
The Design Project is based on the following scenario. Progress of the Design Project will be evaluated in two stages called Progress Report I and 2. You may make any assumptions and indicate them very clearly in your submissions.

Scenario

Fuzzy Processing Unit (FPU) is a specialized hardware designed to accelerate artificial intelligence and machine learning applications. They execute fuzzy logic operations. One of the principal operations is matrix operation. Further, making the matrix operations faster will improve the execution time of these applications. Therefore, having a specialized Fuzzy Matrix operation Unit (FMU) will increase the performance of FPUs.

Fuzzy Matrix operations are extensively used today in many applications. Medical diagnosis, Decision-making, Learning techniques, Appointment procedures, Yoga are some of those applications. Standard microprocessors take a considerable number of operations to do any fuzzy matrix operation. Moreover, when the matrix becomes larger, the time taken for any matrix operation will increase exponentially. Therefore, making these operations faster will improve the execution time of those applications. Your task is to design a Fuzzy Matrix Unit (FMU). Accordingly, anyone can use FMU for supporting general microprocessors or integrating FMU into special purpose processors.

We can define fuzzy addition (+), fuzzy multiplication (\cdot), and fuzzy subtraction ($-$) as follows:

$$\begin{aligned}a + b &= \max(a, b), \\a \cdot b &= \min(a, b), \quad \text{and} \\a - b &= \begin{cases} a & \text{if } a > b \\ 0 & \text{if } a \leq b. \end{cases}\end{aligned}$$

There should be special instructions to handle fuzzy matrix operations such as addition, subtraction, and multiplication. Moreover, you must provide other supporting instructions for matrix operations. For example, instructions for defining the size of a matrix, moving elements of a matrix from memory to registers and vice versa and creating submatrix and any other branching instructions.

You have to do all calculations through registers to obtain maximum performance. You are free to include any special functional units. However, you must describe any specific unit or component included in your design. When answering the questions, clearly state any other assumptions you made, if any.

Design Project
Due date: 16th November 2025

Design the **processor for Fuzzy Matrix Unit (FPU)**, according to the scenario in the Assignment 1. You are advised to use the design that you have already done in the Design Project Progress 1 and 2.

Clearly state the following in your report.

1. Brief description of the project and its design (from the Design Project Progress #1 and #2)
2. Design of the control unit of the processor
3. Design Methodologies used (i.e. Timing diagrams, State diagrams, Truth tables etc.)
4. Design Cycle (i.e. Design steps etc.)
5. Compiled version of VHDL coding
6. Test benches for the processor
7. Social impact and environmental issues
8. Performance
9. Cost of the design