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16 Bit Microprocessor -Design and Simulations in VHDL

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Abstract:
This paper presents the design and simulation of a 16 bit processor. The design has been implemented using VHDL synthesis tool Xilinx 9.2i. Microprocessor is basically an electronic device that consists of ALU and control circuitry which is required to function as computer's CPU. Microprocessor is integrated circuit that interprets and executes the program instructions and behaves intelligently. The processor operates at a speed of the internal clock and the speed of the clock depends upon the no. of pulses per second. With each clock pulse, the processor performs the function that corresponds to the instruction. Thus the power of the processor can be calculated by no. of instructions executed per second. During the execution of instructions, data are stored temporarily in memory units called registers. The control signal is the electronic signals used for communication between various processor units during the execution of the instruction. This paper describes all the sections of microprocessor briefly and later executed the commands.

Key words*: 16 bit processor, ALU, comparator, shift register, CPU*

1. Introduction

16 bit microprocessor contains a number of basic modules which together completes the processor. The processor uses 16 bit data bus to communicate through different sections like General purpose registers, Arithmetic logic unit, CU (control unit), memory, comparator, program counter, address register, instruction register and shift register. With the advancement in integrated circuit technology the power of the processor has increased tremendously. Microprocessors are widely used in the embedded sector based on general purpose application and special purpose application. Microprocessors are used in instruments to make it intelligent using behavioral coding. The CPU consists of different sections which altogether help in performing various functions. The block diagram of CPU used has been shown in the figure.

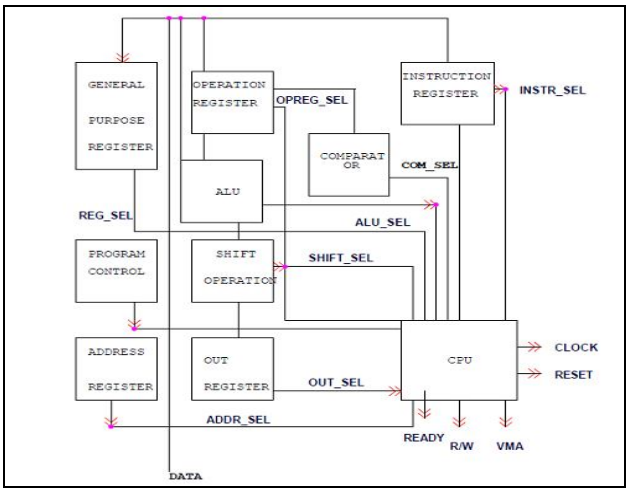

Figure 1: Block Diagram of CPU

2. ALU (Arithmetic Logic unit)

ALU is the most essential entity in processor since it is concerned with arithmetic, logical and decision making operations such as AND, OR, NOT, NAND, etc. It is considered to be the most important unit of processor as the entire processor depends on it. [3]

In ALU, two input data buses are used to provide data and the resultant output is obtained based on the desired operation and is send to the memory register for temporary storage of data. The design of an ALU decides how powerful CPU is, but at the same time it consumes large energy and generate heat. Therefore an efficient designing of ALU is necessary to make the CPU powerful. [2]

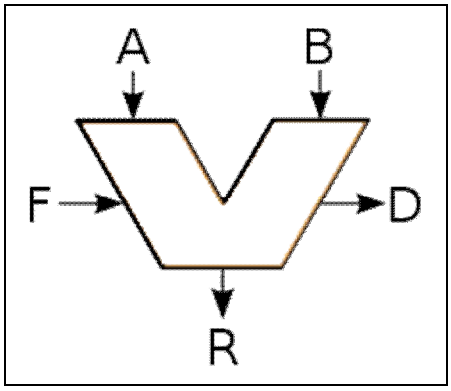

Figure 2: Schematic Symbol of ALU

3. Comparator Unit

The comparator is a unit which accepts two values and performs a comparison between those values to determine their equivalence to each other. It basically compares two values by using various logic gates and determines if the two bits are equivalent or greater or less than other. It uses two data bus and the resultant '1' or '0' will be given as an output. For instance, we can check if a number 'x' is greater than 'y' by selecting comparator's greater than (gt) function, and if ' x' is greater, than result would be '1' otherwise '0'.

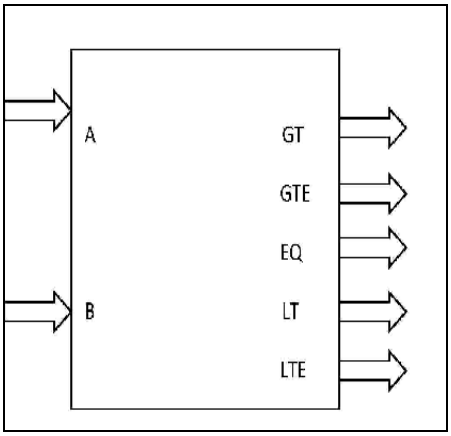

Figure 3: Schematic Symbol of Comparator

4. Control Unit

Control is the main processing unit and the most complex part of the CPU. It helps in controlling process of all the operations performed in the CPU. It directs all the input and output flow by issuing the signals and directing what is to be performed. It fetches codes for the instructions and determines the order of processing of data. This entity also provides timing signals and control cycle to other sections. [5] Control unit has only few inputs and lots of output since it has to coordinate the function of all other units. Control Unit operates on the basis of the input clock signal. It is a simple CPU inside a CPU executing simple micro routines stored in the control unit.

