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Keypad Interfacing and Behavioral Chip Design using VHDL

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***Abstract*: The matrix keypad is used for several embedded devices, telecommunications applications, microprocessor and microcontroller-based interfacing. The main advantage of the matrix keyboard is that it provides scalable and programmable environment to the programmer to minimize the number of pins. The 4 x 4 matrix keypad is following 16 push buttons which are processed row wise and column wise. The buttons can be interfaced to the 8 lines of any microcontroller. In the research paper, the keypad is interfaced to the SPARTAN-3 FPGA and programmed with the help of VHDL code to display the digits 1, 2, 3, A, 4, 5, 6, B, 7, 8, 9, C, *, 0, #, D. The programming is done in Xilinx ISE 14.2 software and simulated in Modelsim 10.0 software.**

***Keywords*: Keypad Interfacing, VHDL Programming, FPGA**

1. Introduction

The keypad [1] is widely used input peripheral in many embedded devices and different electronics circuits. The device considers the inputs as the alphabets and numbers and gives to the system for next level of processing. The key behavior in the keyboard [3, 4] depends on the bouncing and debouncing mechanism. When the user presses the key, it makes a contact. When the switch is released it disconnect to the contacts. The interfacing of the DTMF [8] can be understood as the interfacing of (4 x 4) Keypad used as an input device to read the pressed key by the user and to process the key in the system. The 4 x 4 keypad contains 4 rows (R_1, R_2, R_3, R_4) and 4 columns (C_1, C_2, C_3, C_4).

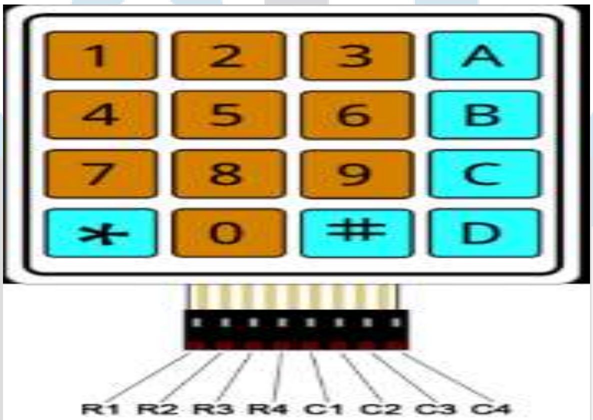

Fig1 Keypad(4 x 4)and connecter (2)

The row and column links are treated as the switch. As the key is pressed, it makes a connection between the corresponding row section and column section, and corresponding switching action is taken place. It is based on the principle of bouncing and debouncing. As the key is pressed it will make the connection and releasing the key will disconnect the connection. The fig 1 shows the keypad (4 x 4) and connectors arranged in (R_1, R_2, R_3, R_4 C_1, C_2, C_3, C_4) to provide the 8-bit binary code against each pressed key. Microprocessors and microcontrollers are used to ns essential to read

2. **Interfacing to Microcontroller and FPGA**

The interfacing of keypad with Arduino microcontroller with row and column selector logic. The digital pins '0' and '1' are referred for connecting rows. The microcontroller Arduino UNO board has digital pins '0' and '1' which are connected to the transmitter (Tx) and receiver (Rx) pins used for serial communication. Fig. 2 and Fig.3 shows an example of interfacing of the keypad to the microcontroller and FPGA.
In initial condition, all the switches are considered as in relax mode. So, there is no connection between row and column matrix. When a switch is pressed, the corresponding row and column are selected, short circuited and specific key is detected. The switching action of the keypad is shown in the fig. 3.6 in which the keys are working on the principle of key bounce and debounce [6] or making the connection and realizing the connection. As the key is pressed, it behaves s closed switch and closed and open switch as it is released.

