

AI-FPU Verification Environment

User Manual Guide

Designed By:

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1. Introduction

Welcome to the AI FPU Verification Environment! The AI FPU is a powerful hardware element with a floating point unit that is useful for many high-performance computing applications, especially those involving numerical computations. It has 22 RISC-V instructions and is designed to be quick and efficient, allowing for quick and accurate computations.

The AI FPU has a complex design, its command-line interface may be difficult for some users to verify this design. To make things easier, we created a Graphical User Interface (GUI) that simplifies the Verification of the AI FPU. With the GUI, you can easily set parameters, perform tests, and automate processes that would otherwise be time-consuming and challenging. Our user-friendly interface puts everything you need at your fingertips, making it easy to use the AI FPU efficiently.

The AI FPU Verification Environment was made to help you generate RISC-V instructions and compare them to the ISS. It ensures that the design is accurate by testing it on a variety of data points. It's a great design for confirming the accuracy and performance of the FPU design, no matter your experience level. Get started today and take your AI FPU verification to the next level!

2. Cloning AI FPU Verification Environment

Clone the AI FPU Verification Environment Git repository from the given URL.

https://github.com/merlds/SAP_FPU_Verification.git

Command to clone the repository

```
git clone https://github.com/merlds/SAP_FPU_Verification.git
```

3. Requirements

To execute the **AI FPU Verification Environment** Graphical User Interface (GUI) on your server/computer you will require the following Python packages.

- 1) PyQt5
- 2) Paramiko
- 3) SCP

Either you can install these packages manually or run the requirement.txt file available in the repository which will install the required packages for you by running the following command.

```
pip3 install -r requirement.txt
```

4. Getting Started with AI FPU Verification Environment

4.1 Launch GUI

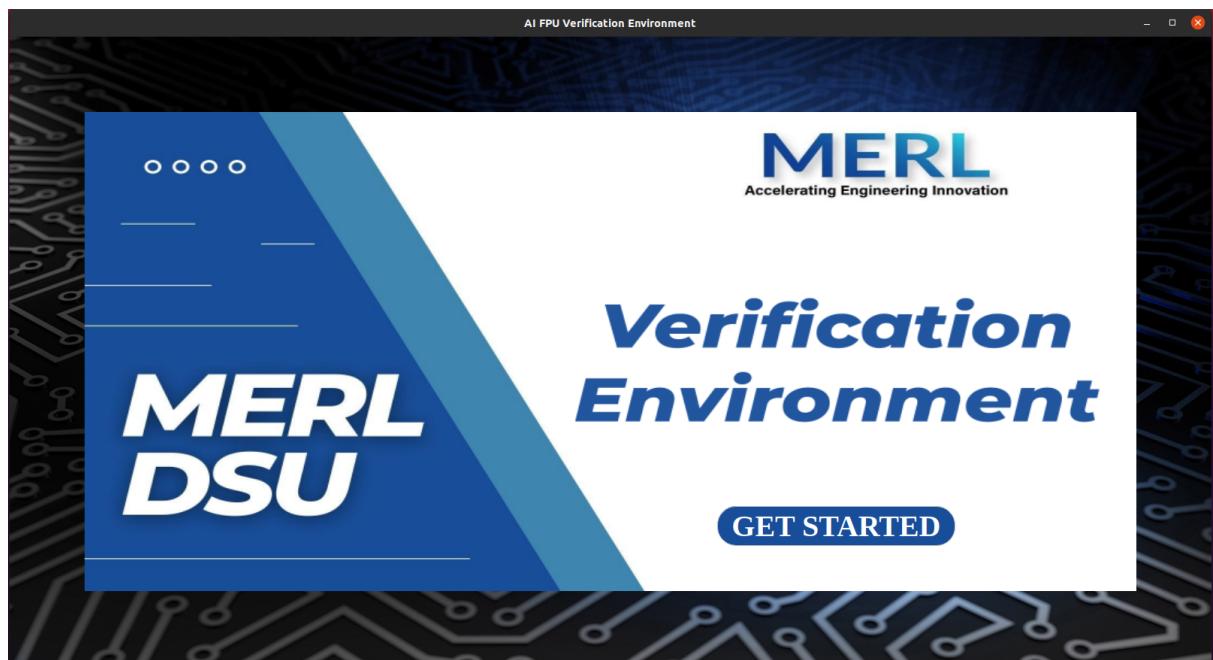
If you are using the Linux operating system you have to give the executable rights to the file before launching the GUI by running the following command.

```
chmod +x AI_FPU_Verification_Environment
```

Launch the GUI by executing the following command on the terminal.

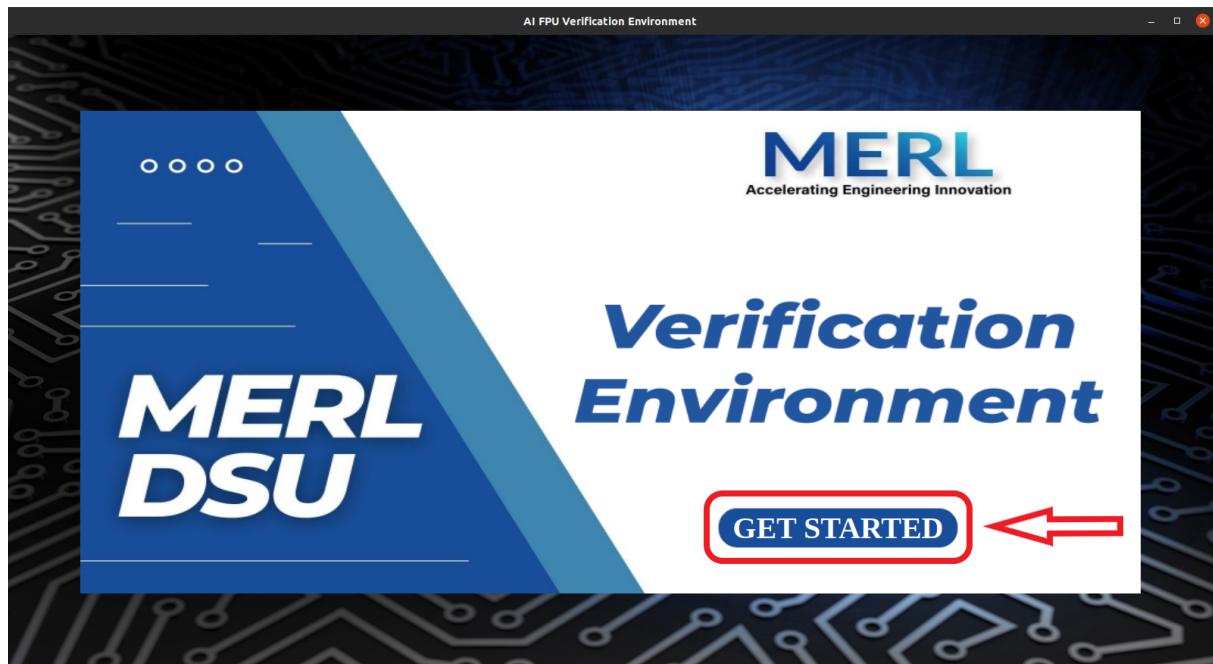
```
./SAP_FPU_Verification/AI_FPU_Verification_Environment
```

The GUI interface window will appear as shown below:



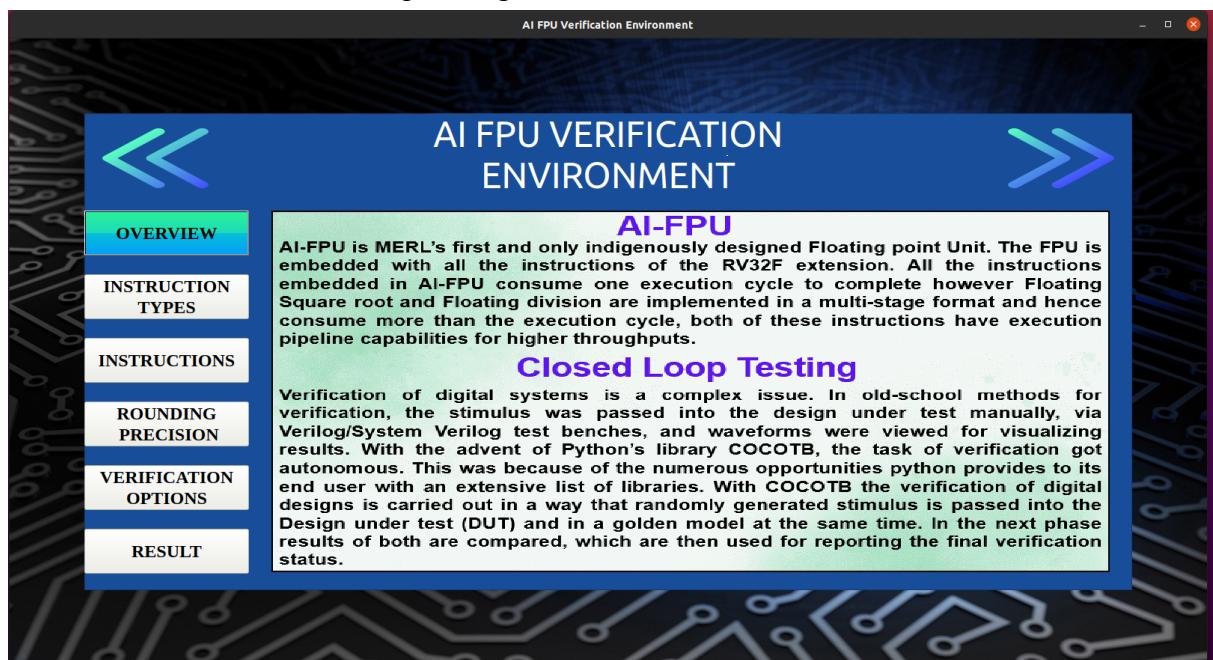
4.2 Start Page

Click on the “GET STARTED” button indicated in the below figure to start the AI FPU Verification Environment.



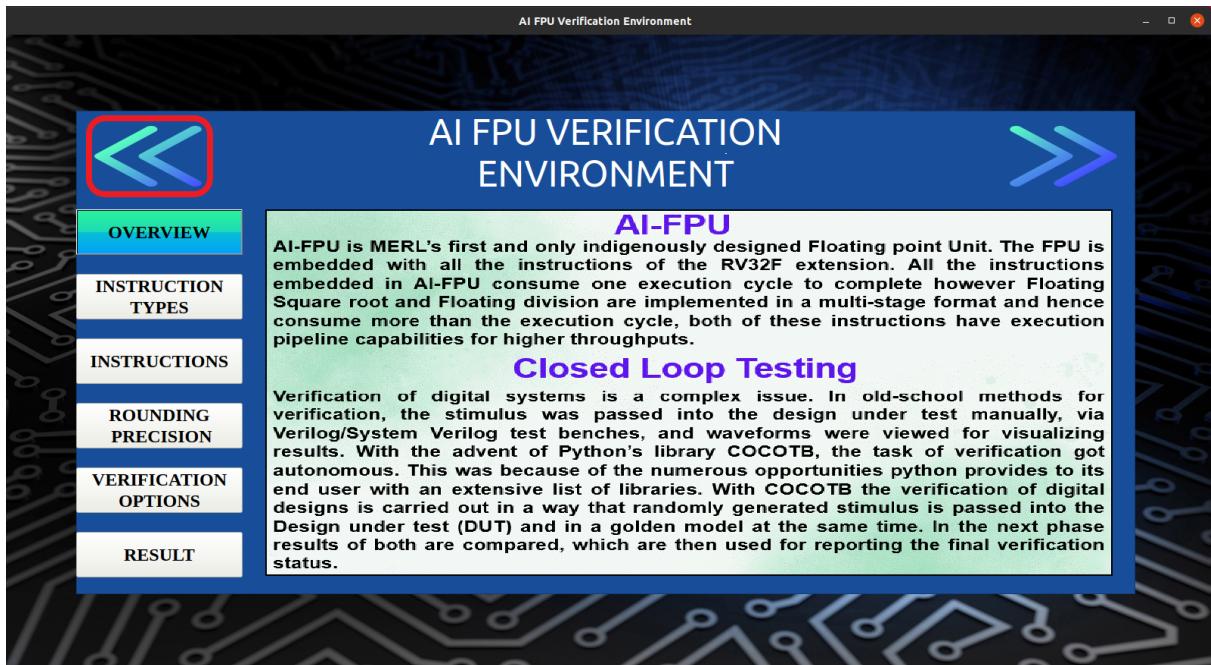
4.3 Overview

After clicking "GET STARTED", you'll see the main window of the GUI. This window gives you an overview of the AI FPU design and its capabilities, including a brief introduction to closed-loop testing.

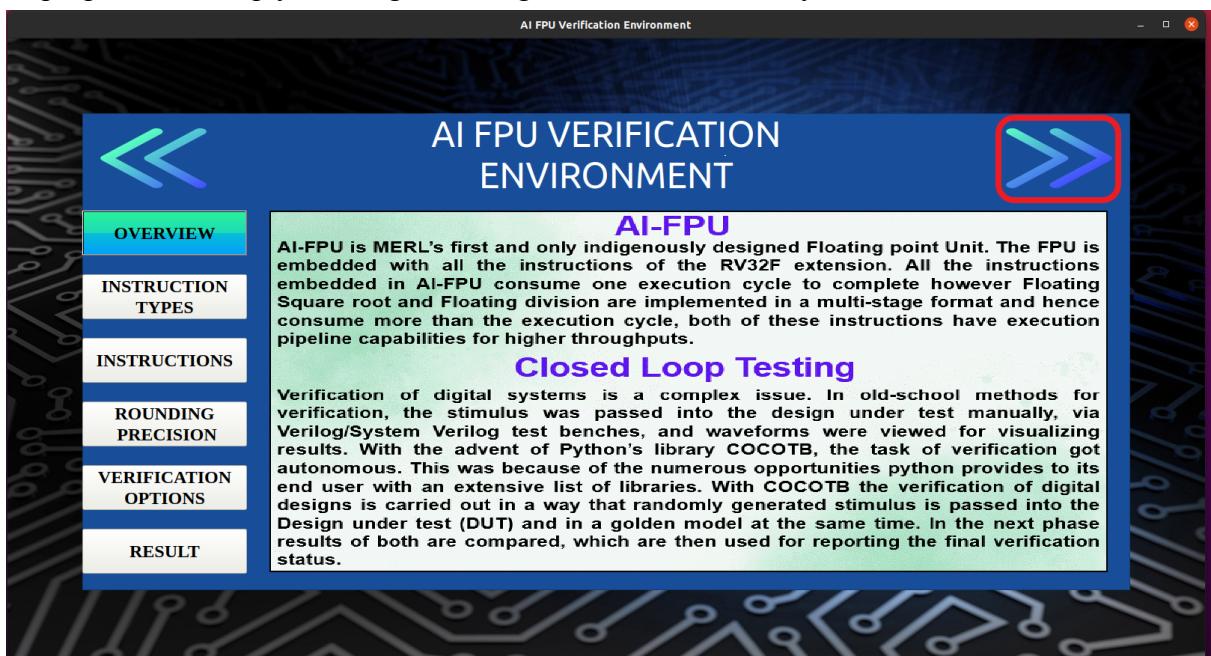


4.4 Navigation

The back button is on the left side of the screen, with a red arrow encircled. It's used for navigation, and you can use it to go back to the previous screen or step in the process. This is useful if you need to change something or review previous settings, and it makes using the GUI easy and smooth.

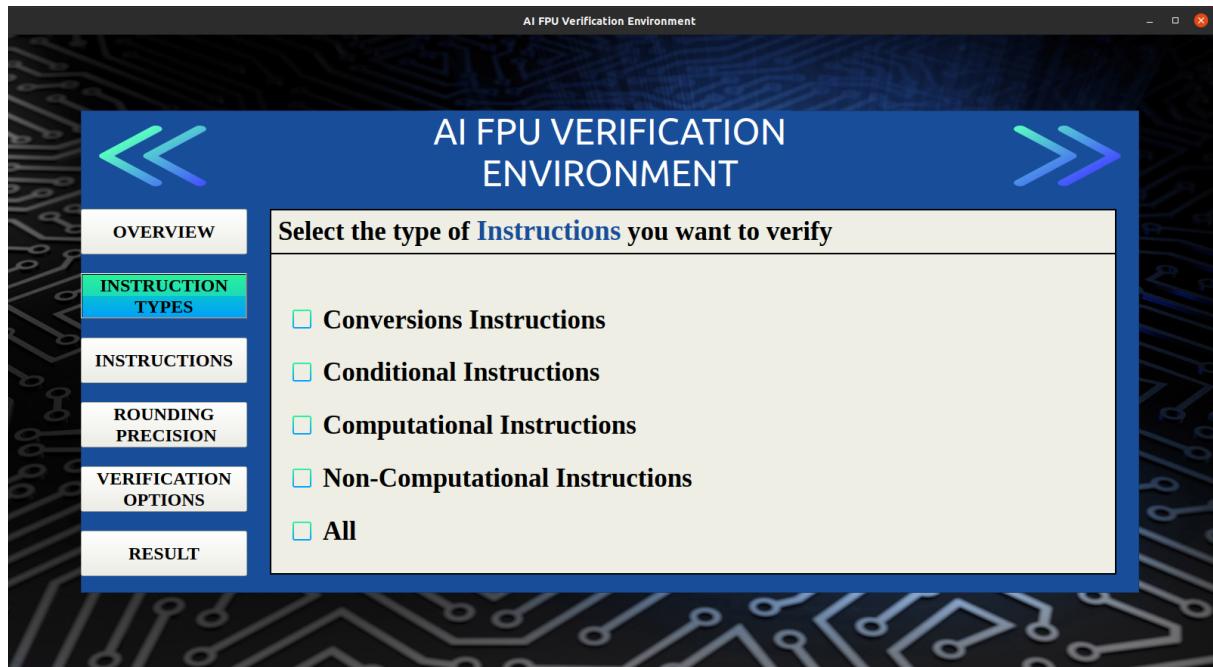


You will find a blue button encircled in red on the right-hand side of the screen. This is the next button that lets you move forward to the next screen or step in the process. Its purpose is to help you navigate through the GUI more easily.



