Cpr E 281 EC-Lab
ELECTRICAL AND COMPUTER ENGINEERING
IOWA STATE UNIVERSITY

CPU Scavenger Hunt
Due: December 2, 2022

Extra Credit Lab (extra 1.5%)

All problems below use the i281 CPU, which was designed specifically for this class. For this assignment you don't need to understand or modify the hardware design. You only need to find the components that are listed below in the wiring diagram and answer some questions about them. Write your answers and add your screen shots in the answer sheet.

Part 1: CPU Scavenger Hunt

Q1. Find the **adder** inside the ALU and answer the following:
- What is the name of this component?
- Is it a ripple-carry or carry lookahead adder?
- Can it also do subtraction?
- What is the size of its two operands in bits?

Q2. Find a 4-to-16 **decoder** and answer the following:
- What is the name of this component?
- Does it have an enable input?
- What are the names of its outputs 4 and 6?
- Can you guess what is its function in this CPU?

Q3. Find a **shifter circuit** and answer the following:
- What is the name of this component?
- What is the size of the input in bits?
- What happens to the most significant bit on shift left?
- What happens to the least significant bit on shift right?

Q4. Find the **program counter** and answer the following:
- What is the name of this component?
- What is the size of the output bus in bits?
- How many control lines does it have?
- What type of high-level circuit does it implement?

Q5. Find a **register file** with exactly 4 registers and answer the following:
- What is the name of this component?
- What is the size of each register in bits?
- What type of Flip-Flops are used to construct each register?
- The contents of how many registers can be read at the same time?

Q6. Find the two **clock dividers** for the **VideoGame_Clock** and answer the following:

- How are they implemented?
- They slow down the clock by a factor of X and Y. What are X and Y?

Q7. Find the **multiplexer** that sits after the ALU and takes the output of the ALU as one of its inputs. Then, answer the following:

- What is the name of this component?
- Where does the other input come from?
- What is the size of each input in bits?
- How many select lines does it have in bits?

Q8. Find the circuit that outputs the signal **DMEM_WRITE_ENABLE** and then answer the following:

- In which block is this circuit located?
- What is the Boolean expression for this signal?

Q9. Examine the **DMEM** box and answer the following:

- What are the names of the control lines for this box?
- What high-level component is used to store the data?
- What is the size of the data memory in bytes?

Q10. Find the **flags register** and answer the following:

- How many flags does it store?
- What are the names of these flags?

Part 2: Play a game of PONG!

It may be called a CPU, but it is actually a full-blown computer! It also has memory, which can store programs written in the assembly language for this processor. In this case, it is preloaded with the classic game PONG, adapted to a display consisting of only four 7-segment indicators.

Follow these steps to play the game:

- Download the file i281_CPU.zip and unzip it on your U: drive
- Go to the new folder and open the file i281_CPU.qpf in Quartus
- Double click on i281_CPU in the upper left
- Compile the project
- Turn the Altera board on
- Ensure that all SW switches are in the 0/off position
- Turn only SW16 to 1/on
- Use the Programmer to load the i281_CPU project onto the board
- Reset the CPU by pressing Key1
- Use switch SW6 to move the paddle up or down
- When the game ends you can press Key1 to play it again
- Enjoy!