BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LVII (LXI), Fasc. 5, 2011
Secţia
ELECTROTEHNICĂ. ENERGETICĂ. ELECTRONICĂ

COMMAND AND CONTROL OF TOUCH-SCREENS AND GRAPHIC LIQUID CRYSTAL DISPLAY MODULES (II)

BY

PETRUȚ DUMA*

"Gheorghe Asachi" Technical University of Iaşi,
Faculty of Electronics, Telecommunications
and Information Technology

Received, January 26, 2011
Accepted for publication: May 9, 2011

Abstract. The paper focuses on the description of the hardware structure of a command and control system for a touch-screen, along with its adequate specialized controller, overlaid on a LCD graphic display module and of a development system equipped with microcontroller AT89S8253. The LCD module has a low resolution, it is monochrome and can be easily interfaced with a microcontroller through two parallel ports. Backlighting of the LCD and powering the graphic module is performed using software-commanded switches. In this manner, the power consumption is reduced to minimum when the graphic module is not in use, which is a major advantage for battery-powered applications. Using the proposed structure allows to eliminate from any application the need for circuitry used for setting initial conditions, operation mode and work parameters. The development and the integration of these touch-screens are increasingly present in wider ranges of applications nowadays, since their use is reconfigurable and ergonomic, they are also relatively easy to implement and cost-effective.

Key words: graphic monochrome LCD module; graphic driver; development system; microcontroller; touch-screen panel; specialized touch-screen controller.

* *e-mail*: pduma@etti.tuiasi.ro

1. Introduction

The liquid crystal display (LCD) represents a passive display method since it does not emit light but uses light from the environment. By controlling this light, the LCD modules are able to display various images using up very little energy. The LCD modules currently manufactured represent a viable display solution and they can be either alphanumeric or graphic.

Graphic LCDs offer a high flexibility since they consist of a pixel matrix grouped in rows and columns. Each pixel is individually addressable in order to allow the display of text, graphic or combinations between these two types of data. Since the dimensions and the shapes of characters are software-defined, the text displayed can use any font and can be written in any language, the only limitations being imposed by the module's resolution. Graphic displays are produced with resolutions ranging from 64 × 32 to 640 × 200 pixels for monochrome and far higher resolutions for colour displays. The main characteristics of these displays include: built with super-twisted nematic (STN) liquid crystals or super-twisted nematic film (FSTN) that allow for an wide viewing angle and good contrast; light and thin; low power consumption; they use LED lighting or cold cathode fluorescent lamps that provide high light intensity and long life; they include graphic drivers on the module, which allow simple parallel interfacing with the microcontroller-based systems; etc.

A command and control system of a touch-screen consists of the touch-screen itself overlaid on a graphic liquid crystal display module, the specialized touch-screen controller, the graphic drivers for the LCD module and a development system equipped with AT89S8253 microcontroller that provides command and control of the whole architecture. In a previous paper (Duma, 2010) details concerning the command and control of the touch-screen were presented. The present work describes the hardware structure of the liquid crystal display, while a future paper will present the command software designed to activate the pixels, to draw lines and geometric shapes, to display alphanumeric characters and graphic icons and to load monochrome images.

2. Interfacing Graphic LCD Modules

Development systems equipped with microcontrollers or microprocessors use graphic LCD modules that feature lower resolutions, monochrome display and smaller video memory for image processing. This application uses a monochrome LCD module GDM12864 with a resolution of 64 × 128 pixels and a 1 kByte DDRAM (Data Display RAM) video memory. The LCD module consists in fact of two adjacent 64 × 64 pixels resolution panels (common rows and different columns), placed on the left and on the right side of the module, respectively, without any demarcation area between them.

The internal structure of the graphic module GDM12864 represented at functional blocks level is shown in Fig.1. The acronyms stand for: GLCDP –

graphic liquid crystal display panel; GD64COM – graphic driver that controls 64 common channels; GD64SEG – graphic driver that controls 64 segment channels; CV – voltage converter; LED-BKL – LEDs backlight; RD – resistive divider.