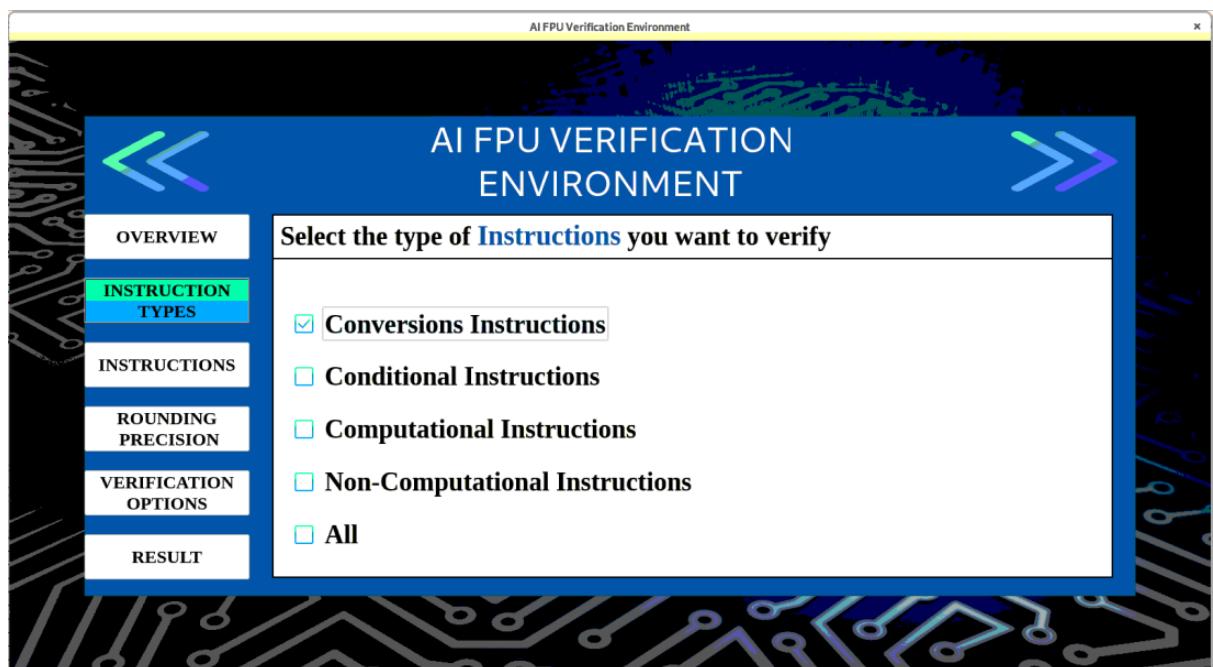
4.5 Instruction Types

After clicking on the Next Button, a window will appear with different options for generating instructions, such as **Conversion**, **Conditional**, **Computational**, and **Non-Computational**. You can choose specific types by clicking on them or selecting all of them at once.



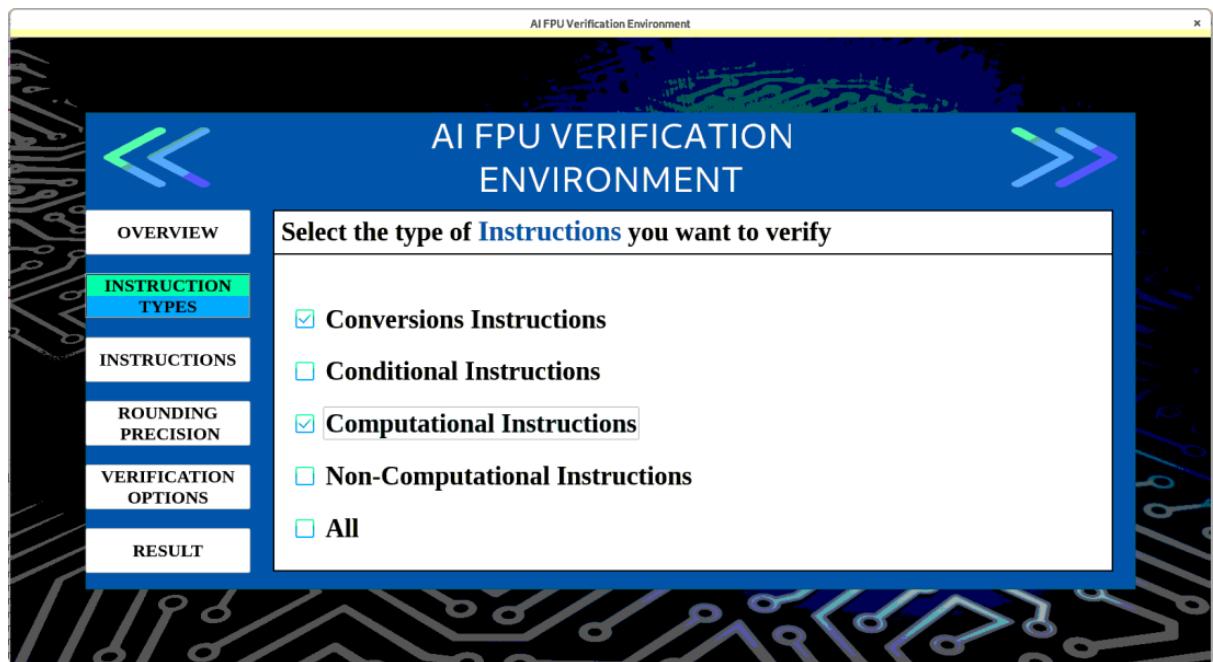
4.5.1 Selection of Single Instruction Type

If you want to verify a specific instruction type you can select the checkbox as shown below.



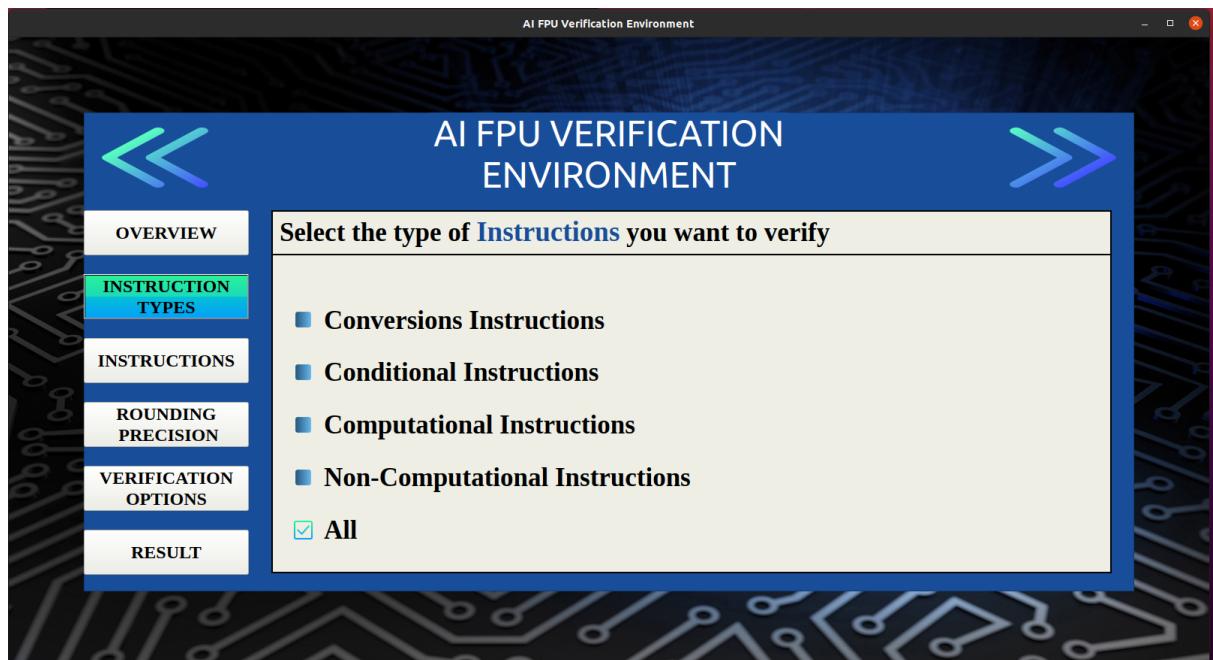
4.5.2 Selection of Multiple Instruction Types

If you want to verify multiple instruction types you can select the checkboxes as shown below.



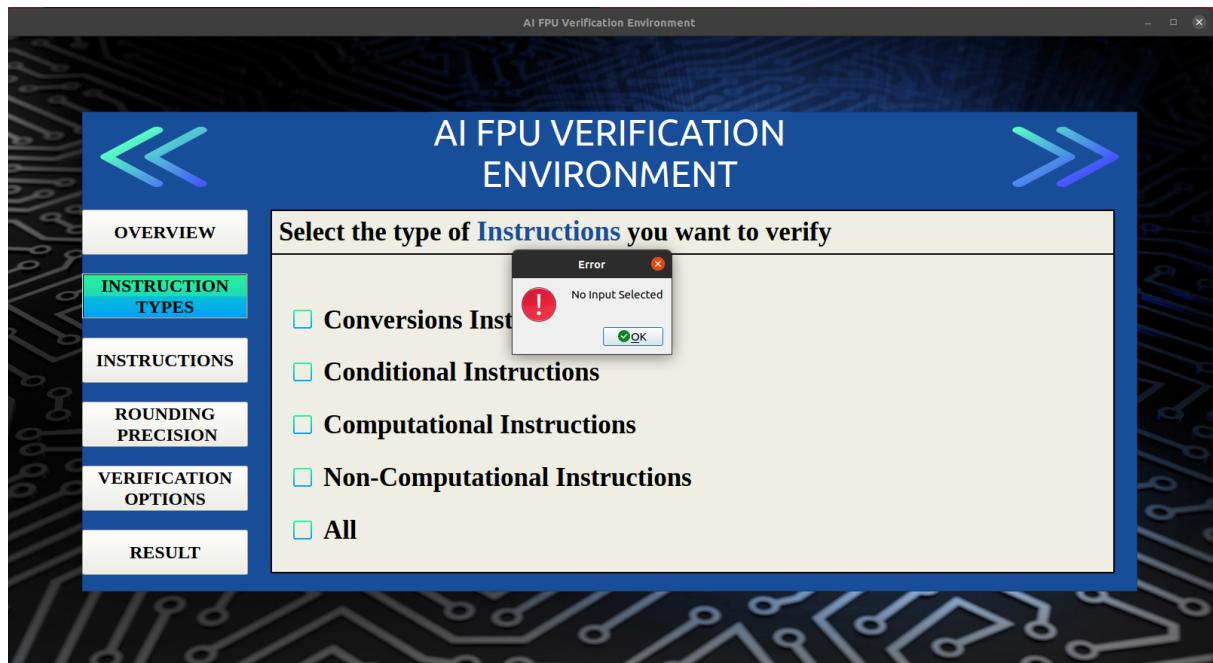
4.5.3 Selection of All Instruction Types

If you want to verify all of the instruction types, tick the "All" checkbox, as shown below, which will select all of them by default.



4.5.4 Error Generation

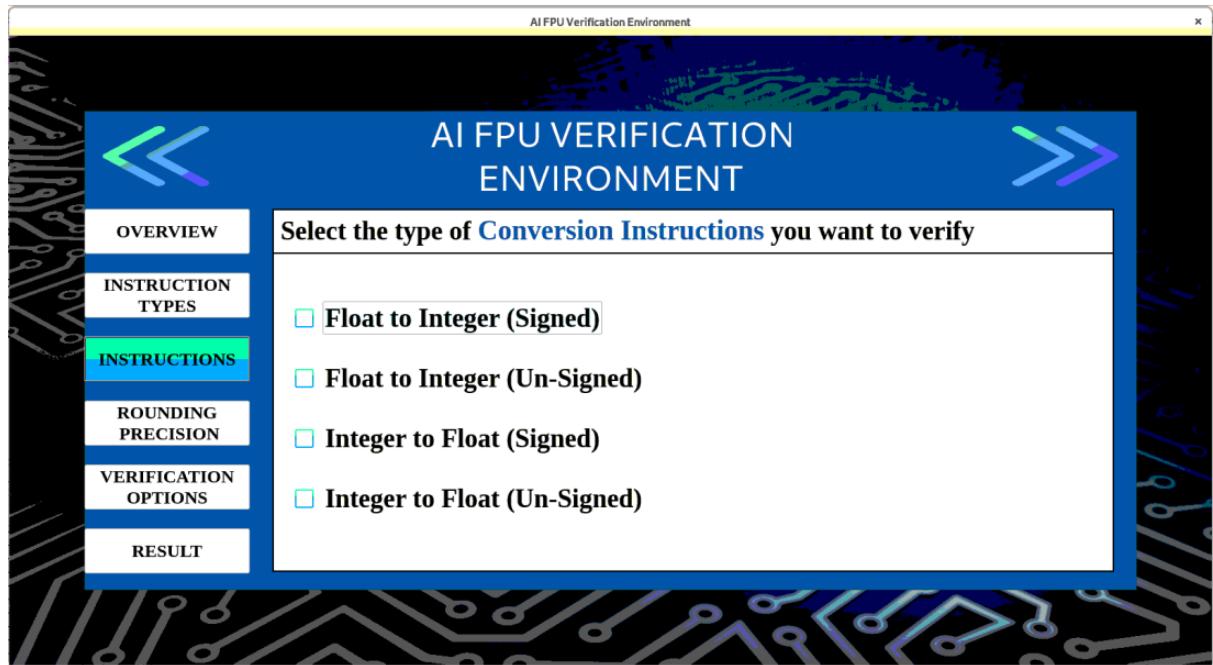
If you try to go to the next step without choosing any instruction type, you'll see an error message indicating **No input is Selected**. Select at least one option to go to the next step. It's important to select relevant types for accurate testing and not waste time and resources on unnecessary ones. Choosing the correct instruction types helps you verify the design's functionality and reliability.



4.6 Instructions

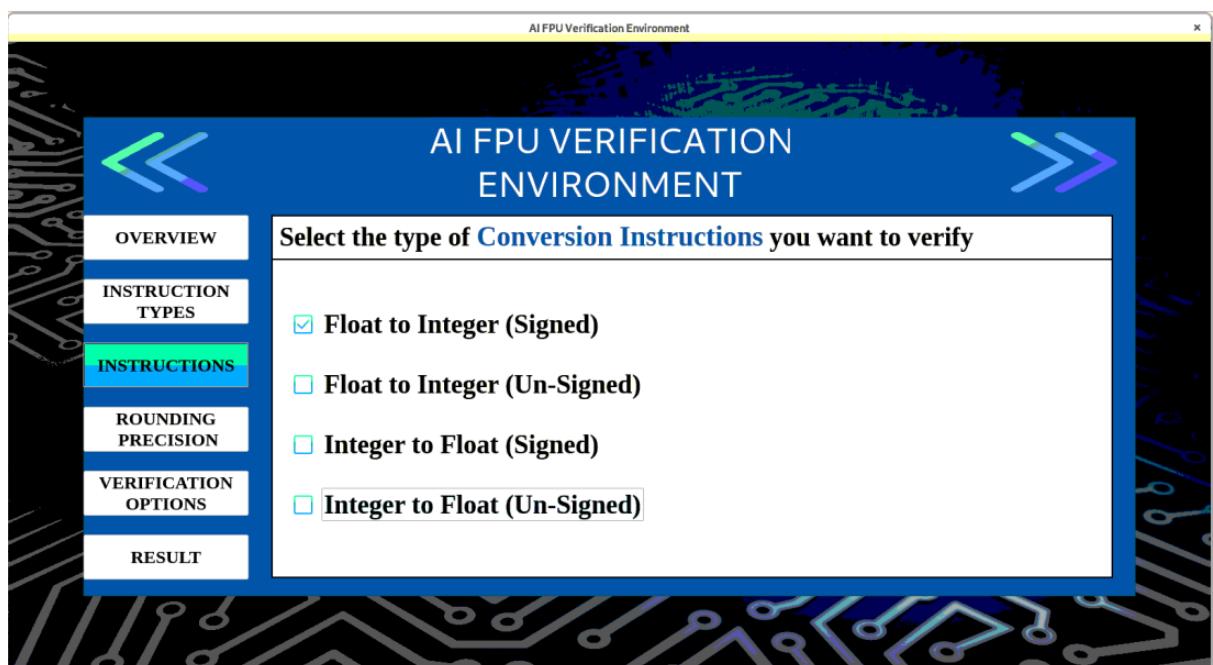
4.6.1 Conversion Type Instructions

The **Conversion** Type Instructions has the following instruction as shown below. Based on your requirements, you can choose any of these options.



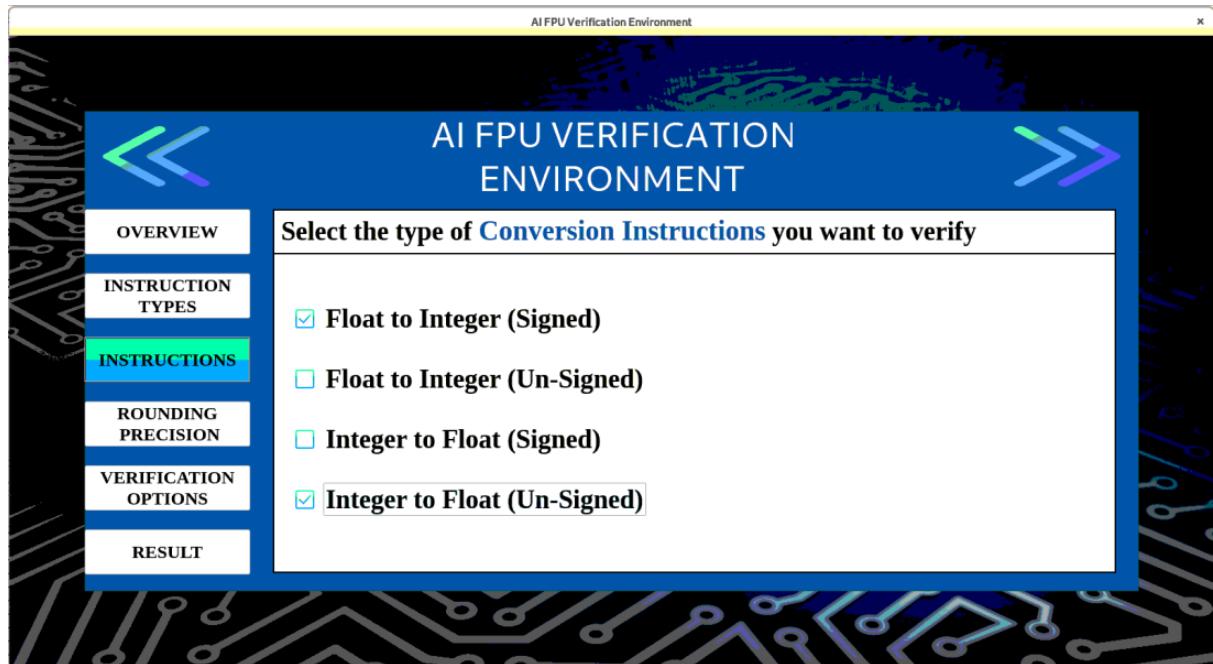
4.6.1.1 Selection of Single Instruction

If you want to verify a specific instruction you can select the checkbox as shown below.



