
S/H	0	Entire shift off			
	1	Entire shift on			

When the power is turned on, KS0066U is initialized automatically by power on reset circuit. During the initialization, the following instructions are executed, and BF (Busy Flag) is kept "High" (busy state) to the end of initialization. The description of parameters for instructions of initialization are shown in Table 1, b.

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II. BLOCK AND PRINCIPLE SCHEMES

A. Block scheme

In order to make usage of the display faster and easier could be created a scheme with inputs labeled as alphanumeric and outputs corresponding to pins of LCD module. For example, the block named “Converter” on figure 1 is logic schematic, function “OR” gate dedicated.

The input frequency “CLK1” is the clock frequency of the “Shift Register”, with serial input and parallel outputs. It defines the duration of time when an output is active. The active one enables internal logic combination of “Converter”, based on “OR” gate array. [6, 7]

Outputs “D0” to “D2” are responsible for the initialization of the display, step 2, 3, 4 in Table 2. They are followed by sequence of symbols which forming the word on the display. The usage of lower frequency for “CLK1” to the input of the register allows displaying the word as slow as is necessary. The higher value of it has to be pursuant by the manufacturer’s timings, Table 1, a.

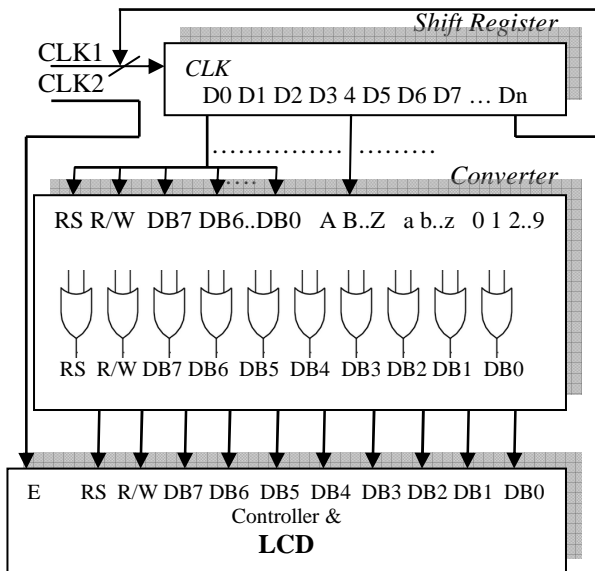


Fig. 1. Block schematic to manage LCD

Block “Converter” owns outputs, which are managing the LCD module. Each of them is the output of a single “OR” gate with a number of inputs extended as it is necessary. The same rule applies for inputs of the block. Whether there is a symbol used more than once, his Converter’s input has to be extended to the number of usage. Character “A” in the example is used twice. In this case an auxiliary logic scheme, based on “OR” gate, between “Shift Register” and “Converter” is useful.

The second frequency “CLK2” is the strobing frequency. It defines the speed of data transfer into the controller.

When the desired information is displayed on the LCD, both frequencies, “CLK1” and “CLK2”, have to be stopped. Otherwise, the word will disappear. To achieve that, last

output of the decoder has to be involved in a logic scheme which will block them.

B. Principle schemes

The frequency “CLK1” proceeds to the input of block “Shift Register”. It consist of a 4-bits counter and 4-bits decoder, figure 2. Every pulse turns the output state of the counter by one, and the binary code changes the output of the decoder.