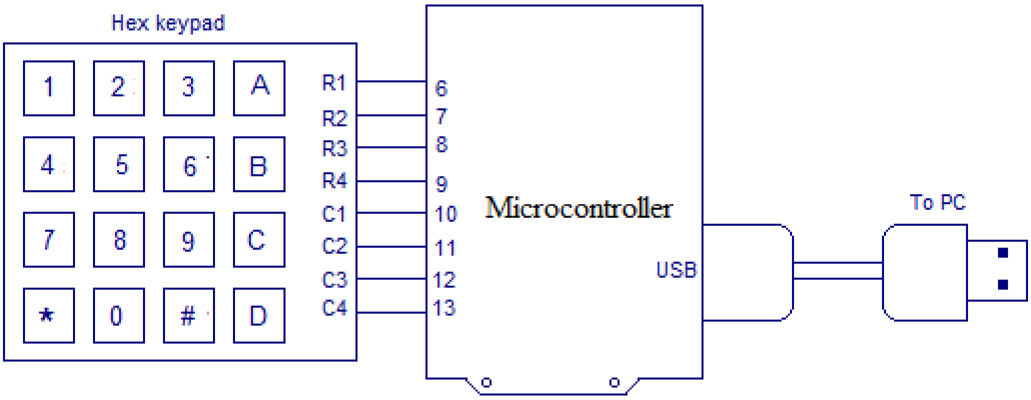

Fig. 2 Interfacing of Keypad with Arduino Microcontroller

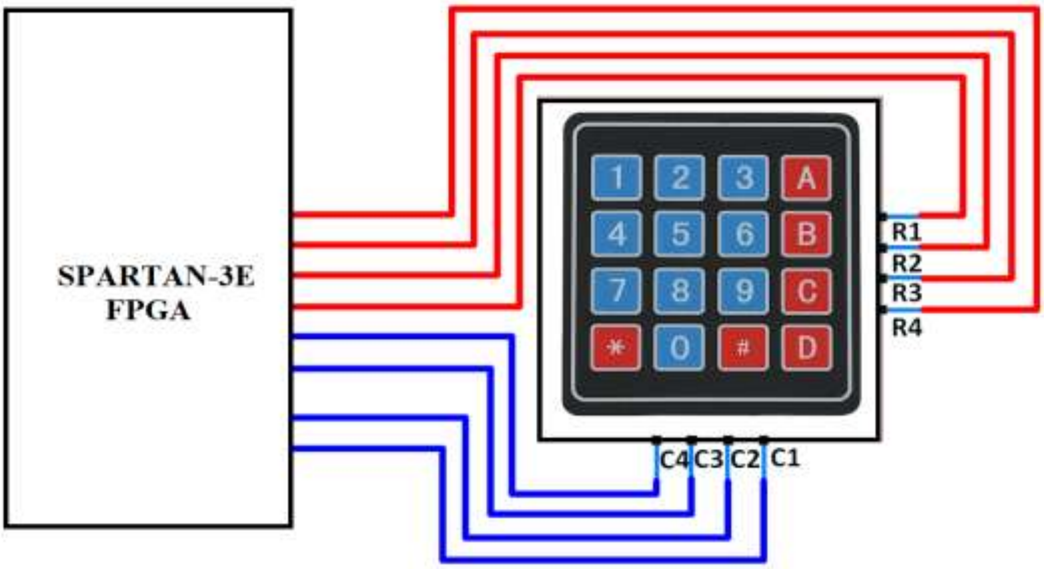

Fig.3 Keypad Interfacing to FPGA [2]

The following steps are followed in the processing of the key

Step-1: In the initial state all, the rows are'1' and columns as logic '0'. Then, (R_1, R_2, R_3, R_4 = "1111") and columns (C_1, C_2, C_3, C_4 = "0000"). The pressed key can be detected by as software mechanism. It is called column scanning.

Step-2: The software is scanning the pins associated with the columns of keypad. It detects the '0' in any of the columns and a press key is made in the column.

Step-3: If a specific column is low that means the key is pressed between the column and row and the program will store the contents of specific key.