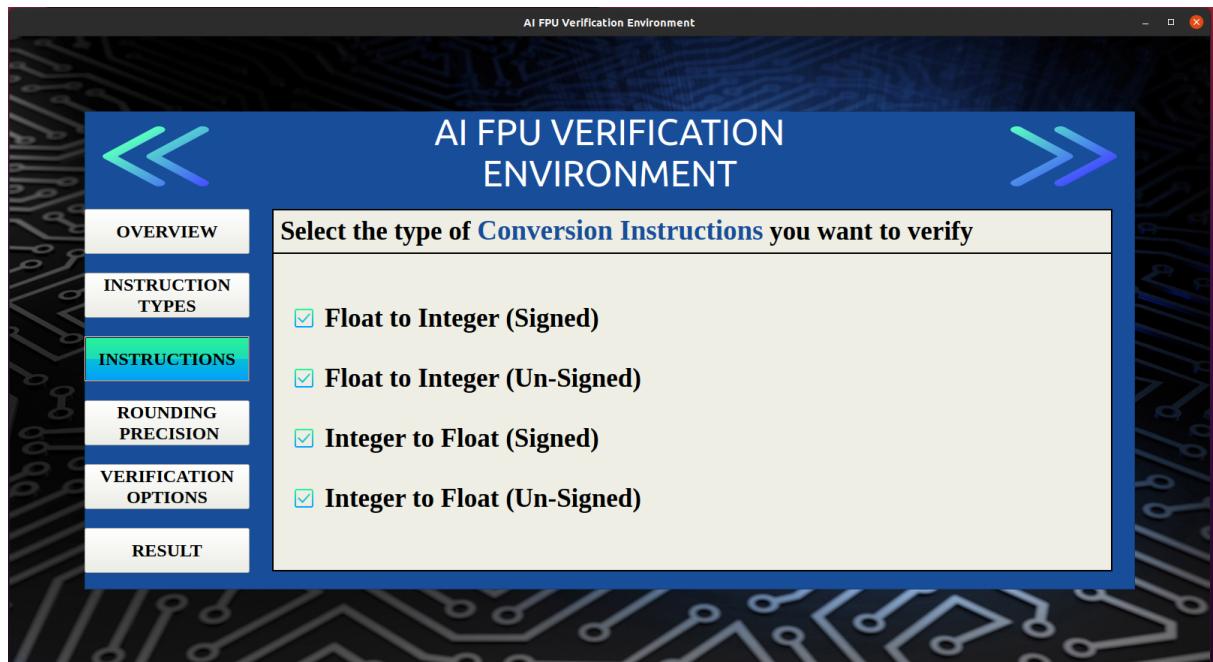
4.6.1.2 Selection of Multiple Instructions

If you want to verify multiple instructions you can select the checkboxes as shown below.



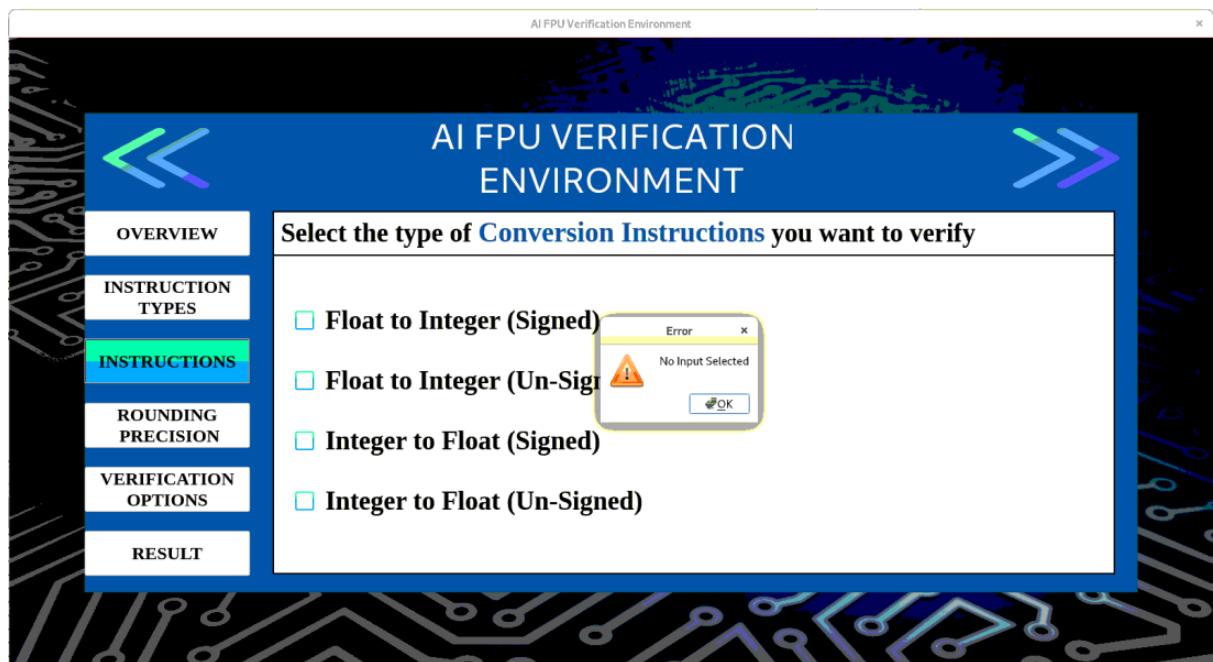
4.6.1.3 Selection of All Instructions

If you want to verify all the instructions, select all checkboxes as demonstrated in the image below.



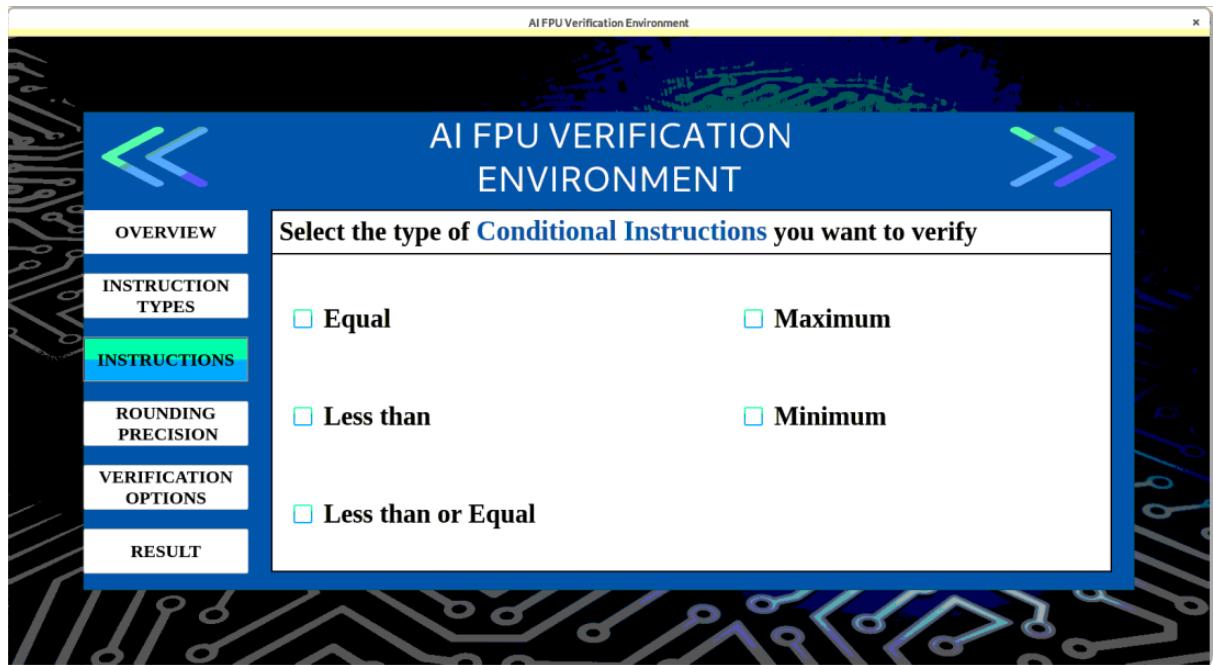
4.6.1.4 Error Generation

If you try to go to the next step without choosing any instruction, you'll see an error message indicating **No input is Selected**. Select at least one option to go to the next step.



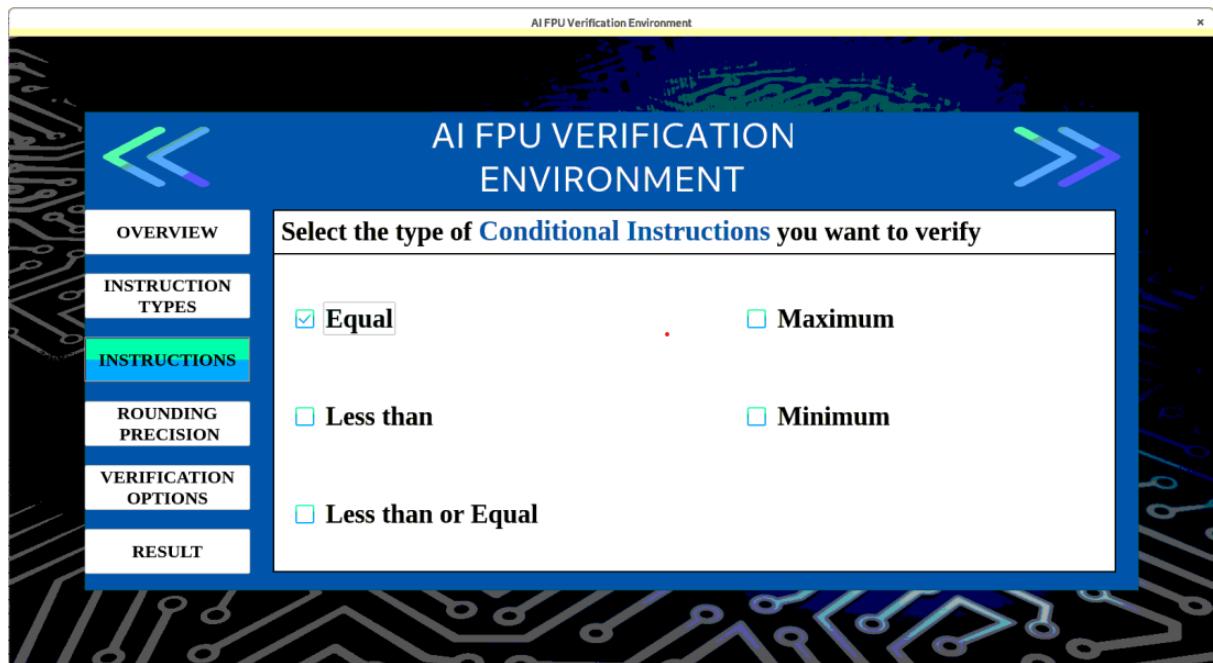
4.6.2 Conditional Instruction

The **Conditional** Type Instructions has the following instruction as shown below. Based on your requirements, you can choose any of these options.



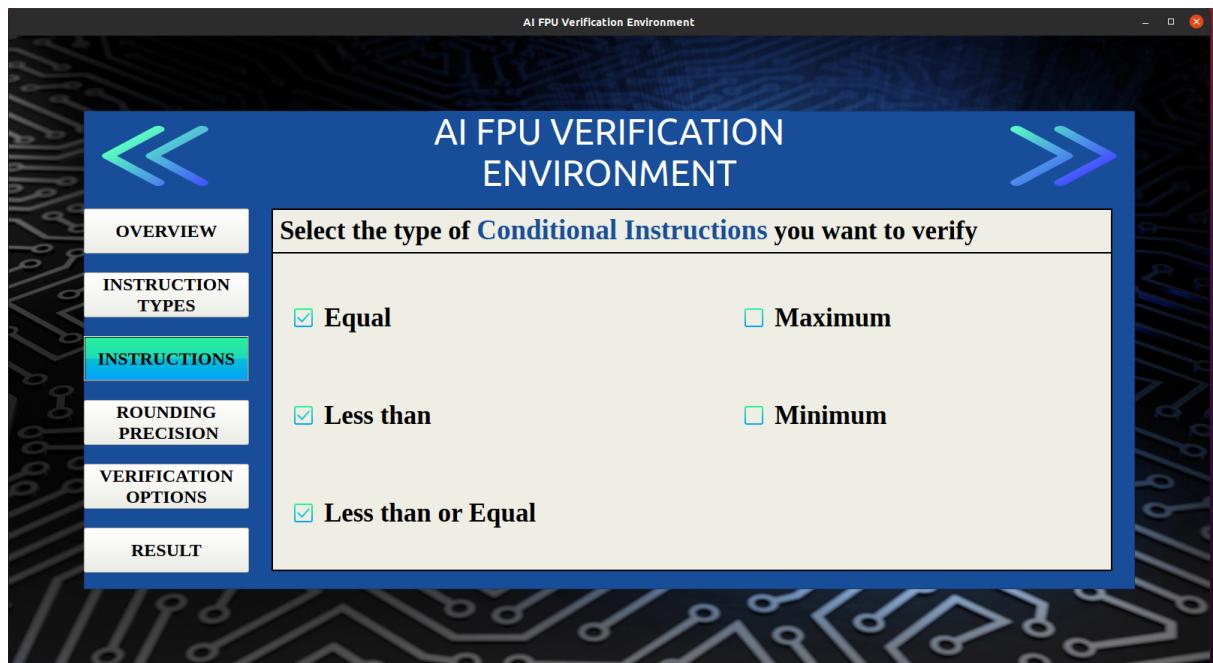
4.6.2.1 Selection of Single Instruction

If you want to verify a specific instruction you can select the checkbox shown below.



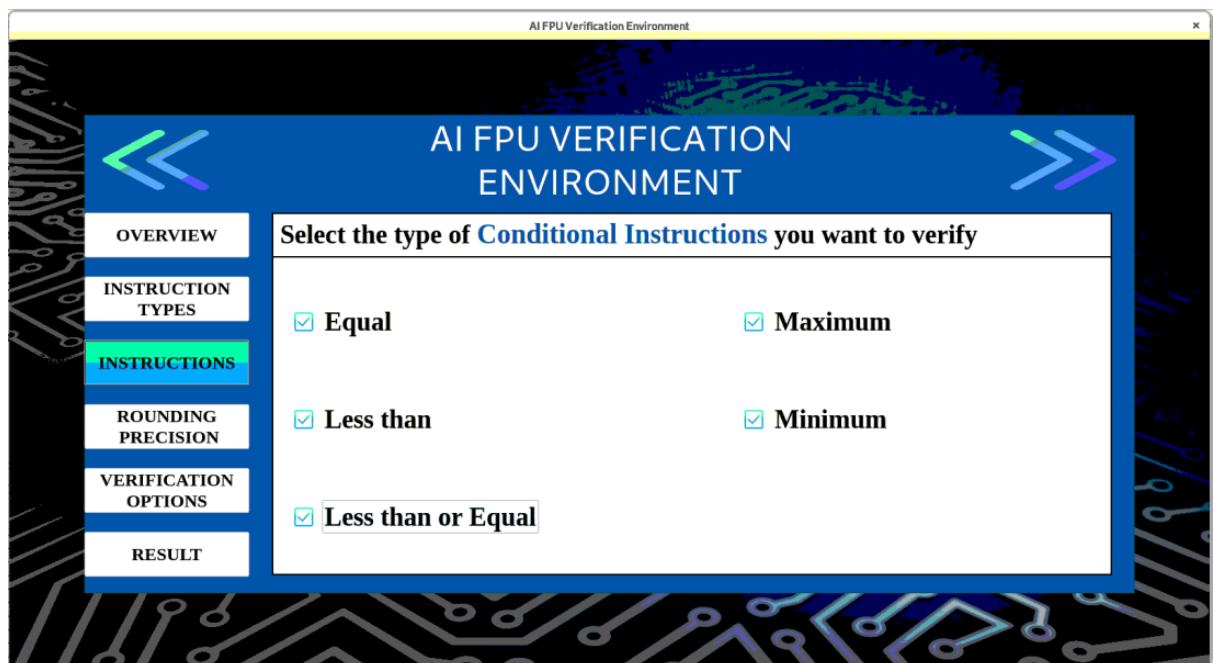
4.6.2.2 Selection of Multiple Instructions

If you want to verify multiple instructions you can select the checkboxes as shown below.



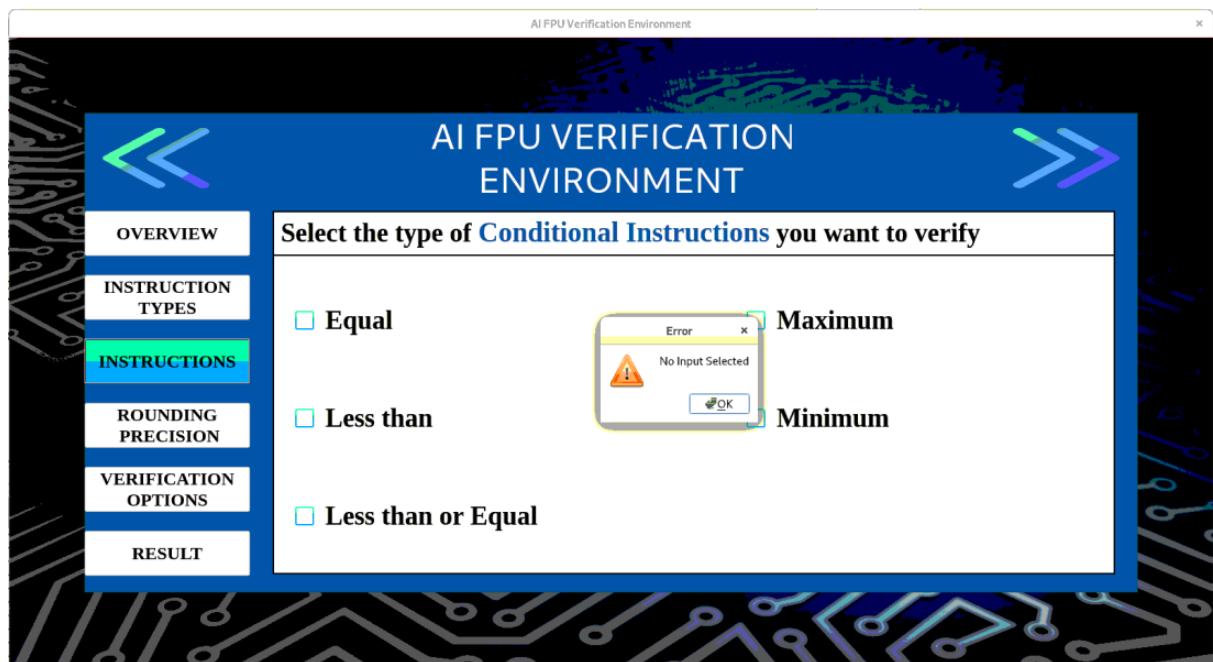
4.6.2.3 Selection of All Instructions

If you want to verify all the instructions, select all checkboxes as demonstrated in the image below.