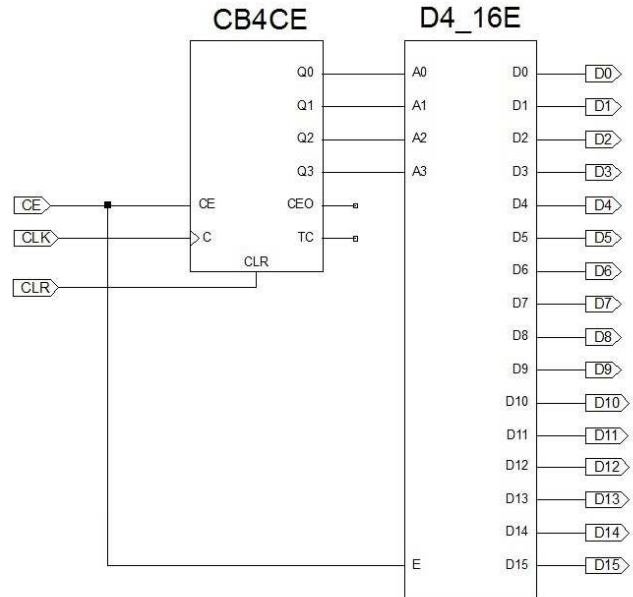


Fig. 2. Shift register scheme

First of decoder’s outputs is “D0”, which starts the

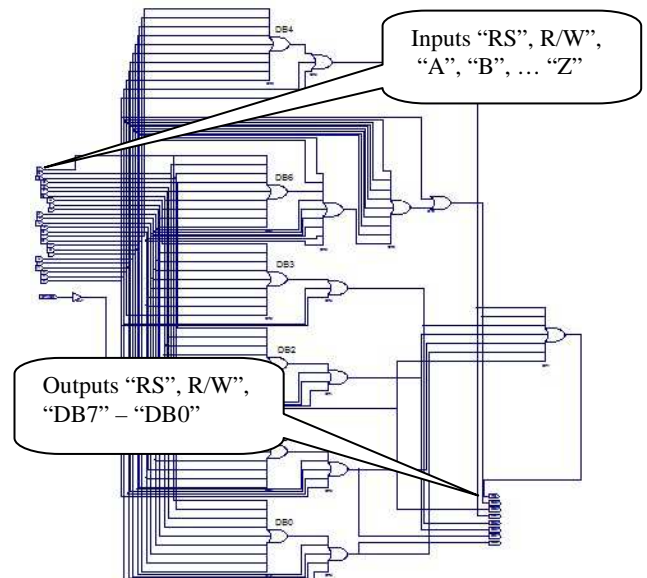


Fig. 3. Converter scheme “OR” gates array

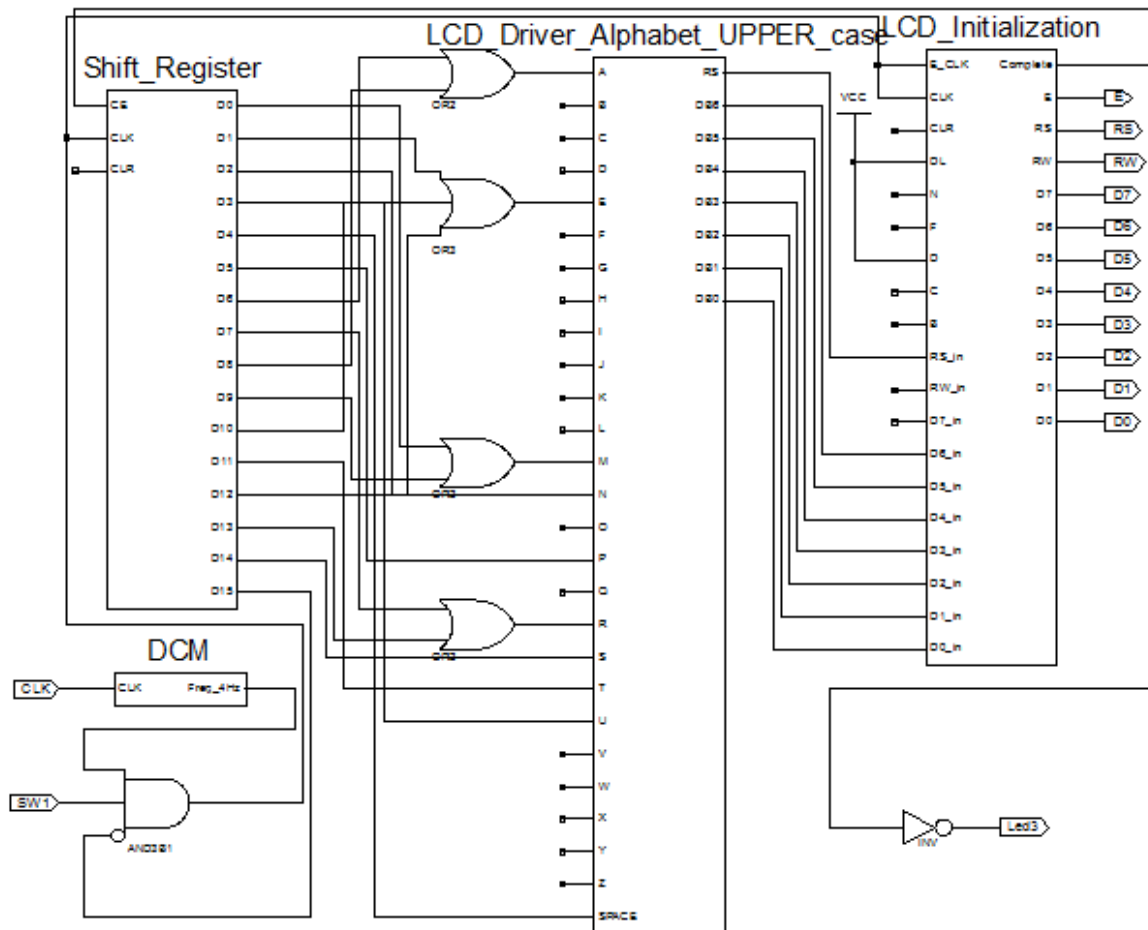


Fig. 4. Principle scheme of external programmable driver for LCD 2x16 dot matrix

sequence of initialization regarding Table 1, a. After the process of initialization, “D0-D2”, commands for desired word are run to the converter block. Every command is coherent character. This block contains logic gates, function “OR” dedicated, which spread a single signal from inputs (“A”, “B”, ... “Z”) to a combination of outputs “DB0”-“DB7” corresponding to the binary code, figure 3. The addition of “RS” and “R/W” busses in this block, is useful for the final scheme of the project. As a matter of fact, every data code for character has to be accompanied by a strobing pulse, and adjacent pulse to “RS”.