The 64 common output channels driver used for controlling the rows of the pixel-matrix LCD panel is implemented with the integrated circuit KS0107B (IC3). This circuit includes 64 shift registers, 64 output drivers and the circuitry needed for generating the timing signals (TS) used to control the segment graphic drivers. The resistive divider connected to V_{DD} (+5 V) and V_{EE} (–10 V) produces the voltages $U_0,\ldots,U_5$, required by the graphic drivers.

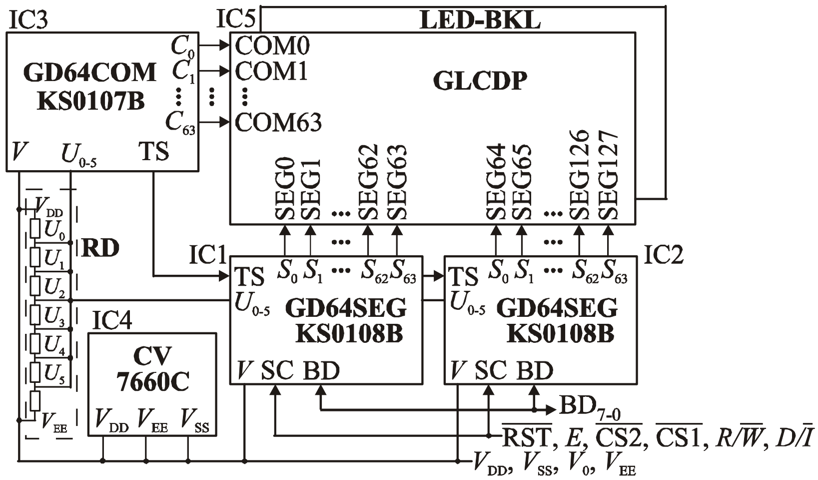

Fig. 1

The 64 segment output channels driver used for controlling the columns of the pixel-matrix LCD panel is implemented with the integrated circuit KS0108B (IC1 and IC2). This circuit includes the video display memory, 64-bit data registers, 64-bit drivers and the decoding logic. The internal memory stores the data required to display the image on the panel. This data comes from a development system that generates it through software, along with all the signals required for controlling the graphic LCD module. IC1 driver controls the columns on the left side screen (SEG0…SEG63) while IC2 controls the ones on the right side (SEG64…SEG127).

The DC voltage converter, implemented using integrated circuit 7660 (IC4), powered by V_{DD} (+5 V) generates a negative voltage of –10 V at output, V_{EE} , used for adjusting the contrast of the LCD panel.

The graphic LCD module GDM12864 is connected to a development system equipped with microcontroller AT89S8253 like in Fig.2. The digital signals of the module are connected adequately to port *P*0 (data) and *P*2 (command signals). Their roles and significances are detailed below:

a) $BD_{7\ldots0} = P0_{7\ldots0}$ – bidirectional data bus for writing instructions or data and for reading status information or data, respectively to/from the graphic LCD module (Table 1).

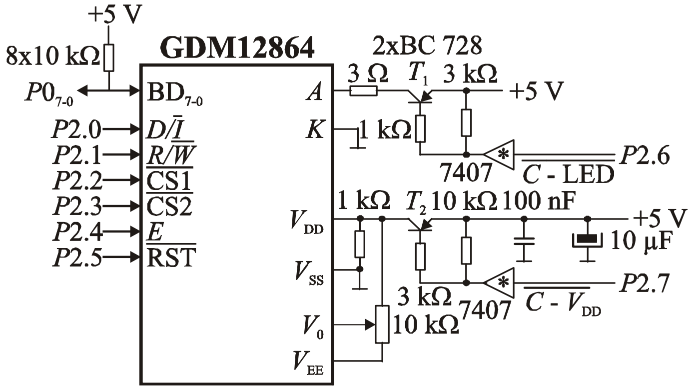

Fig. 2

b) $D/\overline{I}$ = P2,0 – command signal for writing an instruction or reading the state ($D/\overline{I}$ = 0), and respectively for writing data or reading it ($D/\overline{I}$ = 1) to/from the graphic LCD module (Table 1).

c) $R/\overline{W}$ = P2.1 – command signal for writing an instruction or data ($R/\overline{W}$ =0), and respectively for reading status or data ($R/\overline{W}$ = 1) to/from the graphic LCD module (Table 1).