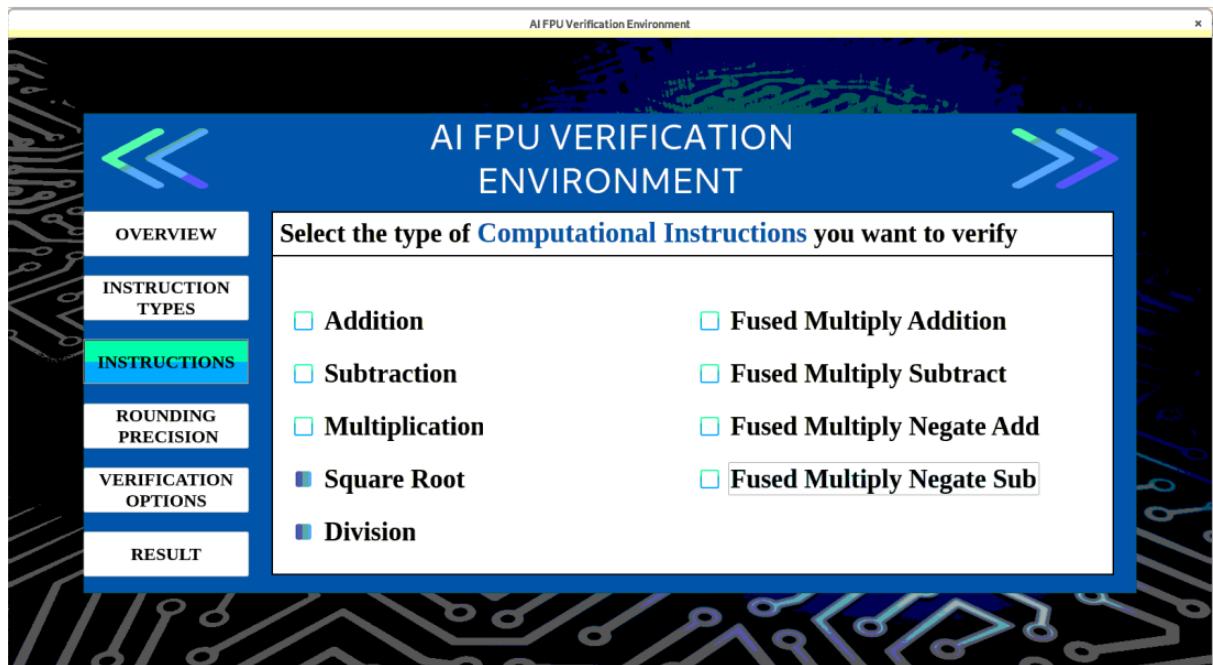
4.6.2.4 Error Generation

If you try to go to the next step without choosing any instruction, you'll see an error message indicating **No input is Selected**. Select at least one option to go to the next step.



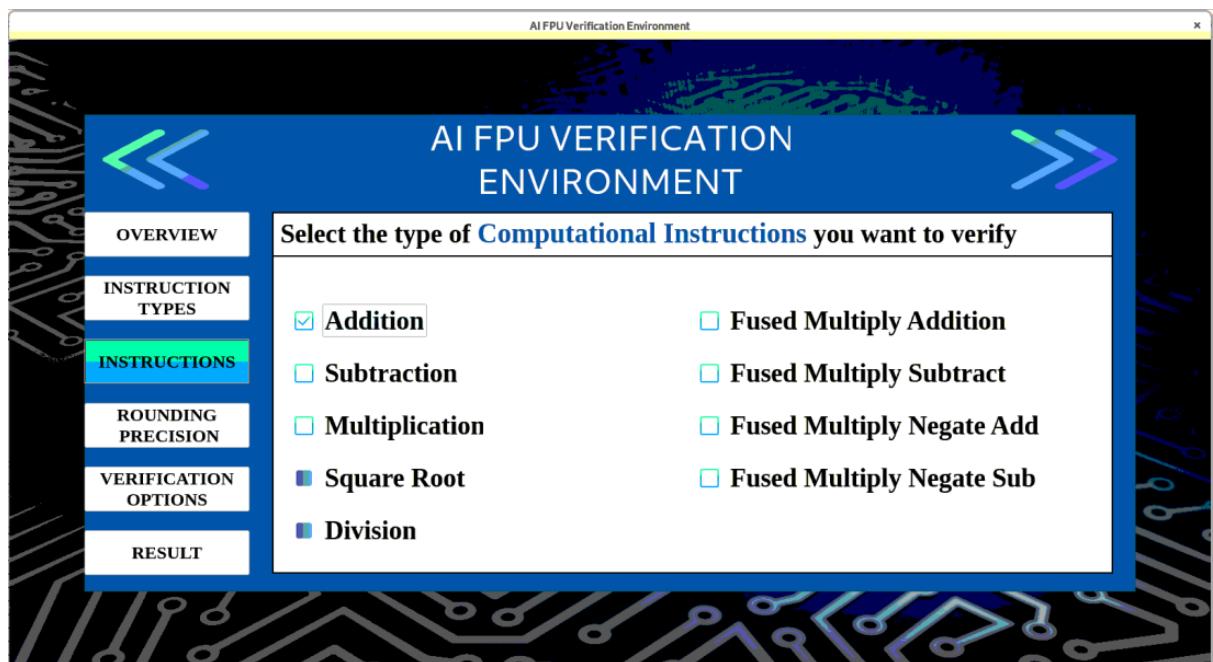
4.6.3 Computational Instruction

The **Computational** Type Instructions has the following instruction as shown below. Based on your requirements, you can choose any of these options.



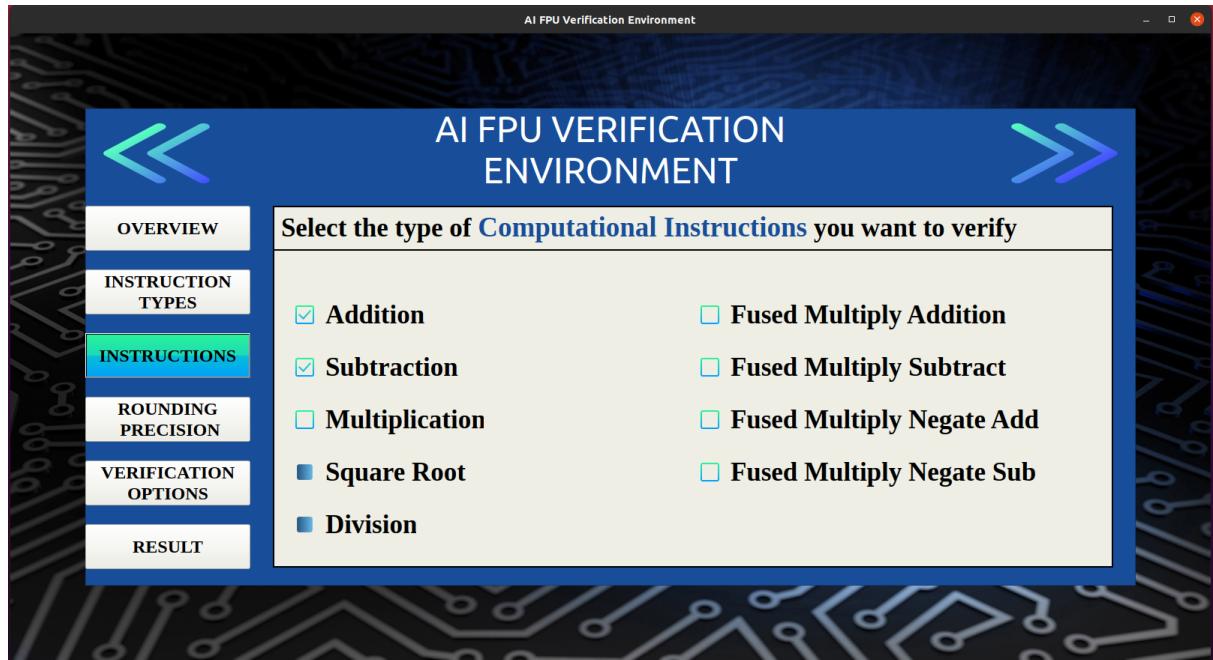
4.6.3.1 Selection of Single Instruction

If you want to verify a specific instruction you can select the checkbox shown below.



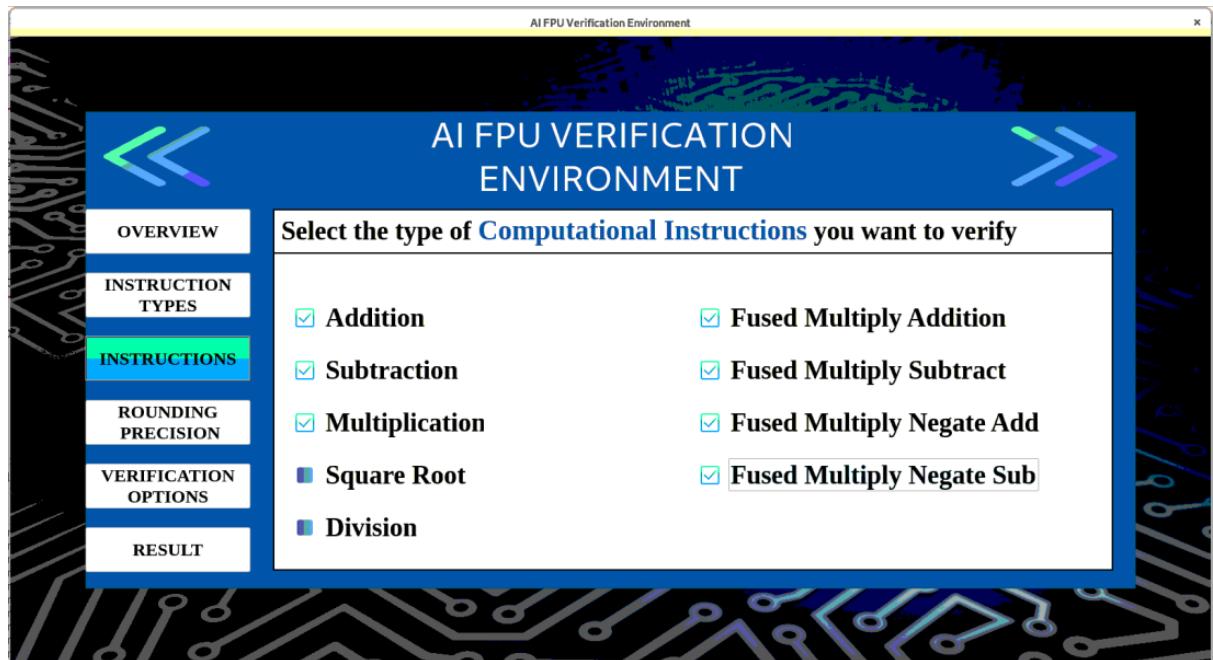
4.6.3.2 Selection of Multiple Instructions

If you want to verify multiple instructions you can select the checkboxes as shown below.



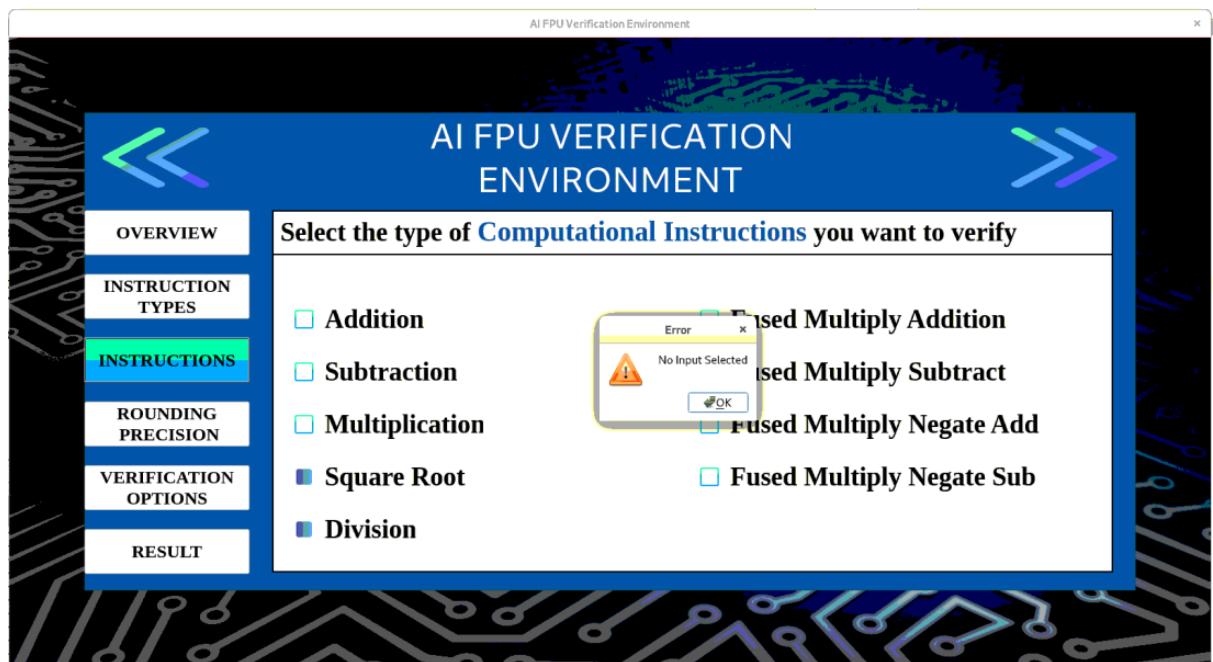
4.6.3.3 Selection of All Instructions

If you want to verify all the instructions, you can select all the checkboxes as shown in the image. However, please note that **Square Root** and **Division** instructions are not available in this version.



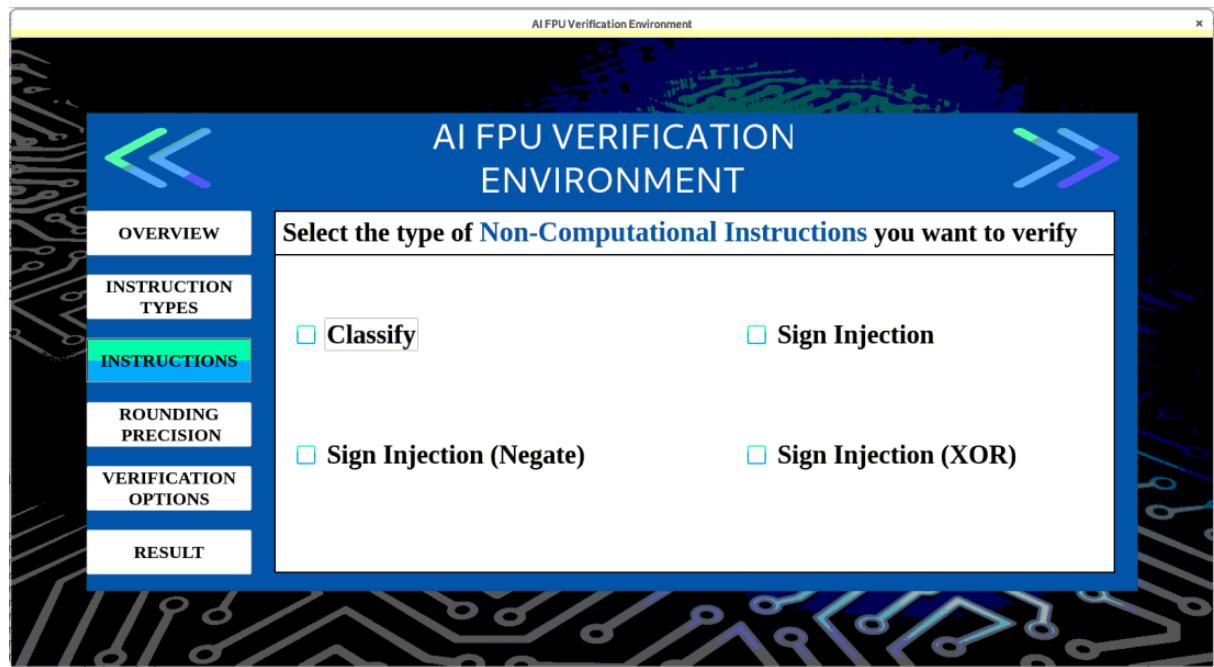
4.6.3.4 Error Generation

If you try to go to the next step without choosing any instruction, you'll see an error message indicating **No input is Selected**. Select at least one option to go to the next step.



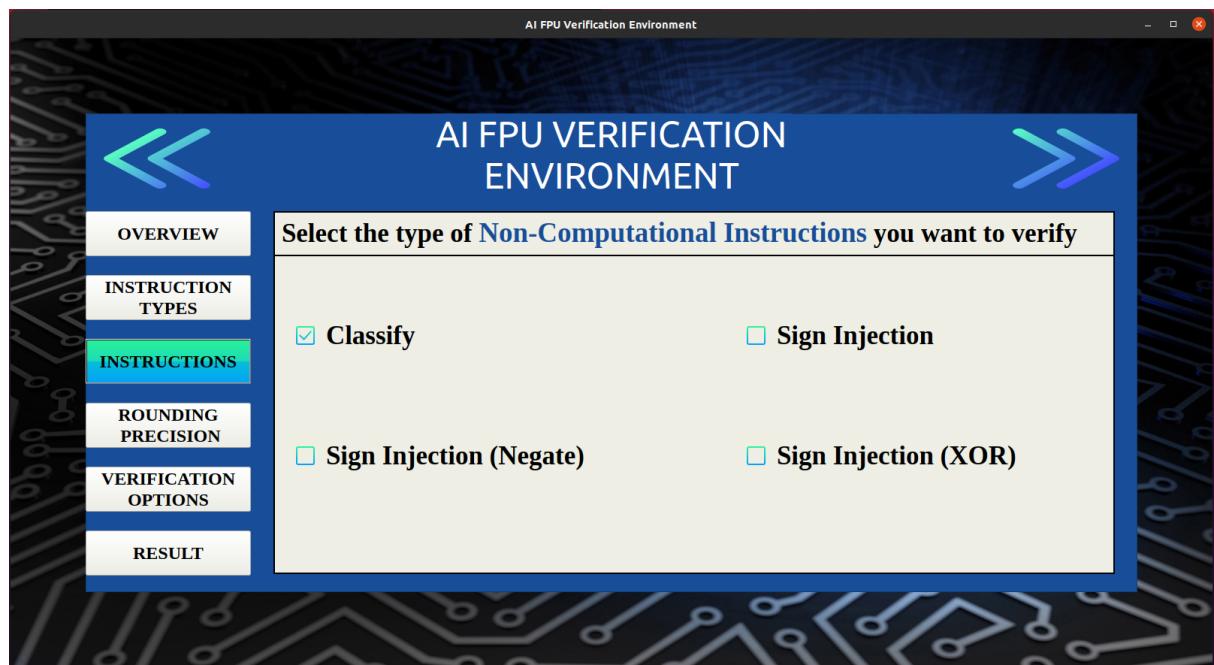
4.6.4 Non-Computational Instruction

The **Non-Computational** Type Instructions has the following instruction as shown below. Based on your requirements, you can choose any of these options.