III. EXPERIMENTS

In order to make usage of the display faster and easier could be created a scheme with inputs labelled as alphanumeric and outputs corresponding to pins of LCD module. For example, the scheme of “Converter” is assembled to “LCD_Driver_Alphabet_UPPER_case”, on figure 4.

The block “Shift_Register” represents the scheme from figure 2. To minimize the symbols among bigger schematic modules on figure 4, the approach with the counter and decoder is imported for input scheme of the last block called “LCD_Initialization”. Their function is to set initialization

instructions, which states could be ordered to the “DL”, “N”, “F”, “D”, “C”, “B” inputs. When the process is completed, active signal appears on output “Complete” and enables “Shift_Register” to write characters. In this case, the desired inscription is “MENU PARAMETERS”, so “D0” is responsible for symbol “M”, and his active signal is spread out for his relevant binary code. The output “Led3” is control signal for monitoring. [1, 2]

Block “DCM” is a digital clock manager which is a generator assembled by counters provides frequency 4Hz. Logic gate “AND3b1” stops the frequency when the whole line is displayed. The four “OR” gates extend the inputs for doubled symbols “A”, “M”, “R”, and the tripled “E” one. Input “SPACE” is added to implant the empty space.

The sequence of data instructions for the example are systematically arranged, shown in Table 2. The description of parameters for instructions of initialization are shown in Table 1, b.

TABLE II
Example of writing “MENU PARAMETERS”.

Step №	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Display	Description
1												Power supply
2	0	0	0	0	1	1	0	0	*	*		Function set
3	0	0	0	0	0	0	1	1	1	0		Display on/off
4	0	0	0	0	0	0	0	0	0	1		Display Clear
5	1	0	0	1	0	0	1	1	0	1	M_	Write data to CGRAM/DDRAM
6	1	0	0	1	1	0	0	1	0	1	ME_	Write data to CGRAM/DDRAM
7					.				.			
8	1	0	0	1	0	1	0	0	1	1	MENU PARAMETERS	Write data to CGRAM/DDRAM

IV. RESULTS

The approach allows writing easy a simple word, or a line, figure 5. It could be developed to more complicated system forming a menu. Every line, or lines, shown on the display, needs a register, which will activate the sequence of the letters. Well known is that they have control enable pin, so in a bigger designed system, the inscriptions on the LCD could be summoned by one bit.

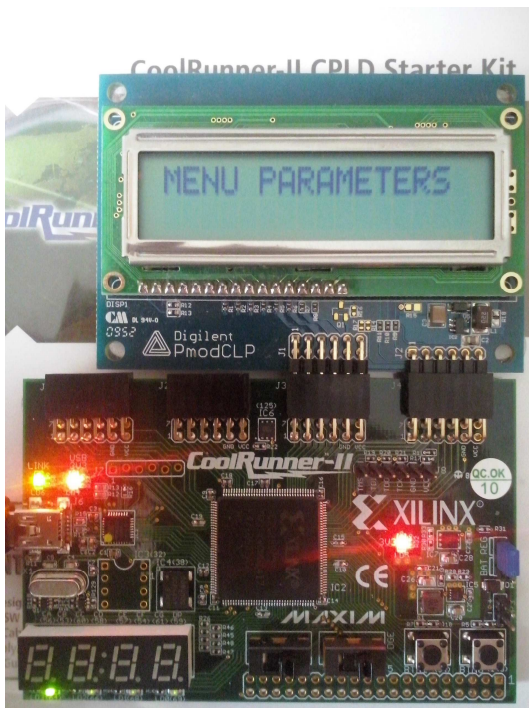


Fig. 5. Inscription is already shown

V. CONCLUSION

In this paper the mention approach for using dot matrix LCD 2x16 is based on a hardware solution. Owing to the purpose to show a simple word on the display, the project could be realized by discrete integrated circuits. Advantage is the low cost. Actually it is a difficult method to create a system menu, with adjacent submenus, with embedded different parameters and values, with options to adjust them. Disadvantages could be the large number of ICs, and the space they will require.

Another solution is the usage of a programmable logic device. The choice concerning to the program language, capacity of the product, functionality, and additional peripheral devices is variety and rich enough in nowadays.

One balanced solution according to the list of demanding is “CoolRunner-II” board. Produced by Digilent, based on Xilinx’s platform XC2C256TQ144. It is a CPLD (complex programmable logic device) generation structure, i.e. a logic matrix consisting of “OR” and “AND” logic gates. There are more than 60 peripheral devices formed to extend board’s functionalities, called “Pmods”. A “PmodCLP” is a board with LCD controller “KS0066U” and dot matrix LCD 2x16, managed by parallel interface. Thus designed system - board with LCD, is a reliable configuration for developing a more complicated system. [3, 4]

For example, designed menu in this way could be useful for a control system for driving electrical motor. [5]

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