Table 1

$R/\overline{W}$	$D/\overline{I}$	$BD_{7...0}$	Description
0	0	In (instruction)	Write an instruction to the graphic LCD module
0	1	In (data)	Write data to the graphic LCD module
1	0	Out (Status)	Read graphic LCD module status
1	1	Out (Data)	Read data from the graphic LCD module

d) $\overline{\text{CS1}}$ = P2.2 – IC1 graphic driver selection signal, active on logical level "0", which commands segments SEG0…SEG63 for the left side of the liquid crystal screen (Table 2).

e) $\overline{\text{CS2}}$ = P2.3 – IC2 graphic driver selection signal, active on logical "0", which commands segments SEG64…SEG127 for the right side of the liquid crystal screen (Table 2).

f) E = P2.4 – general graphic LCD module enable signal, active on logical level "1" (Table 2).

Table 2

E	$\overline{CS1}$	$\overline{CS2}$	Description
0	–	–	Graphic module not enabled
1	1	1	Graphic module not enabled
1	0	1	Select IC1 driver that controls the display on left side of the LCD panel
1	1	0	Select IC2 driver that controls the display on right side of the LCD panel
1	0	0	Forbidden selection mode

The waveforms corresponding to the write operation ($R/\overline{W} = 0$) of an instruction ($D/\overline{I} = 0$) or data ($D/\overline{I} = 1$) into the left side of the LCD panel ($\overline{CS1} = 0$ and $\overline{CS2} = 1$) are presented in Fig. 3. The write operation into the input register is performed on the descending edge of the enable signal, E. Since the microcontroller of the development system works on a different frequency, a temporary storage is required. After an instruction is written, the next step is to be executed, while after writing data into the input register, the next step is to write it into the video memory (DDRAM) at the current page and address.

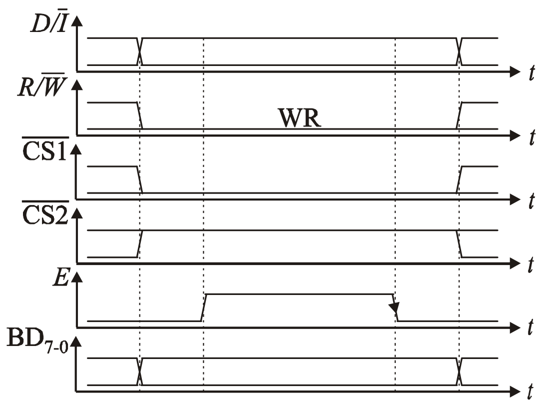

Fig. 3.

Similarly, the waveforms corresponding to the read operation ($R/\overline{W} = 1$) of the status ($D/\overline{I} = 0$) or data ($D/\overline{I} = 1$) from the right side of the LCD panel ($\overline{CS1} = 1$ and $\overline{CS2} = 0$) are presented in Fig. 4. The reading occurs when the enable signal, E, is active, after the delay interval for data delivery (t_D = 320 ns max.) expires. In order to read the status from the graphic module, a single instruction is necessary, while for reading the video memory (DDRAM) two reading instructions must be executed. The first one transfers the data from the video memory into the output register, from where it is read by the microcontroller using a second read instruction.

g) $\overline{\mathrm{RST}}$ = *P*2.5 – graphic module initialization signal, active on logical level “0”. After initialization, the display is turned off and the register for the start line is loaded with 00H data. During the graphic module initialization only the status read instruction is accepted. Any other graphic module instruction will only become available after the RESET and BUSY flags from the status register are reset.