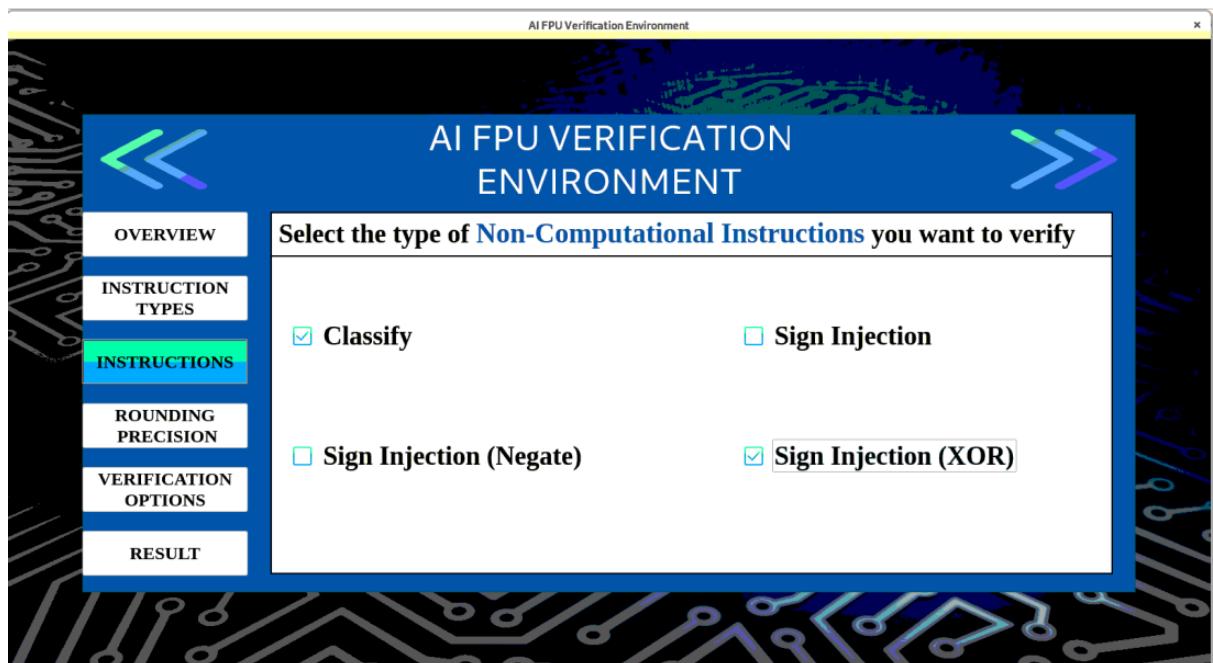
4.6.4.1 Selection of Single Instruction

If you want to verify a specific instruction you can select the checkbox shown below.



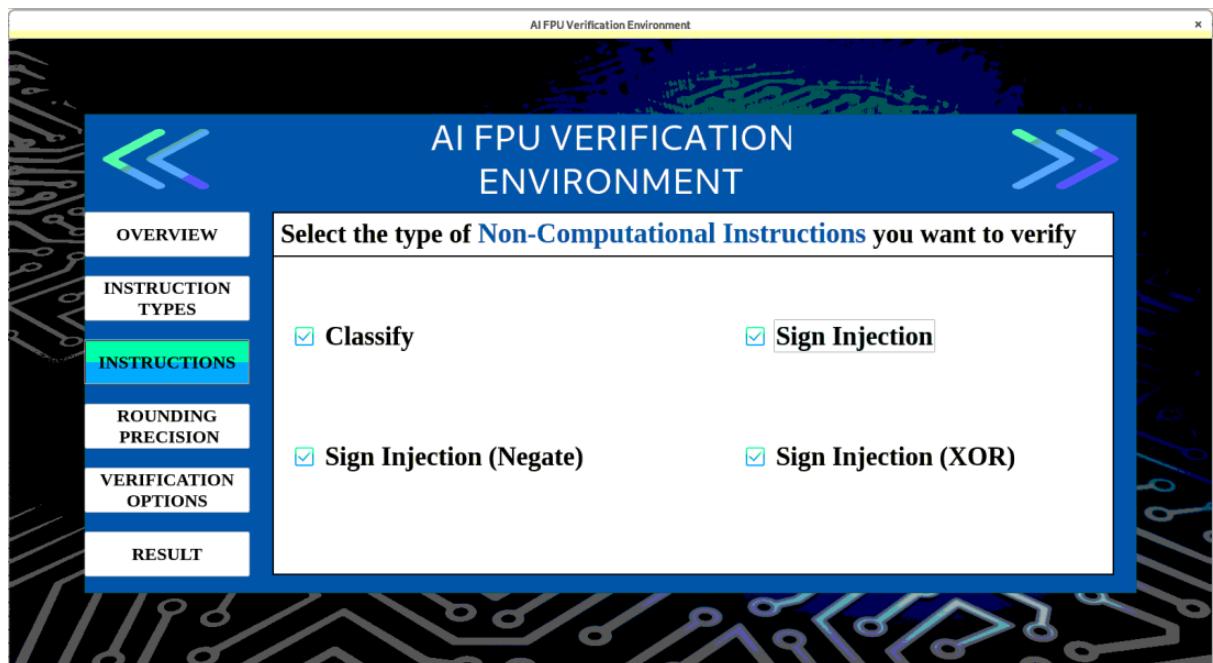
4.6.4.2 Selection of Multiple Instructions

If you want to verify multiple instructions you can select the checkboxes as shown below.



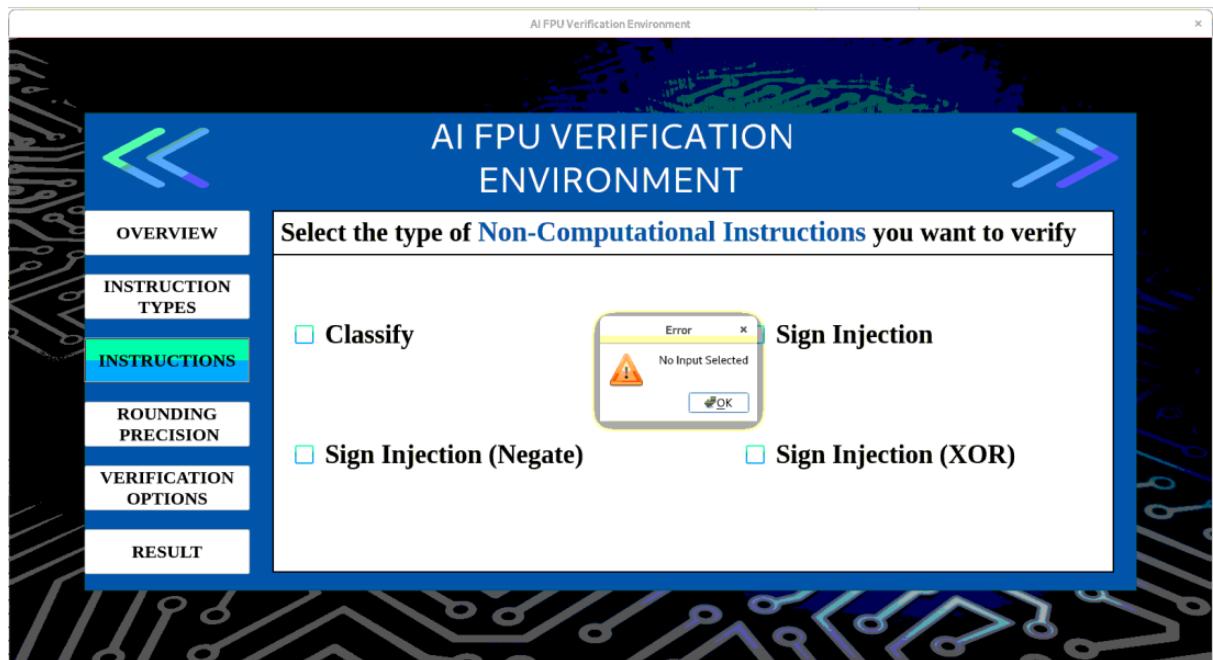
4.6.4.3 Selection of All Instructions

If you want to verify all the instructions, select all checkboxes as demonstrated in the image below.



4.6.4.4 Error Generation

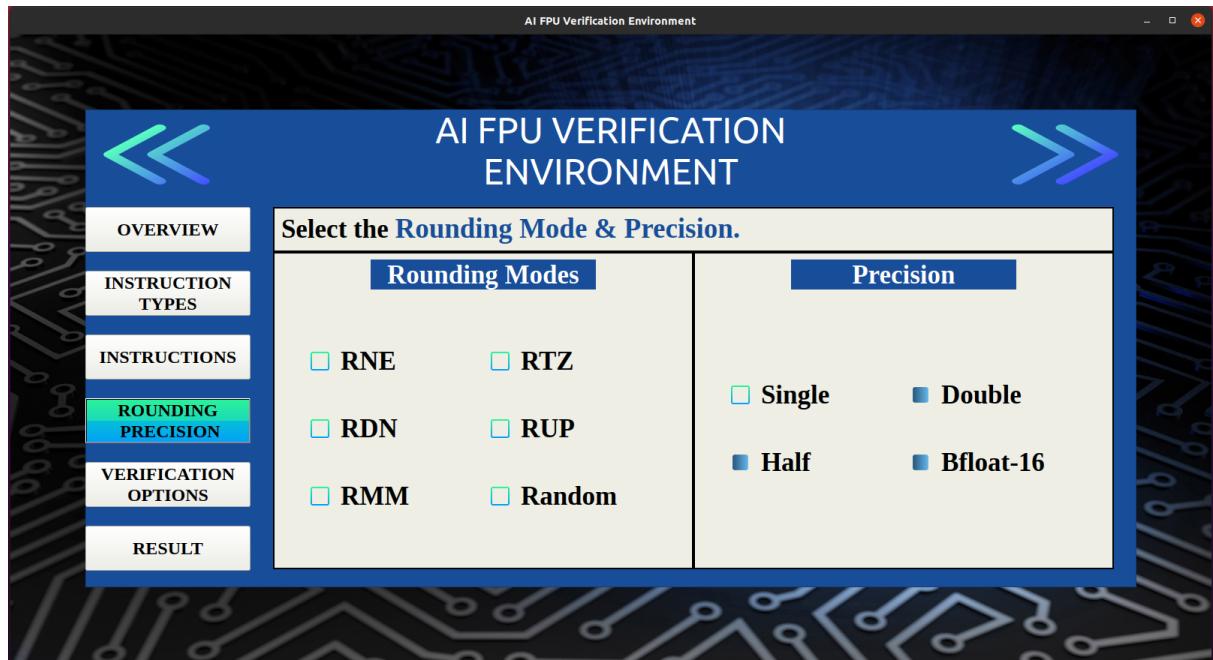
If you try to go to the next step without choosing any instruction, you'll see an error message indicating **No input is Selected**. Select at least one option to go to the next step.



4.7 Rounding Modes & Precision

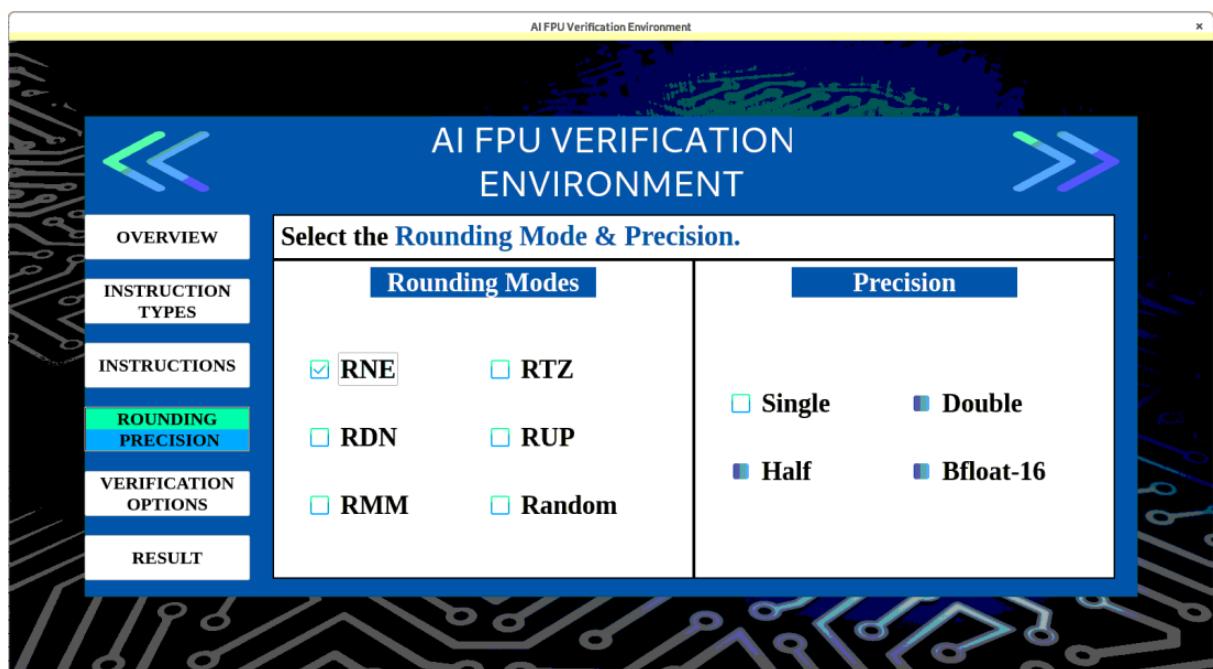
4.7.1 Rounding

AI-FPU supports several RISC-V rounding modes, including "Round to Nearest, ties to Even (**RNE**)", "Round-Up (**RUP**)", "Round Down (**RDN**)", "Round to Zero (**RTZ**)", and "Round to Nearest, ties to Max Magnitude (**RMM**)".



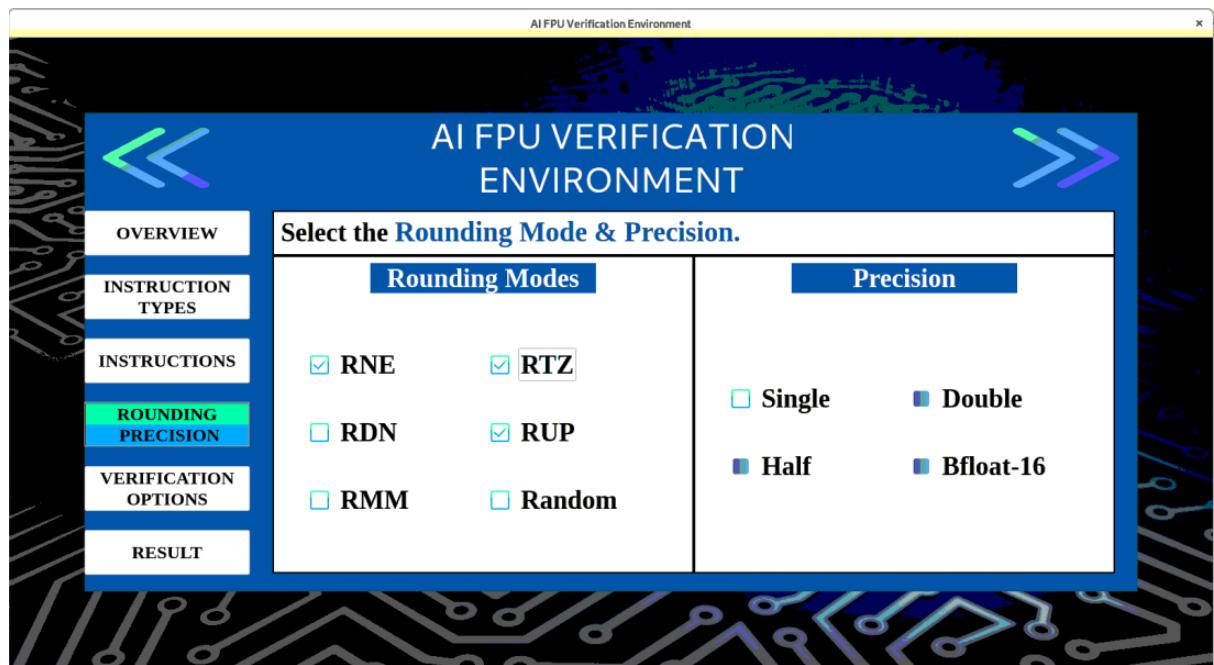
4.7.1.1 Selection of Single Rounding Mode

If you want to apply a specific rounding mode you can select the checkbox as shown below.