Step-4 : For example, if R_1 = 0 and C_1 =0. It means the key '1' is detected**.** It is repeated for all the keys.

The Fig. 4 presents the row and column processing of keypad with key identification using bush buttons based on

Fig. 4 Push buttons as row and column processing

The hex keypad is having 8 communication lines (R_1, R_2, R_3, R_4 C_1, C_2, C_3, C_4) as row wise (R_1- R_4) and column wise (C_1- C_4). As a key is pressed the corresponding row and columns [6, 7] gets short circuited. The program which identifies the key is referred as column processing [9]. The digital pins of the microcontroller named as Pin-6, Pin-7, Pin-8, and Pin-9 are connected to the rows R_1, R_2, R_3 and R_4 of the keyboard. The microcontroller pins Pin-10, Pin-11, Pin-12, and Pin-13 are connected to the columns C_1, C_2, C_3 and C_4 of the keyboard. The microcontroller is interfaced to computer with the help of USB port. The circuit is driven from the USB itself and no other component is required for power circuit.

3.Simulation Results of Keypad

The VHDL code is written for the all keys detection in VHDL. The RTL view of the keypad is shown in fig. 5 and internal logic schematic is presented in fig. 6. The functional details of the all pins is listed in table 1. The main inputs of the chip are clock and reset. The selection of the specific key is dine using selection <3:0> input and column_values <1:4> and row_values <1:4> are stored as binary values.