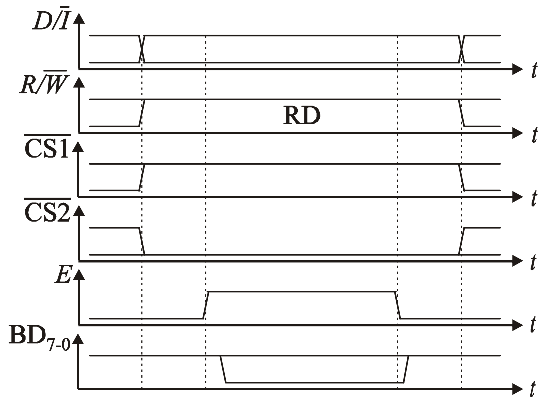

Fig. 4.

h) $\overline{C\text{-}\mathrm{LED}}$ = *P*2.6 – command signal for LCD lighting. A logical level “0” brings transistor T_1 (BC728-40) to saturation, thus allowing it to supply a current of maximum 320 mA to the LEDs behind the screen that insure the lighting. A logical “1” blocks the T_1 transistor, stopping the back lighting of the panel when it is not in use.

i) $\overline{C\text{-}V_{\mathrm{DD}}}$ = *P*2.7 – command signal for graphic module power supply. A logical level “0” forces transistor T_2 (BC728-40) to saturation, allowing a module power supply current up to 10 mA. A logical level “1” blocks transistor T_2 cutting of the power to the graphic module.

j) V_{EE} – the output of the DC converter that supplies a negative voltage of –10 V for the LCD panel contrast.

k) V_0 – command input for the LCD panel contrast. It is recommended to be connected to a variable resistor of 10 kΩ (Fig.2) that allows the user to adjust V_0 in order to obtain a maximal contrast for the viewing angle of the panel and also to compensate the temperature variations.

Every segment graphic driver has a 512 Bytes video memory (DDRAM) containing the data corresponding to the shape of the image to be displayed on the screen. A bit with binary value of “1” lights up a certain pixel, and obviously a “0” value bit turns the corresponding pixel off. The video memory is organized in eight pages of 64 Bytes each. The three-bit page address is set using a single instruction loaded into register *X*. Each segment graphic driver contains a six-bit column counter, *Y*, that stores the address of the video memory location corresponding to the current page. The address of the column counter is set by one instruction at it is incremented with one unit at every read or write from/to the video memory. The segment graphic drivers also include a six-bit register, *Z*, that specifies the start line where the data begins to be displayed from the video memory.

The graphic LCD panel instructions that command and control the status of the segment graphic drivers are briefly listed in Table 3 (the instructions in the table correspond to the currently selected segment graphic driver).

Table 3

$D/\overline{I}$	$R/\overline{W}$	DB_7	DB_6	DB_5	DB_4	DB_3	DB_2	DB_1	DB_0	Description
0	0	0	0	1	1	1	1	1	0	Turn off the selected screen
0	0	0	0	1	1	1	1	1	1	Turn on the selected screen
0	0	0	1	Y_5	Y_4	Y_3	Y_2	Y_1	Y_0	Load column counter *Y* with $Y_5...Y_0$
0	0	1	0	1	1	1	X_2	X_1	X_0	Load page register *X* with $X_2...X_0$
0	0	1	1	Z_5	Z_4	Z_3	Z_2	Z_1	Z_0	Load start line column register *Z* with $Z_5...Z_0$
0	1	*B*	0	*Q*/*Q*	*R*	0	0	0	0	Read status (*B* = BUSY, *O*/*O* = ON/OFF, *R* = RESET)
1	0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	Writes data $D_7...D_0$ into video memory
1	1	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	Reads data $D_7...D_0$ from video memory

The internal structure of the graphic module contains the following three flags: BUSY – availability flag: BUSY = 1 signifies that internal operations are executed and no instructions are allowed, BUSY = 0 – the circuit is available and ready to accept other instructions; ON/OFF – display operation flag: ON/OFF=1 – the display is on, ON/OFF=0 – the display is off; RESET – initialization flag: RESET = 1 – the graphic module is initialized, RESET = 0 – the initialization is complete and the module is in normal operation mode.