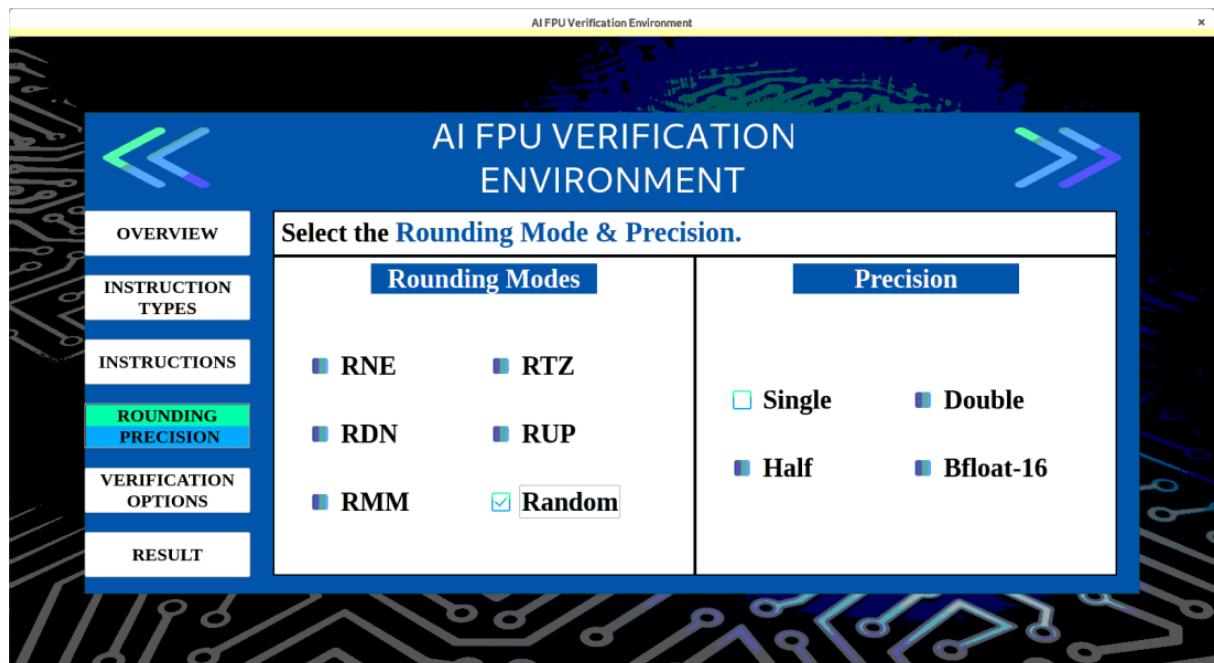
4.7.1.2 Selection of Multiple Rounding Modes

If you want to apply multiple rounding modes you can select the checkboxes as shown below.



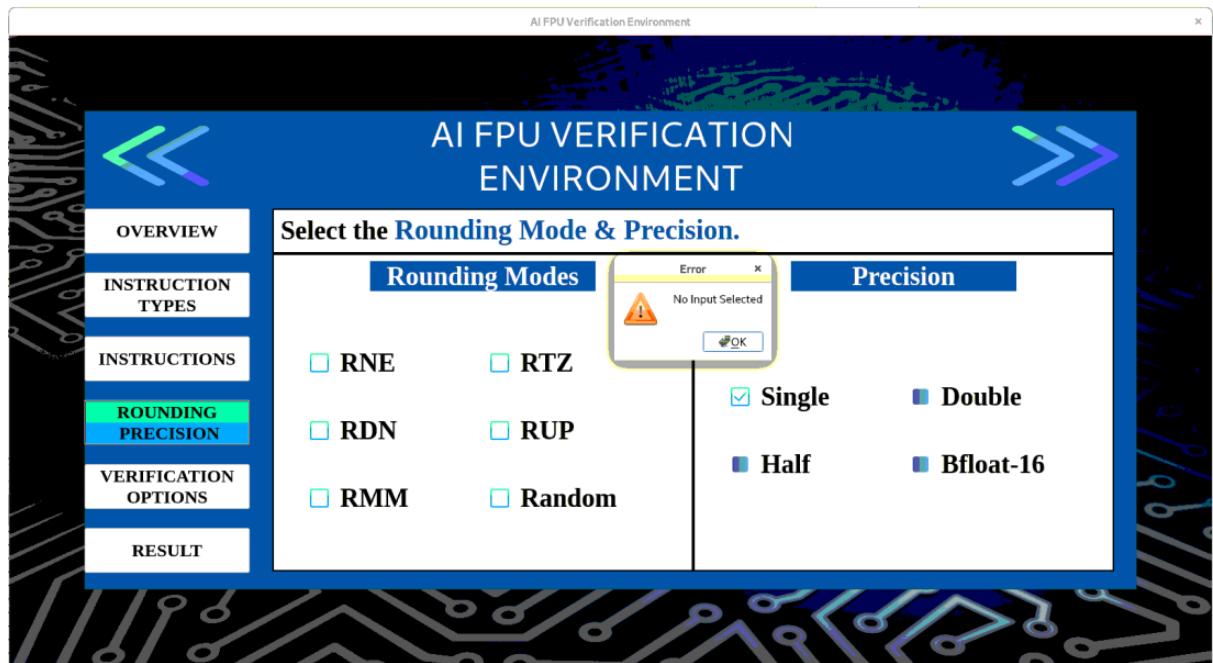
4.7.1.3 Selection of Random Rounding Modes

If you want to apply a random rounding mode, select the "Random" option as shown below.



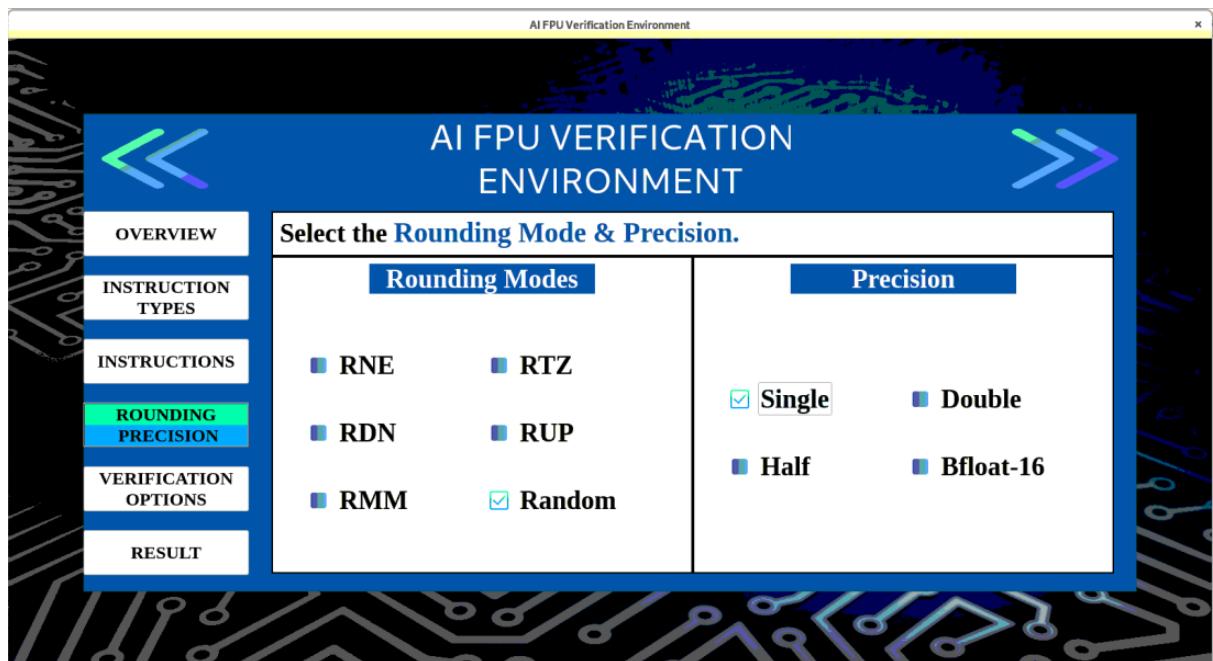
4.7.1.4 Error Generation

If you try to go to the next step without choosing any rounding mode, you'll see an error message indicating **No input is Selected**. Select at least one option to go to the next step.



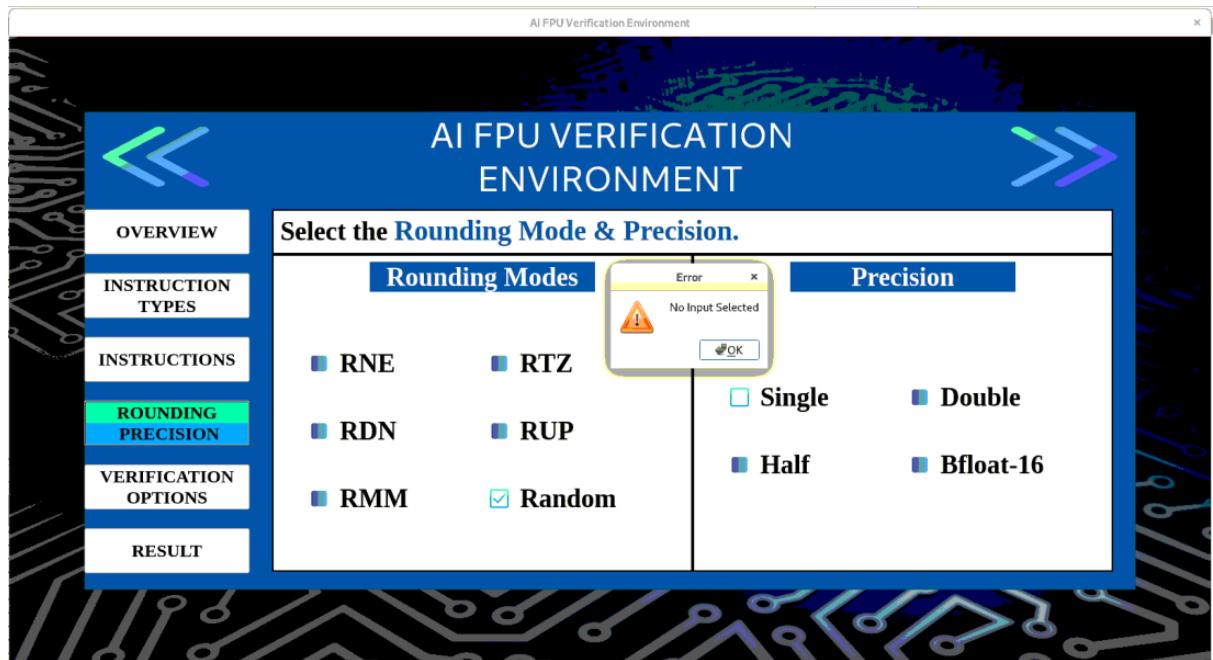
4.7.2. Precision

Currently, only the "Single Precision" option is available for **Precision Selection**. Select the option as shown below.



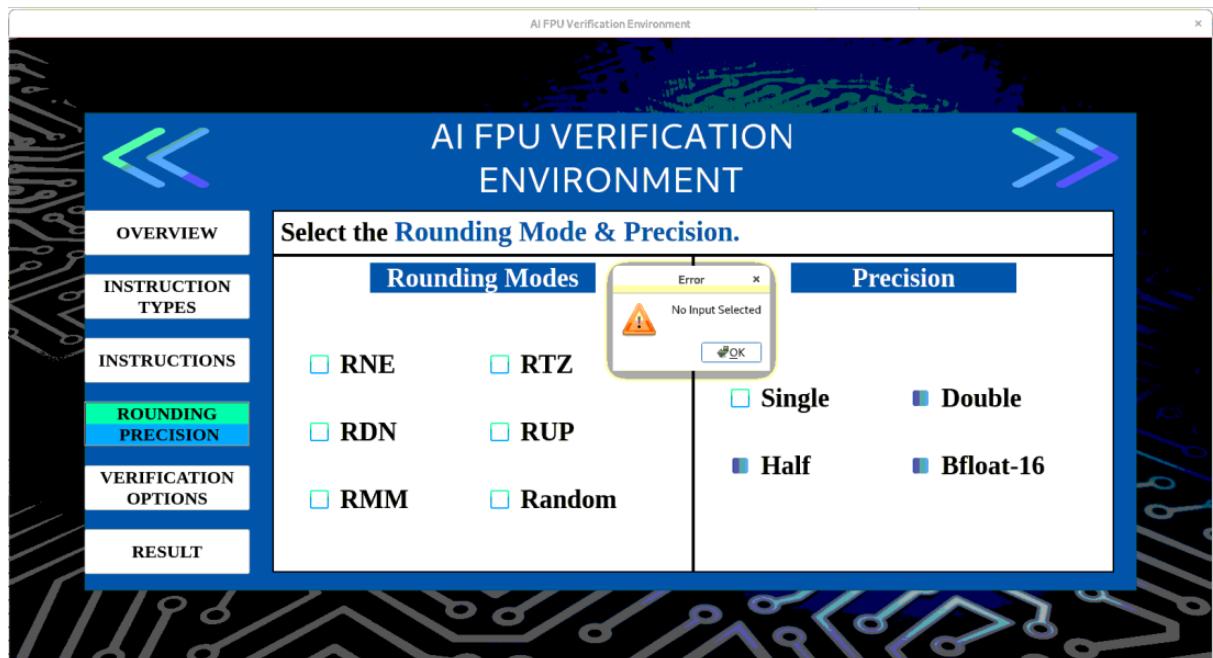
4.7.2.1 Error Generation

If you try to go to the next step without choosing precision, you'll see an error message indicating **No input is Selected**. Select at least one option to go to the next step.



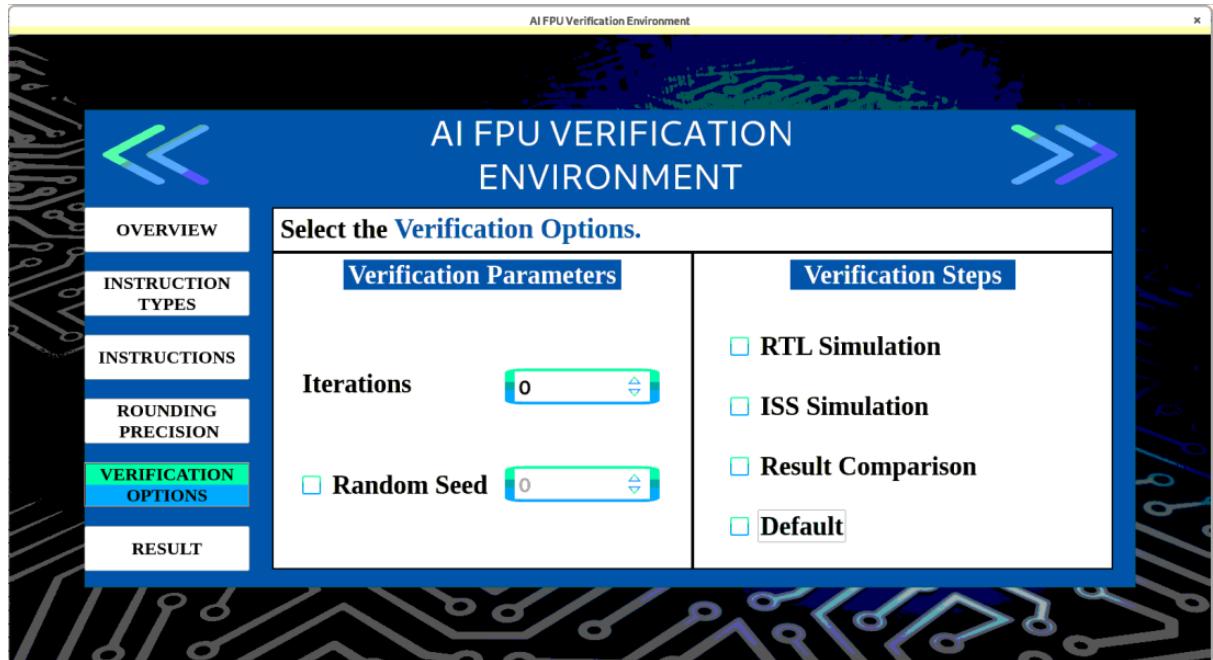
4.7.3 Error Generation

If you try to go to the next step without choosing any option, you'll see an error message indicating **No input is Selected**. Select at least one rounding mode and precision as shown below to go to the next step.



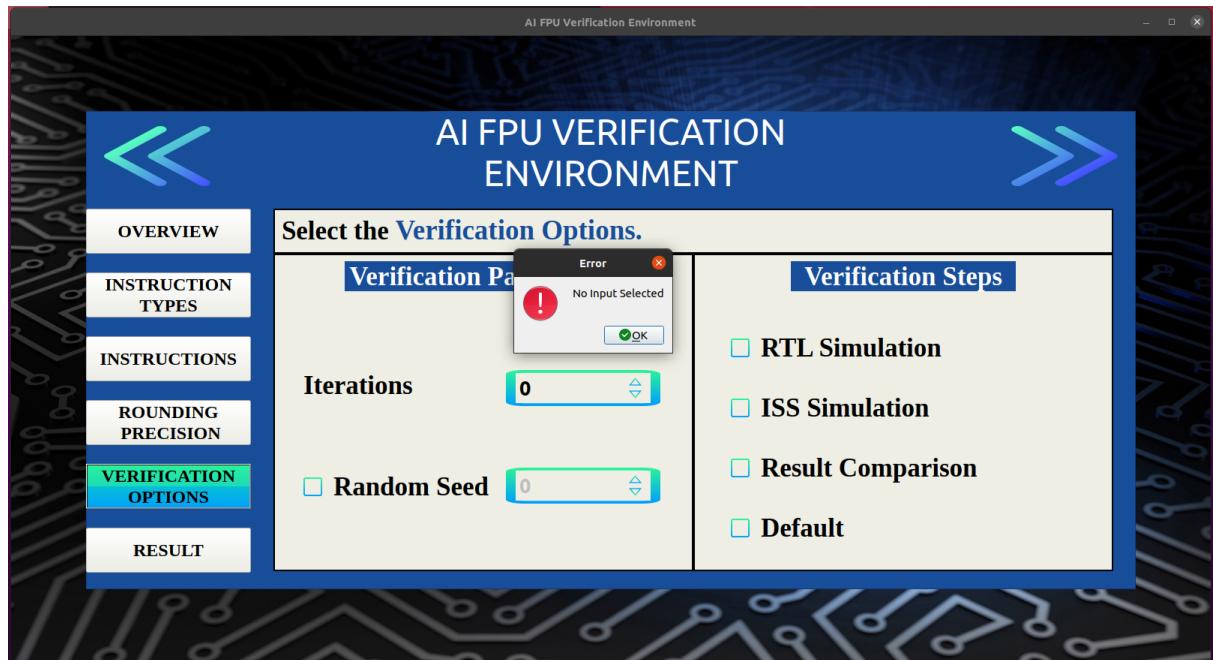
4.8 Verification Options & Result

Verification Options are divided into two sections: **Verification Parameters** and **Verification Steps**. **Verification Parameters** are used to set the iteration value and random seed value if needed. **Verification Steps** help the user choose which option they want to use for the design verification.



