Lab 2 - Keypad and Display Interface

Introduction

In this lab you will compile and run a C program to read the keypad and write to the 8-character ASCII display on the laboratory computer. You will use these two functions in a demonstration program.

The Laboratory Computer

Each station in the lab is equipped with a PC as well as a microcomputer based on the Motorola 68000 microprocessor (the "lab computer").

The lab computer includes a 'bus' which allows various plug-in printed circuit interface cards to be connected to the microprocessor. These interface cards provide input/output facilities for the laboratory apparatus. In this first lab you will use the keyboard/display card. This card will be used as a control panel and status display in subsequent experiments.

The laboratory computers run a very simple "operating system" that does not support a compiler. However, it does accept commands to read and alter the contents of the lab computer's memory. Your software will run on the PC and will send commands to the lab computer over a serial interface. These commands will read and write specific memory locations which in turn will control the lab hardware.

The remainder of the laboratory computer system consists of a cabinet and a power supply.

Compiling your Program

Create a project file for your lab using the Turbo C editor. On the first line put the name of your C file (e.g. `LAB2.C`) and on the second line put the file name `IOLIB.LIB`. Save this file with the extension `.PRJ` (e.g. `LAB2.PRJ`).

The project file will allow your program to use the `speek()` and `spoke()` routines which allow the PC to read and write the lab computer's memory by sending commands over the serial port.

Each time you start up Turbo C you will need to define the project name using the Project→Project Name menu item.

If you do not do these steps then Turbo C will not be able to find the `speek()` and `spoke()` functions when you compile your program.

Reading and Writing I/O Ports

The peripherals on the lab computer are controlled by reading and writing values from/to specific locations in the lab computer's memory. These special memory locations are often called "ports" or "registers".

The keypad/display card has a control port and a data port. Each port can be treated as an 8-bit (1 byte) memory location. The addresses (locations in memory) of the control and data ports are:

port	address
data port	0xd0
control port	0xd1

The following two functions are available to your Turbo C program to access the lab computer's memory:

```
int speek( int address ) ;
int spoke( int address, int value ) ;
```

The `speek()` function allows you to obtain the value of the memory at a given address and the the `spoke()` function allows you to set the value of a memory location. To use these functions you should include the line `#include <iolib.h>` at the start of your program.

Display

The display has 8 character positions. Each position can display an upper-case letter or digit. To display a character on the display, you must write the

ASCII value of the character to be displayed or'ed with 0x80 (i.e. with the most-significant bit set to '1') to the *data* port. Then you must write the following sequence of three values to the *control* port:

- the segment position (the rightmost digit is position zero)
- the segment position or'ed with 0x08
- the segment position

The effect of writing this sequence of values to the control port is to cause a short pulse to appear on bit 3 (value 8) of the control port while the character position remains on the least-significant 3 bits.

For example, to display an 'A' in the leftmost position, you would write the following sequence of values:

address	value (decimal)
0xd0	'A'
0xd1	7
0xd1	15
0xd1	7

Display Handler Function

Write a function that displays the contents of an 8-character array on the lab computer's LED display. The definition of this function will be as follows:

```
void display( char string[] )
{
   ...
}
```

You may assume the string has at least 8 characters but you should not assume that it is zero-terminated.

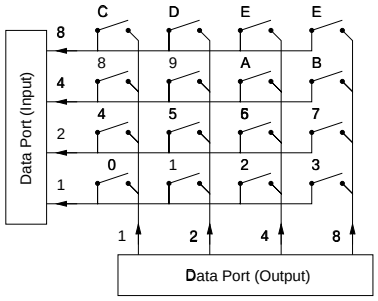
Keypad

The data port is really two separate ports (an input port and an output port) that appear at the same address.

Unlike a conventional memory location, the value read from an I/O port is *not* the last value written to that memory location. Instead it corresponds to the logic levels on the data port's input signals.

The keypad consists of 16 push-button switches arranged in a square matrix. Each pushbutton controls a switch which can short (make a connection between) a wire running horizontally and a wire running vertically.

The diagram below is a schematic of the keypad:



The values shown on each wire are the values read or written when a wire is set to '1'. The vertical wires are driven by the least significant four bits of the data port output while the horizontal wires are connected to the least significant four bits of the data port input.

Due to the keypad's construction a data port bit will be read as a '1' only if the switch on that row is pressed *and* a '1' has been written to the data port bit for that switch's column. You will have to come up with an algorithm to determine which key (if any) is being pressed. You must do this by writing and reading the data port.

Note that the upper four bits of the value read from the data port may not be set to zero.

Keypad Handler Function

Write a function `int rdkbd (void)` that waits until a key is pressed and returns a value corresponding to the number pressed (e.g. if the button with the label 'A' is pressed the function should return the value 10).

Before trying to detect whether a button has been pushed your function should wait until all buttons have been released. This will avoid having one button press detected several times.

Demonstration Program

Using the keypad and display handler functions, write a C program that lets the user enter a hexadecimal number from the keypad and displays it on the display unit. The program should do the following:

- Display as many characters your surname as will fit on the display starting at the leftmost column.

- When a key (0 to F) is pressed, scroll the display one position to the right and display the new character on the leftmost character position.

Hints

Make sure you understand the description of the hardware interface in detail before you begin to write and debug your program. You may want to write one or more short test programs while developing your program to verify that the hardware indeed operates as you expect ("bottom-up implementation").

Use `#define` to define constants such as port addresses or bit masks.

The following code waits for all buttons to be released:

```
spoke ( 0xd0, 0xF ) ;
while ( speek ( 0xd0 ) & 0xF ) { } ;
```

The following code sets the third column of the keypad matrix to a logic '1' and then test whether the top-most row is a logic '1'. If so, then the `E` key has been pressed.

```
spoke ( 0xd0, 0x4 ) ;
if ( speek ( 0xd0 ) & 0x8 ) {
   ...
}
```

You may use the lab at any time since no other groups are using the lab this term. The TA will only be available during the scheduled times.

Demonstration

Demonstrate the proper operation of the keypad/display demonstration program to the lab demonstrator. She will ask you some questions to make sure you understand the code you've written.

Write-up

Submit a program listing for the keypad/display demonstration program. It should include comments as described in Lab 1.

Keep the keypad handler and display routines for use in the next lab.