3. Conclusions

The hardware structure described is a simple one. It has been built in practice and consists of a touch-screen overlaid on a liquid crystal display and of a development system equipped with microcontroller AT89S8253.

The graphic module that was used, GDM12864, can be easily interfaced with a microcontroller through two 8-bit parallel ports, an output one that generates the command and control signals, and a bidirectional one for data transfer. This graphic module contains all the graphic drivers required for the command of the output channels assigned to rows and columns, including the converter used for adjusting the contrast voltage and thus reducing to minimum the external hardware structure required.

The use of two software driven switches implemented with transistors allow to power the LCD graphic panel from a DC supply source, and to command the LED back-lighting of the panel. In this manner, using the hardware described above, the power consumption can be reduced to minimum when the graphic module is not used, which is an important advantage particularly for battery-powered applications.

This hardware structure as a whole can eliminate the need for circuitry used for the selection of the initial conditions and of the operating mode and parameters. The use of a liquid crystal display beneath the touch-screen provides the means to display various messages, icons and menus that allow the user to select the initial conditions and the operating mode and parameters for various applications.

REFERENCES

Căpăţînă O., *Proiectarea cu microcalculatoare integrate*. Edit. Dacia, Cluj-Napoca, 1992.

Duma P., *Microcontrolerul INTEL 8051. Aplicaţii*. Edit. „TEHNOPRESS”, Iaşi, 2004.

Duma P., *Command and Control System for Touchscreen Panels and LCD Modules* (I). Bul. Inst. Politehnic, Iaşi, **LVI (LX)**, *2*, s. Electrot., Energ., Electron., 55-63 (2010).

Peatmann B.J., *Design with Microcontrollers*. McGraw Hill, New York, 1998.

Somnea D., Vlăduţ T., *Programarea în Assembler*. Edit. Tehnică, Bucureşti, 1992.

* * * *Family Microcontroller*. ATMEL, Data Book, 1998.

* * * *Graphic Liquid Crystal Display Module*. Xiamen Ocular, GDM12864, Data Book, 2007.

* * * *Samsung Electronics*. Data Sheet, KS0107B, KS0108B, 2000.

* * * *Voltage Converter*. 7660C, CMOS, Texas Instruments, Data Sheet, 2006.

* * * *Burr-Brown*. ADS7846, Data Book, 2005.

* * * *Shenzhen Top - Touch Electronics Co*. Touch Panel, Product Specification, 2006.

* * * Data Book,Texas Instruments, 1992.

COMANDA ŞI CONTROLUL ECRANELOR SENSIBILE LA ATINGERE ŞI A MODULELOR GRAFICE DE AFIŞARE CU CRISTALE LICHIDE (II)

(Rezumat)

Este descrisă structura hard a unui sistem de comandă şi control pentru un ecran sensibil la atingere cu controlerul specializat necesar, suprapus peste un modul grafic de afişare cu cristale lichide şi un sistem de dezvoltare echipat cu

microcontrolerul AT89S8253. Modulul grafic de afişare cu cristale lichide are o rezoluție redusă, este monocrom şi se interfațează simplu cu un microcontroler prin intermediul a două porturi paralele. Iluminarea ecranului cu cristale lichide şi alimentarea modulului grafic se realizează prin intermediul unor switchuri comandate prin soft. Astfel, se reduce la minim consumul de energie electrică atunci când modulul grafic nu este utilizat, iar pentru aplicațiile alimentate de la baterii constituie un avantaj important. Cu structura descrisă se pot elimina din orice aplicație circuitele utilizate pentru stabilirea condițiilor inițiale, a modului de lucru şi a parametrilor de funcționare. Dezvoltarea şi integrarea acestor ecrane tactile în diverse echipamente câştigă în prezent tot mai mult teren, deoarece utilizarea acestora este reconfigurabilă, ergonomică, sunt relativ uşor de introdus şi sunt ieftine.