5. Register Unit

There are eight general purpose registers in 16 bit processor. They are the small amount of storage units available in CPU. Registers are used to store the value of instructions during processing. It acts as a memory unit for temporary storage of data. The number of registers available and their size leads to the determination of the power and speed of CPU. Data can be written in the register or can be read from the register by selecting the specific commands, for instance, wr can be used for writing a data and rd can be used to read a data by selecting the desired location in register where data is to written or read from. The result of ALU operation is stored here and can be later used for further process.

6. Shift Register

Shift registers are sequential circuits mainly used for storage of digital bits. In microprocessor it has been used for shifting and rotations of data in left or right direction as the clock signal. Shift and rotate has a very important function in microprocessor. They are used in multiplication and division module. Shift register has 16 bit input data bus, input sel for selecting which operation it has to perform and a 16 bit output data bus for displaying results.

7. RTL Schematics

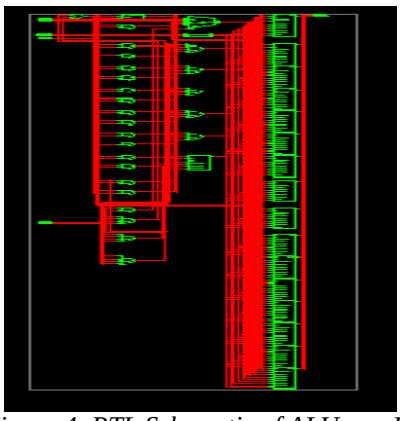

Figure 4: RTL Schematic of ALU

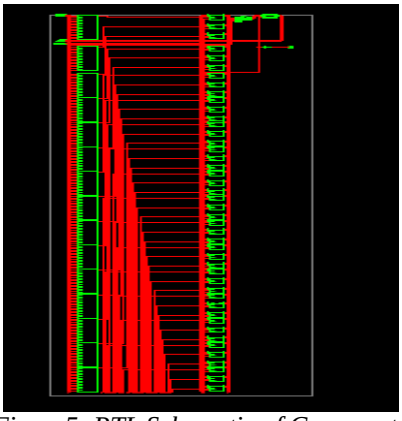

Figure5: RTL Schematic of Comparator

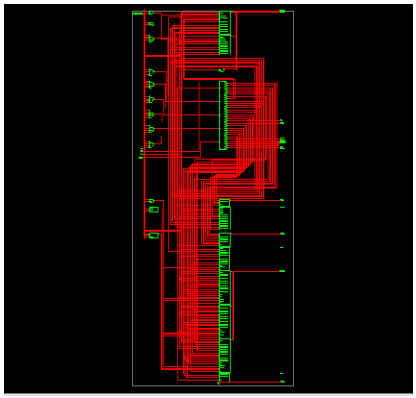

Figure 6: RTL Schematic of Control Unit

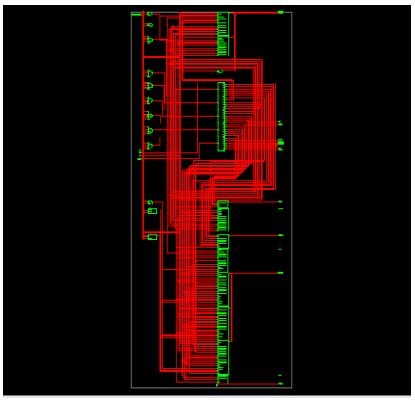

Figure7: RTL Schematic of Register Unit

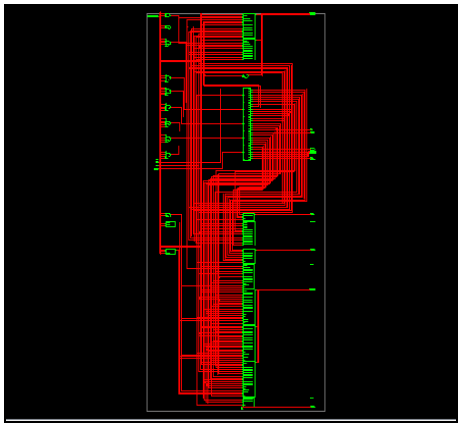

Figure 8: RTL Schematic of Shift Register Unit

8. Conclusion

I have designed a 16 bit microprocessor using Xilinx 9.2i and simulated the instructions. The simulation shows that the processor executes for all the functional units described in the paper. There is a scope in this processor by increasing the no. functional units and instructions with increased number of bits.

9. References

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