4.8.1 Error Generation

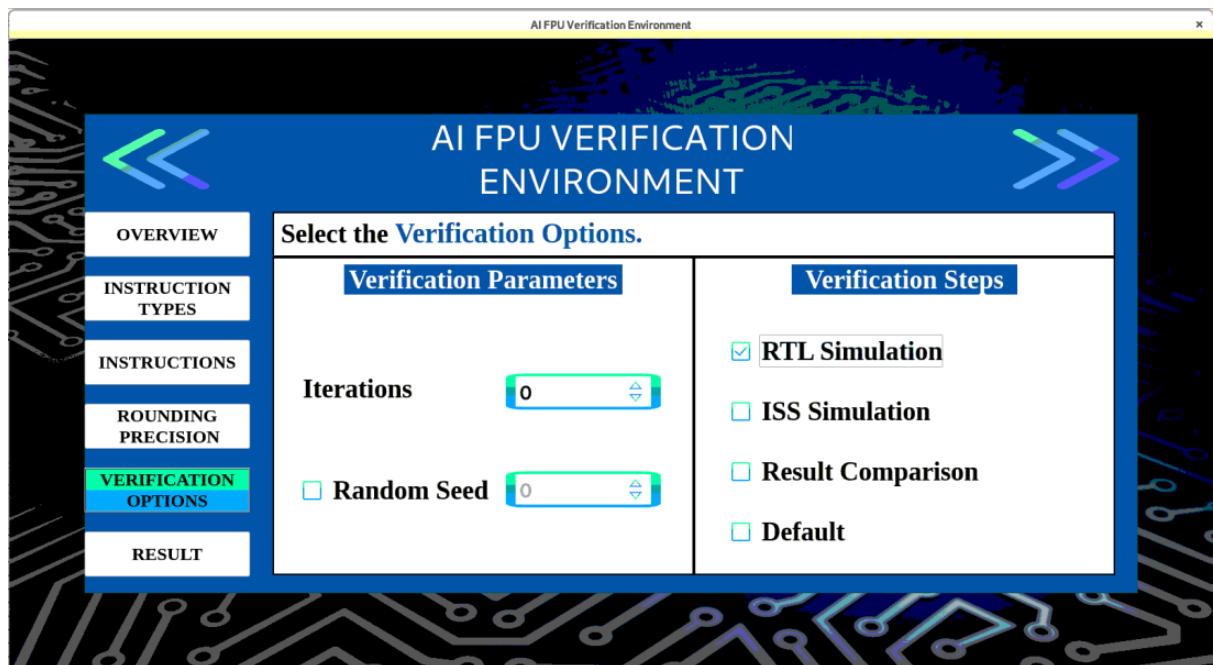
You need to select **Verification Parameters** and **Verification Steps** before proceeding to the next step, otherwise, you will see an error message when clicking the next button.



4.8.2 RTL Simulation

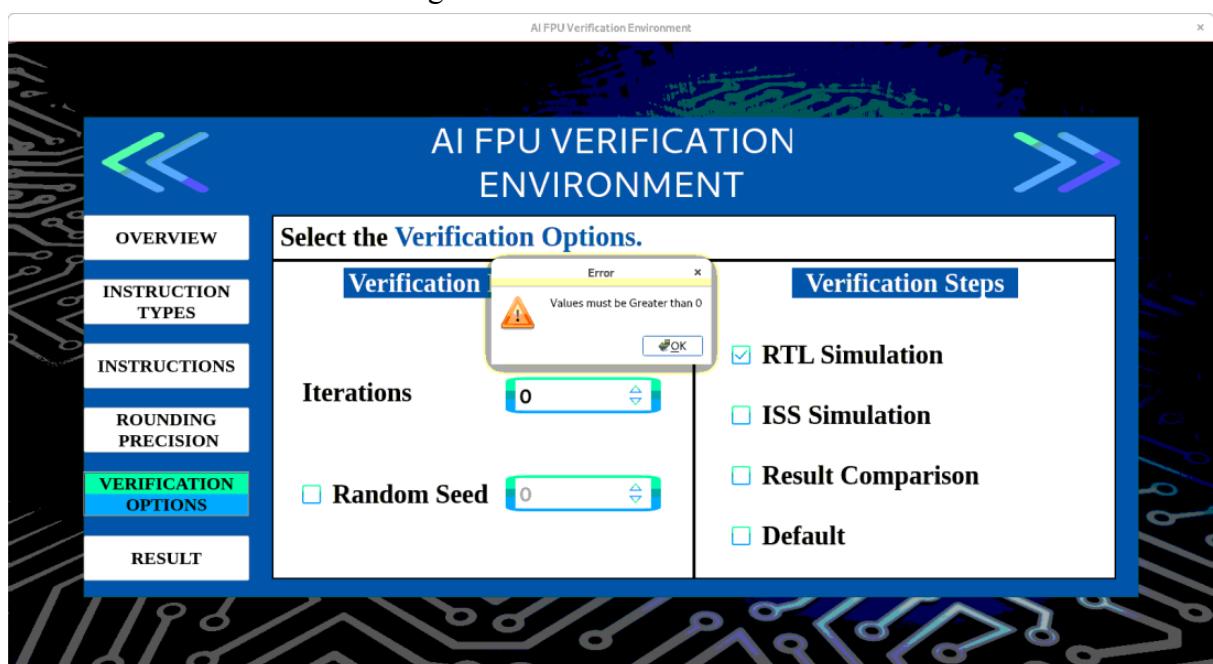
4.8.2.1 Verification Step

If you want to verify the "RTL" design only so you can select an "RTL Simulation" checkbox as shown below.



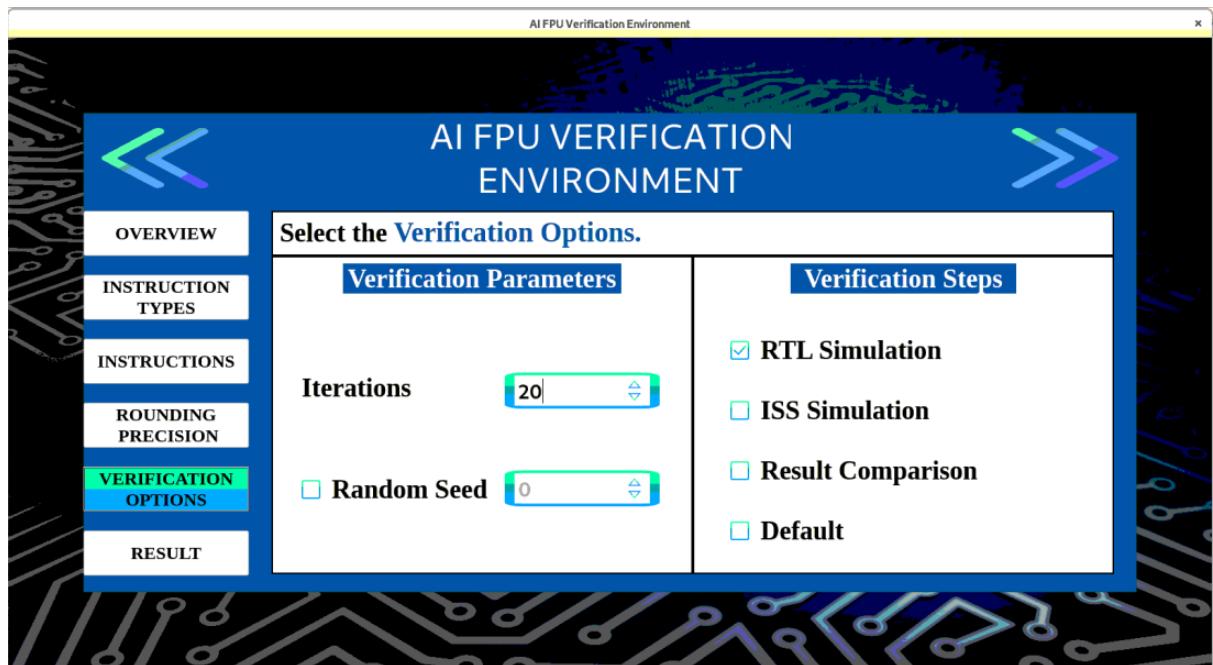
4.8.2.2 Error Generation

When choosing **RTL Simulation**, it is necessary to set the **Verification Parameters**. Otherwise, an error message will appear when clicking the "next button" instructing the user to set the iteration value greater than zero.



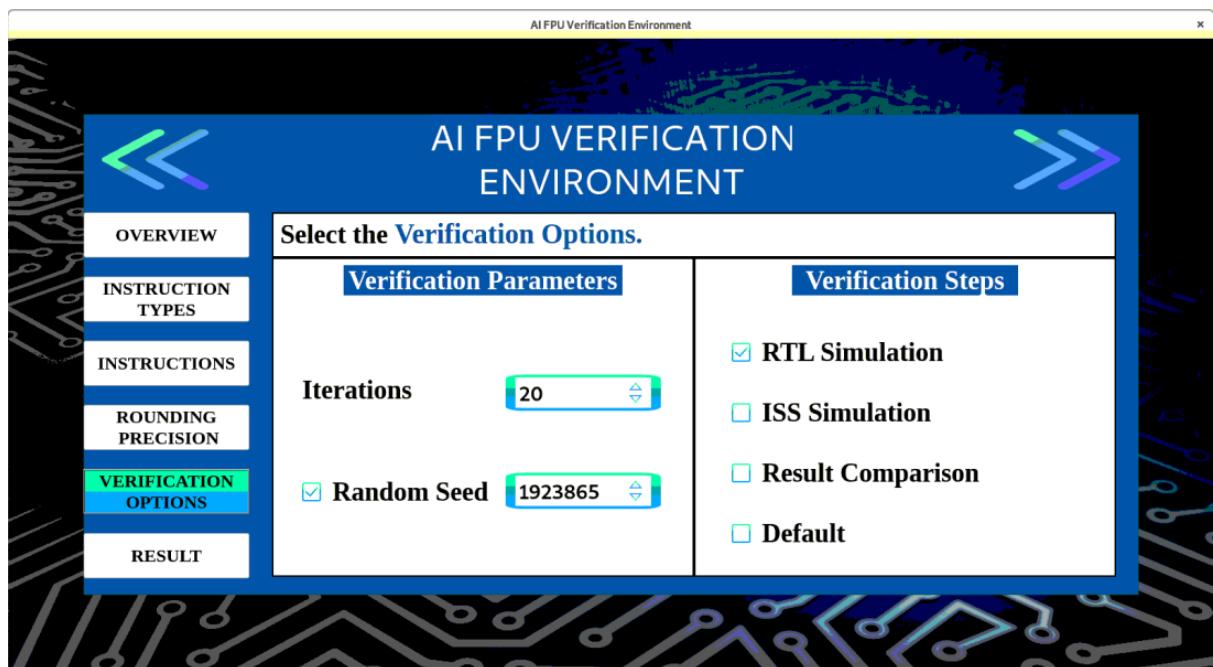
4.8.2.3 Iteration Value

The **Iteration Value** indicates that for how many times you want a particular instruction to be tested. You can enter the iteration value as per your requirements, as shown below.



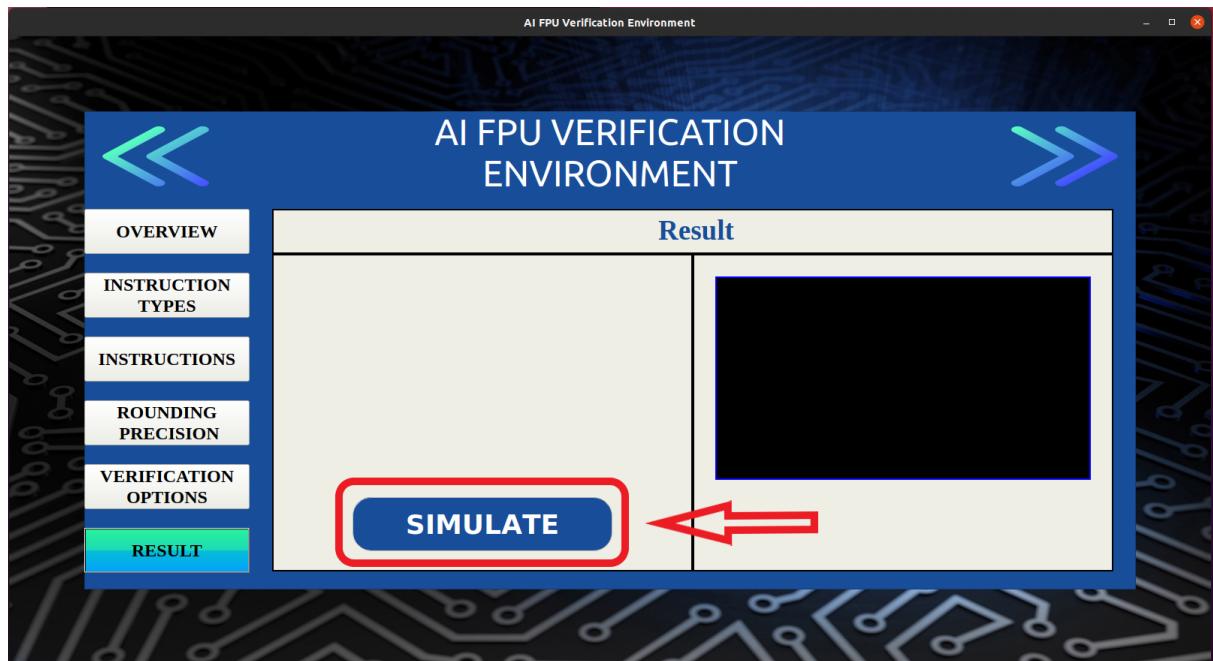
4.8.2.4 Random Seed

It is used to initialize the random functions in Python. You can also use the **Random Seed** option if you want to generate the same random numbers for multiple tests. You can enter any **Random Seed** value as shown below.

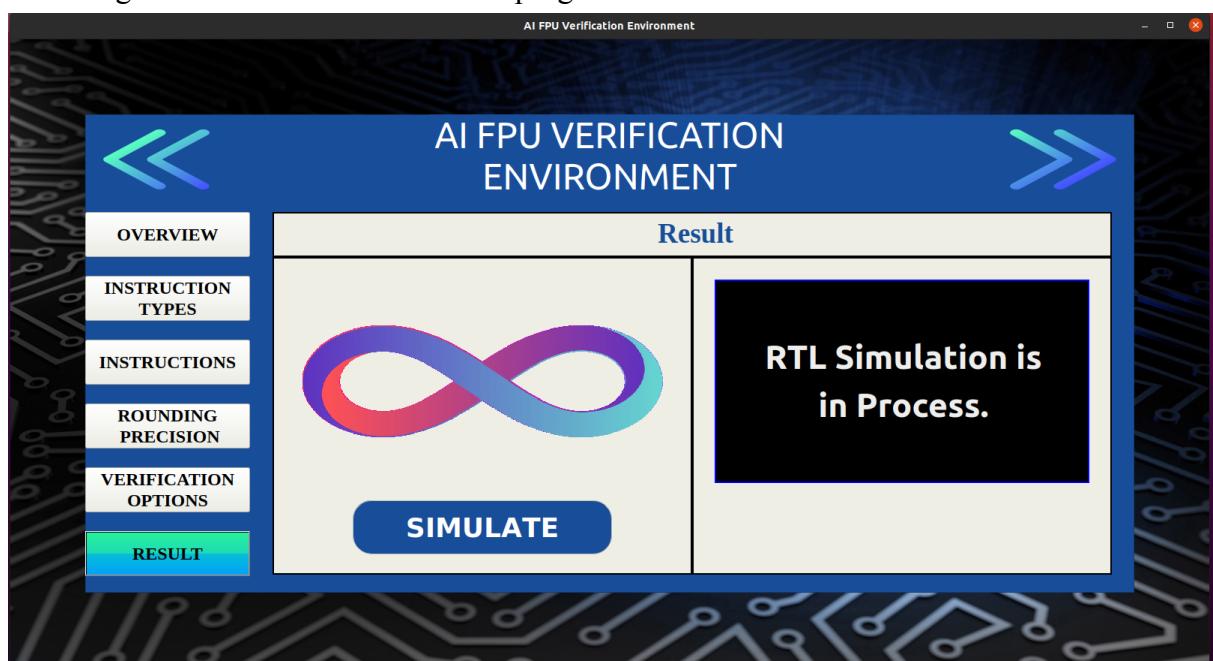


4.8.2.5 Simulation

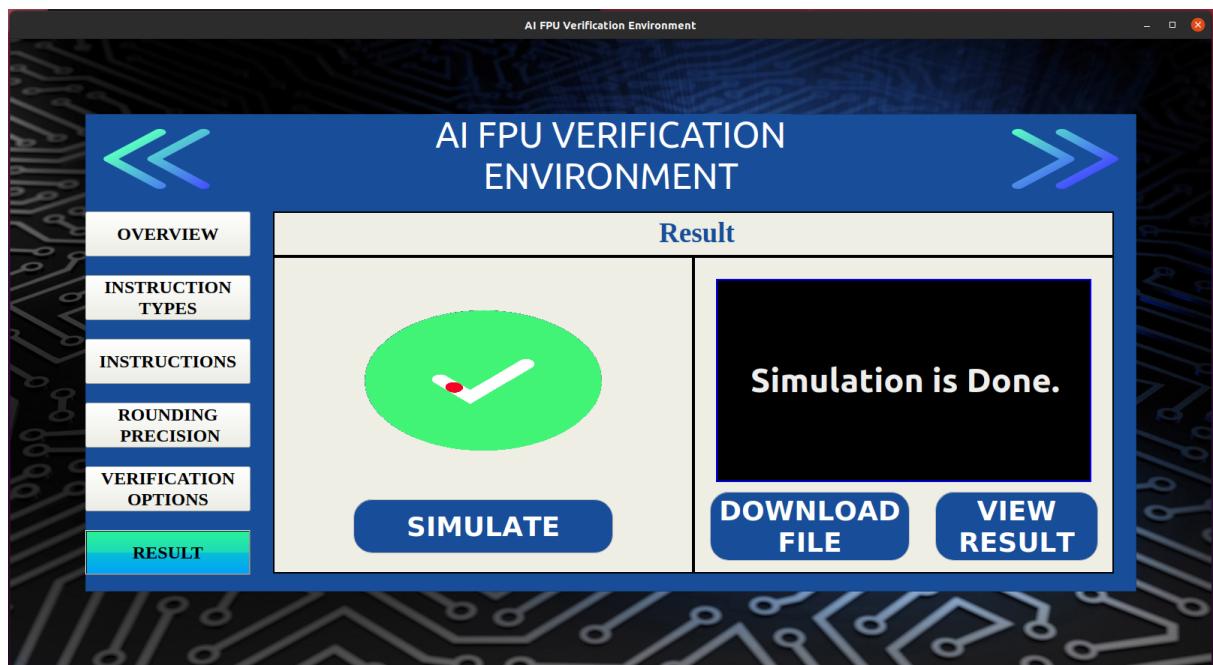
Once you have completed all the steps in the Verification options and pressed the next button, a display similar to the one shown will appear. Press the **SIMULATE** button indicated in red to initiate the simulation.



