***Input from a PS/2 keyboard***

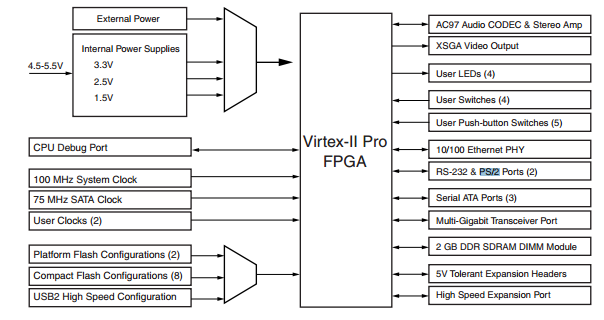
**Introduction**

A Xilinx Virtex II Pro FPGA Board with a XC2VP30 device and 896 package has been used. The kit has an onboard 4 light LED display and a 6 pin PS/2 serial port to support the keyboard used.

***Objective:*** The main objective is to learn to use the FPGA to accept input from a PS/2 keyboard by the above said development kit. This assignment basically makes us write Verilog code in order to display numbers on the LEDs when keys are pressed on the keyboard. Here, we just use the numerical keys placed on the keyboard below the function keys.

By the end of the experiment, we should be able to display the binary coded decimal on the available LEDs by pressing numerical keys on the keyboard.

***Background:***



**Fig. 1**: *Block Diagram of Virtex II Pro Development Board* ***[1]***

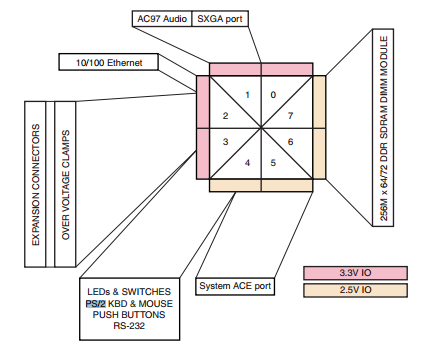
These are the onboard hardware that we are interested in for this assignment:

* PS/2 Connector
* Clock Generator
* LEDs

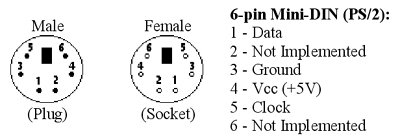
1. ***LED Display:***

Four LEDs are provided on board and each of them can be made to light up when a logic 0 for the corresponding led is passed. All four LEDs are used here since we have only 10 digits to display starting from 0 to 9.

1. **PS/2 Connector:**



**Fig. 2***: I/O Bank Connections to Peripheral Devices showing LEDs and PS/2 on #4* ***[1]***



**Fig. 3***: Pins on PS/2 connector* ***[2]***

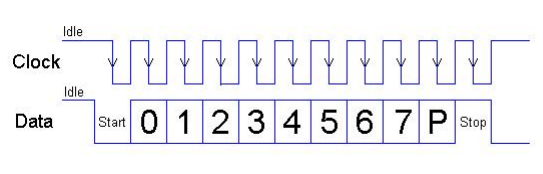
* The development kit has three serial ports on board namely:
* RS-232 ….. x 1
* PS/2 ….. x 2

RS-232 is a 9pin connector used to communicate to a host computer via COM port. There are also two PS/2 ports mainly to support the keyboard and mouse use. System. All of the serial ports are equipped with level-shifting circuits, because the Virtex-II Pro FPGAs cannot interface directly to the voltage levels required by RS-232 or PS/2. [1]

**Procedure**

This section of the report provides a brief description of the steps that were followed to implement the assignment. Xilinx ISE 9.2i design software was used for Verilog code write-up, synthesize and implementation and to burn the code to the FPGA kit.

1. Created a new project in ISE named ‘Lab3’. The logic implemented to write the code has been given below.
2. *Types of signals used:* There are two signals involved in this procedure, one is the clock signal and the other is the data signal which is received from the keyboard. This signal is sampled at the negative clock i.e. at the falling edge.



**Fig. 4***: Nature of Data and clock signal* ***[3]***

1. *Reading the keys:* The data signal from the keyboard is collection of 11 bits in which the main data is stored in the 8 bits starting from the 2nd bit and ending at the 9th bit as shown in the figure above. The rest of the bits indicate the start, end and parity. Each key has a unique code which is sent in the mention 8 bit data set. This data is sent continuously until the key is pressed followed by the ending bit 0.

|  |  |  |
| --- | --- | --- |
| Key codes in Hexadecimal | BCD | Decimal |
| 45  16  1E  26  25  2E  36  3D  3E  46 | 0000  0001  0010  0011  0100  0101  0110  0111  1000  1001 | 0  1  2  3  4  5  6  7  8  9 |

**Table 1**: *Keyboard scan codes [4]*

1. An idle counter determines when the transaction is finished, defined by the PS/2 clock remaining at a high logic level longer than half of the worst-case PS/2 clock period. Combinational error checking logic verifies the start bit, stop bit, and parity bit with the data. [4]
2. Using the LED: As mentioned in the previous section, the value of this output depends on the number pressed on the keyboard. 4 LEDs are used to display a value from 0 to 9, starting from 0, the number increments every time the key on the next value is pressed.
3. The logic is written in such a way that the LEDs become high if any key apart from the numerical keys below the function keys are pressed.
4. *UCF:* The UCF values were downloaded from [5] used.

|  |  |
| --- | --- |
| Signal | Value |
| Clock | AG2 |
| Data | AG1 |
| led[0] | AG4 |
| led[1] | AG3 |
| led[2] | AG6 |
| led[3] | AG5 |

**Table 2**: *UCF Values [5]*

1. Next, we check the syntax form design utilities 🡪 check syntax option in the processes window.
2. We then synthesize the written code. If no errors occur, we proceed to the next step. Else, we need to debug the code accordingly.
3. One the synthesis is finished successfully, we need to implement design.
4. Generate the programing file. The tools for these three steps can be found on the processes window.
5. A bit file is generated in the project folder. With the same name as the name of the project.
6. We now connect the FPGA kit to the system and the monitor to the FPGA kit and turn both the kit and the monitor ON.
7. We use the generated bit file and map it using configure device (iMPACT) tool available in the generate programming file tool.
8. The board is now ready for testing.

***Difficult part:***

The most difficult part of the assignment for me was to understand the functionality of the PS/2 keyboard. I didn’t understand that each read bit had to be shifted in order to access the next bit. After going through various materials on the internet, I was able to understand this functionality. The sources I could find have been mentioned on the last section of this report.

**Results**

The results were obtained as expected. The LEDs could independently be lighted using the keyboard. Also, when any key other than the numerical keys below the function keys was pressed, all the 4 LEDs would go high. The BCD would be displayed only with the use of these numerical keys and not with the ones on the num pad.

**Conclusion**

The obtained result supports the desired objective. All 10 digits were shown based on the key pressed and irrespective of the order in which the keys were pressed.

**References**

1. <https://www.digilentinc.com/Data/Products/XUPV2P/XUPV2P_User_Guide.pdf>
2. <http://www.computer-engineering.org/ps2protocol/>
3. <http://www.eecs.ucf.edu/~mingjie/EEL5722/EEL5722c%20lab3%20Tutorial.pdf>
4. <https://eewiki.net/pages/viewpage.action?pageId=28278929>
5. <http://www.digilentinc.com/Products/Detail.cfm?NavTop=2&NavSub=453&Prod=XUPV2P&CFID=18922620&CFTOKEN=ff23df9a79e4c2ac-061E4AC0-5056-0201-02D0AEB908347149>