

Client/Company/Organization: Alexander Stoytchev (ISU)

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Project Title:

Implement the i281 CPU in Hardware

Project Abstract:

Implement the i281 CPU in Hardware

Faculty Adviser: Alexander Stoytchev

The i281 CPU is an 8-bit microprocessor that was designed to support the curriculum in CprE 281: Digital Logic. The CPU was designed as a teaching tool. Everything is implemented down to the logic gates. The design runs on the Altera FPGA boards that are available in the labs in Coover hall. It is called a CPU, but it is actually a computer. It has memory and can run the sample programs that ship with it. The output is displayed on the 7-segment indicators. User input can be accepted through the switches on the Altera boards.

The goal of this project is to take that design and implement it in hardware. The results will be used to support and enhance the curriculum in Computer Engineering and Electrical Engineering. The design and specification documents could be used as educational materials or to support future lectures and labs.

One option is to implement it on breadboards similar to how this was done for a different 8-bit architecture in these youtube videos:

<https://www.youtube.com/playlist?list=PLowKtXNTBypFbtuVMUVXNR0z1mu7dp7eH>

<https://www.youtube.com/playlist?list=PLowKtXNTBypGqImE405J2565dvjafgIHU>

Another option is to design a PCB that implements the design.

The hardware implementation must be as close to the original design as possible, but some optimizations are possible. For example, the control logic box can be implemented as a lookup table mapped to EEPROM. The bus multiplexers could be implemented with tristate drivers. Additional LEDs could be used to illustrate the contents of registers and control signals.

Some design constrains: The clock should support variable speeds and manual stepping. It should be possible and easy to switch from one sample program to another. The PONG game must be included as well :)

The ideal team will consist of a mixture of EE's and CprE's that have taken CprE 281, preferably with Stoytchev in Fall 2019, 2020, or 2021 when the i281 CPU was introduced.

Supporting materials:

The CPU is described in the following sides:

https://www.ece.iastate.edu/~alexs/classes/2021_Fall_281/slides/41_i281_CPU_Architecture.ppt

https://www.ece.iastate.edu/~alexs/classes/2021_Fall_281/slides/42_Assembly_Language.ppt

https://www.ece.iastate.edu/~alexs/classes/2021_Fall_281/slides/43_ALU_and_PC.ppt

https://www.ece.iastate.edu/~alexs/classes/2021_Fall_281/slides/44_Intersection_of_Software_and_Hardware.ppt
https://www.ece.iastate.edu/~alexs/classes/2021_Fall_281/slides/45_Assembly_Examples.ppt

The FPGA implementation of the CPU is posted here:

https://www.ece.iastate.edu/~alexs/classes/2021_Fall_281/i281_CPU/i281_CPU_Hardware.zip

The assembly examples and the compiler from assembly to machine code:

https://www.ece.iastate.edu/~alexs/classes/2021_Fall_281/i281_CPU/i281_CPU_Software.zip

The i281 simulator:

<https://www.ece.iastate.edu/~alexs/classes/i281/index.html>

Expected Deliverables:

Working CPU that runs the sample programs.

Specialized Resources Provided by Client:

Expertise in the subject matter.

Anticipated Cost: _____

Financial Resources Provided by Client: None. The parts will have to be purchased with departmental funds. _____

Preferred Students for the Project:

- Electrical Engineering
- Computer Engineering
- Software Engineering
- Cyber Security Engineering
- Other:

Other Special Skills: Experience with breadboards and hardware design. General knowledge of how a CPU works.

Anticipated Client Interaction (estimate):

- 1 meeting per week
 - In person, Over the phone, Web / video conferencing
- 1 meeting per month
 - In person, Over the phone, Web / video conferencing
- 2 or more meetings per month
 - In person, Over the phone, Web / video conferencing
- 1 meeting per semester
 - In person, Over the phone, Web / video conferencing

Meeting ABET Criteria

Please rate the following statements as they relate to your proposed project:

0 – Not at all *1 – A Little* *2 – Somewhat* *3 – A Lot* *4 – Completely*

On this project, students will need to apply knowledge of mathematics, science, and engineering 0 1 2 3 4

This project gives students an opportunity to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability 0 1 2 3 4

This project involves students from a variety of programs, i.e., CprE, EE, and SE 0 1 2 3 4

This project requires students to identify, formulate, and solve engineering problems 0 1 2 3 4

This project gives students an opportunity to use the techniques, skills, and modern engineering tools necessary for engineering practice 0 1 2 3 4

Project Approval – for use by ECpE Senior Design Committee

- Approved: sddec22-proj035
 - Project Assigned: _____
 - Advisor(s) Assigned: _____
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