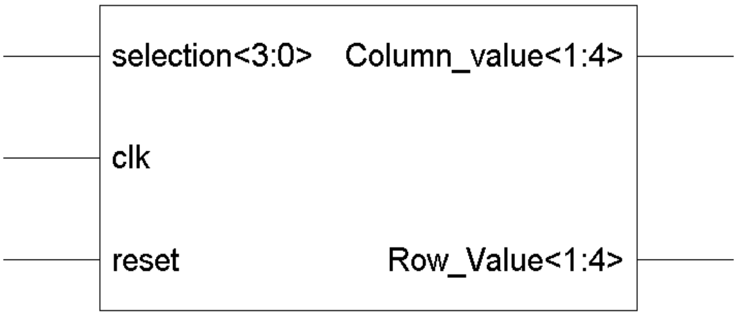

Fig. 5 RTL view of keypad

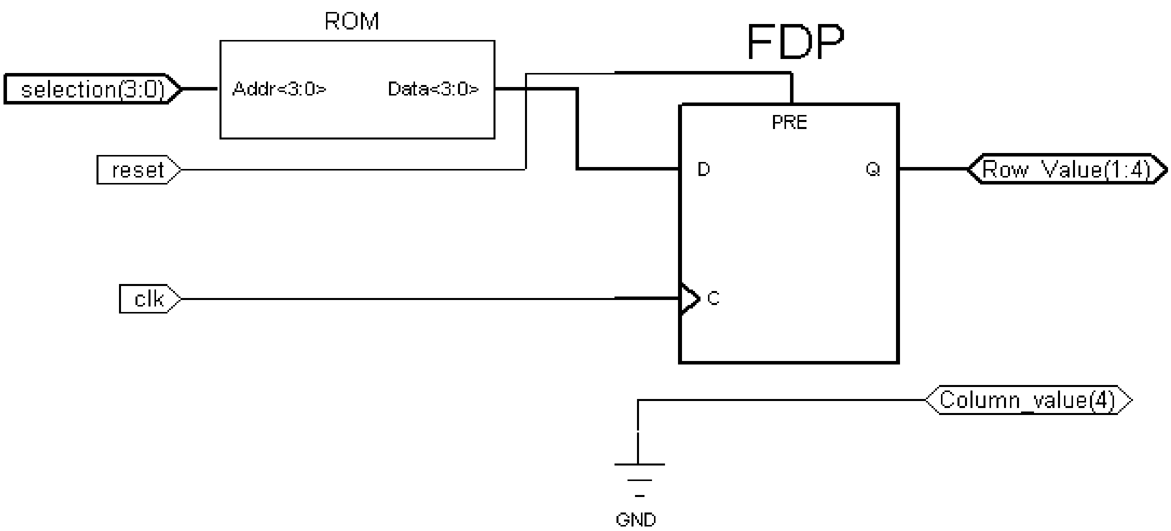

Fig. 6 Internal logic schematic of keypad

Table 1 Pin details of keypad chip

Pin	Direction	Description
Clk	Input (Std_logic)	It is the clock signal input used to provide the clock with 50 % duty cycle and works on rising edge.
Reset	Input (Std_logic)	It is the input to reset the contents and when reset = '1' the number will be zero, when reset = '0'. Then (R_1, R_2, R_3, R_4 = "1111") and columns (C_1, C_2, C_3, C_4 = "0000").
Selection<3:0>	Input (std_logic_vector)	It is 4-bit logic input to presents the dialing or dialed digit selection from "0, 1, 2, 3, 4, 5, 6, 7, 8, 9, *, #, A, B, C, D" as the key inputs of keypad.
Column_value<3:0>	Inout (std_logic_vector)	It is the 4-bit digital value against the column processing of the key when the
Row_Value<3:0>	Inout (std_logic_vector)	It is the 4-bit digital value against the row processing of the key

The Modelsim simulation of the keypad is shown in fig. 7. The figure presents the reset condition of the keypad. Fig. 8 Modelsim simulation of the hex keypad when the keys are pressed sequentially 1, 2, 3, A, 4, 5, 6, B, 7, 8, 9, C, *, 0, #, D.

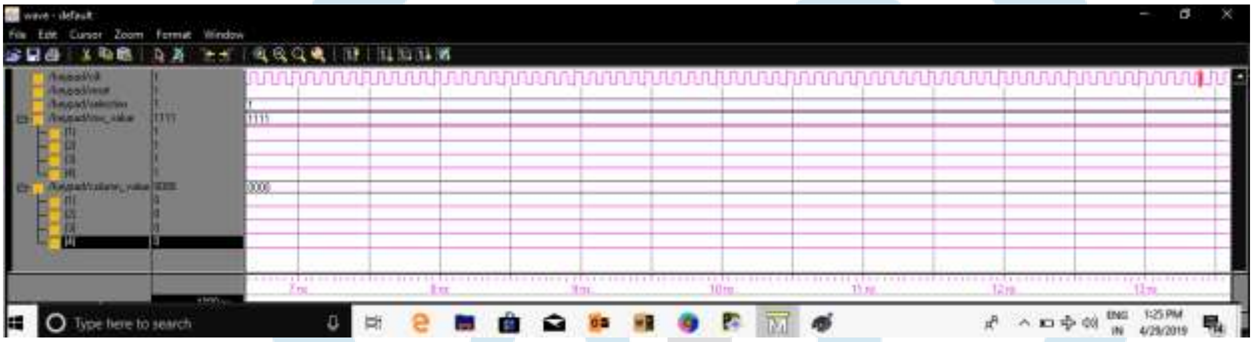

Fig. 6.7 Modelsim simulation of the hex keypad in initial condition

Fig. 8 Modelsim simulation of the hex keypad when the keys are pressed sequentially

1. Conclusions

The keypad is the essential part in embedded system-based applications. It provides input to may devices, microcomputers, microprocessor and microcontrollers. The keyboard interfacing with SPARTAN 3 FPGA is done successfully and simulated in Xilinx ISE 14.2 software. The key detection is understood with the behavior of key bouncing and debouncing with making and releasing the connections and interfacing is performed using 8 lines named as (R_1, R_2, R_3, R_4 C_1, C_2, C_3, C_4) as row wise (R_1- R_4) and column wise (C_1- C_4). The specific row and columns are shorted when the key is pressed. The Modelsim simulation for several key inputs is also done to verify the functionality of the design and tested on FPGA.

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