Once you click the **SIMULATE** button, a message will appear on the GUI Terminal, indicating that the RTL simulation is in progress.

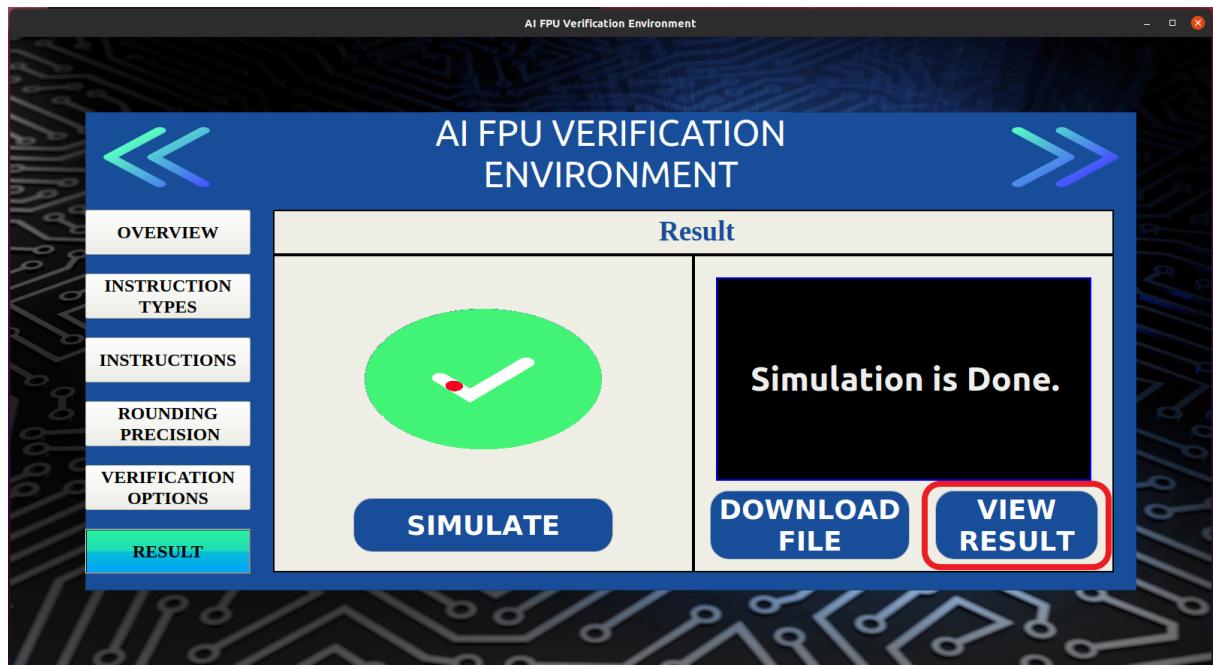


After the successful simulation, a message will appear on the GUI Terminal, indicating that the RTL simulation has been Done.

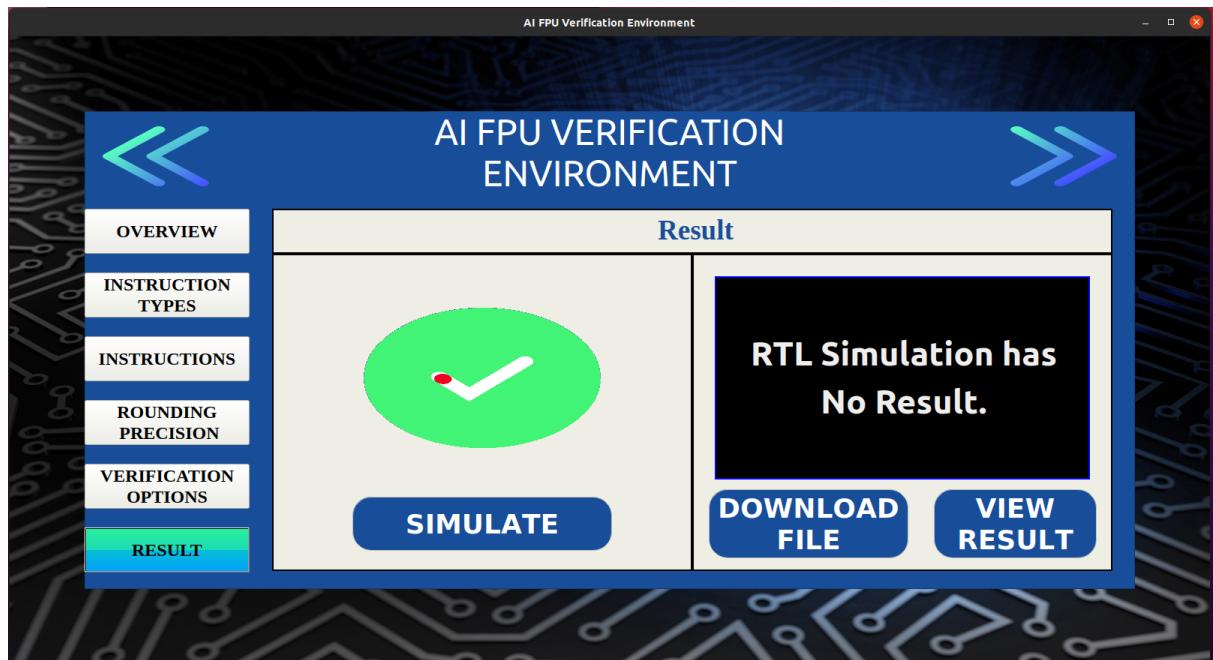


4.8.2.6 View Results

To view the results, click the "VIEW RESULT" button encircled in red.

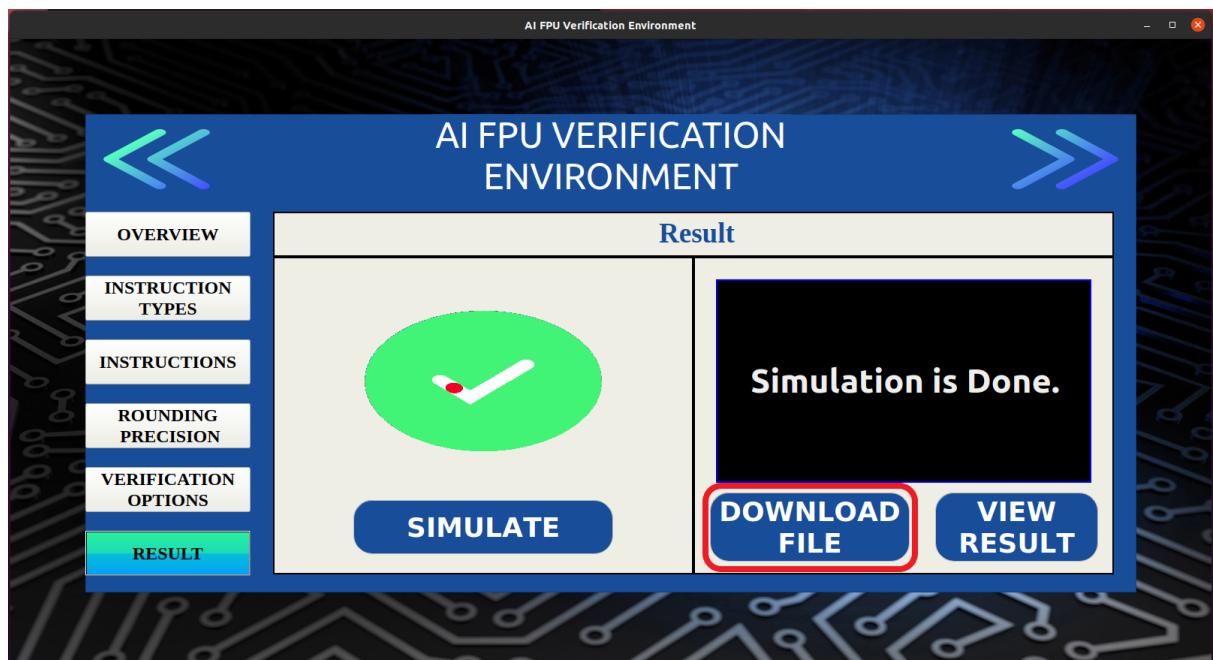


When you click the "**VIEW RESULT**" button after an RTL simulation, a message will appear on the GUI Terminal, indicating that the RTL simulation has No Result. This is because the RTL simulation has only generated its own results and has not yet compared them to a known answer to determine their correctness. To verify the accuracy of the results, they must be compared to the results of another design / Golden Model.

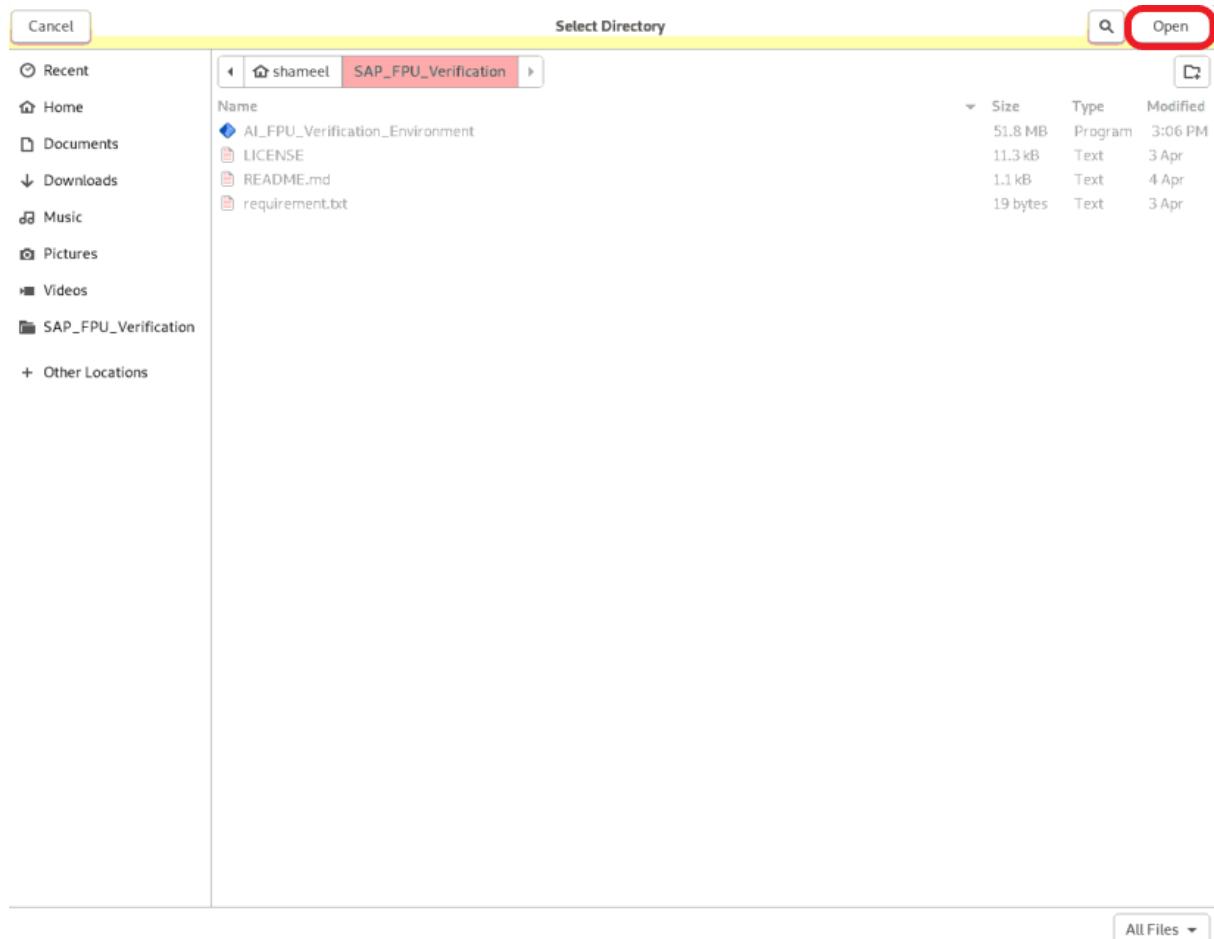


4.8.2.7 Downloading File

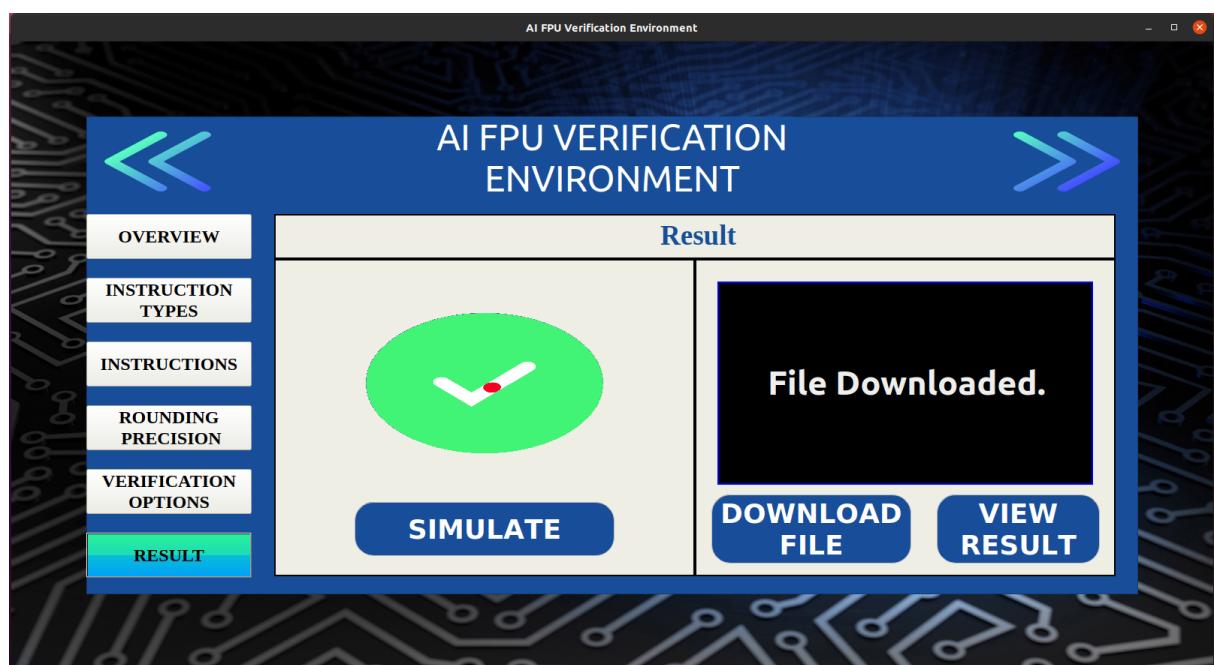
To download the file, click the "**DOWNLOAD FILE**" button encircled in red.



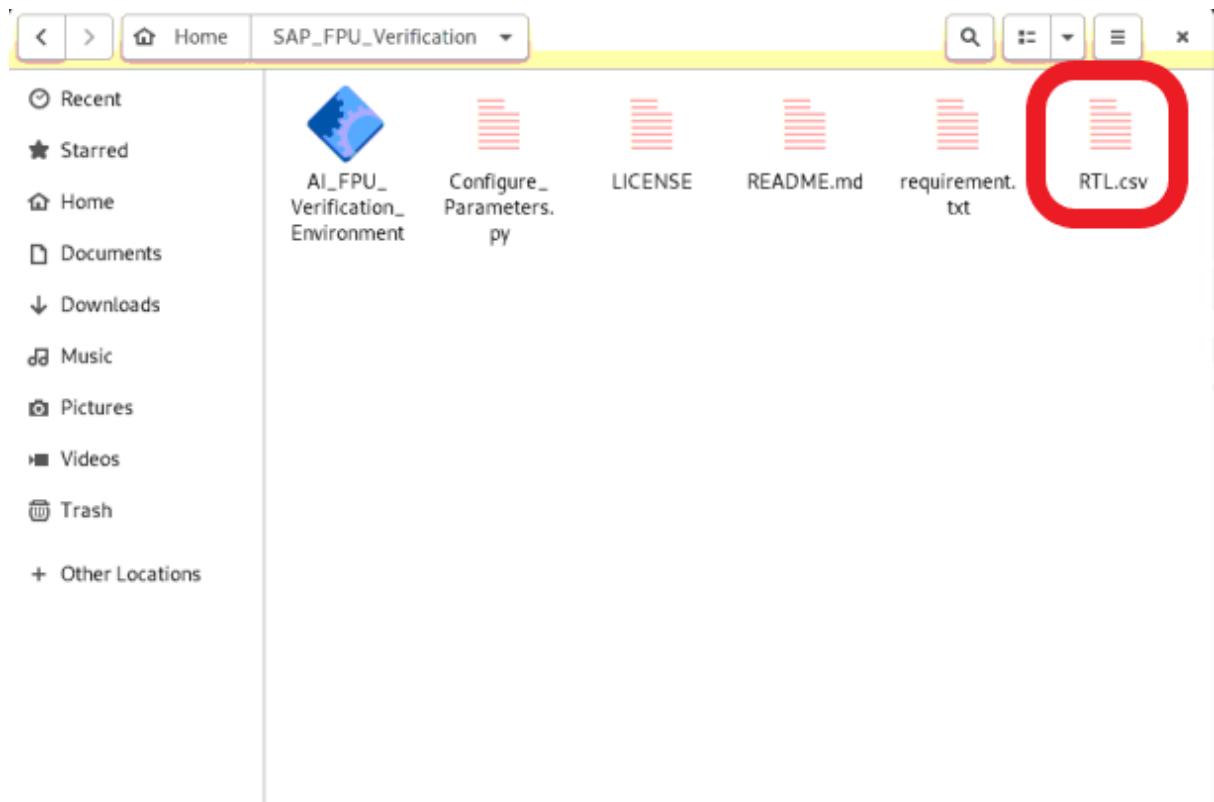
Once you click on the "**DOWNLOAD FILE**" button, a window will pop up asking you to select the directory where you want to save the file. Click on the red indicated button to start the download process.



On successful operation the message will appear on the GUI Terminal, indicating that the file has been downloaded.



RTL simulation only generates the RTL CSV file as indicated below.

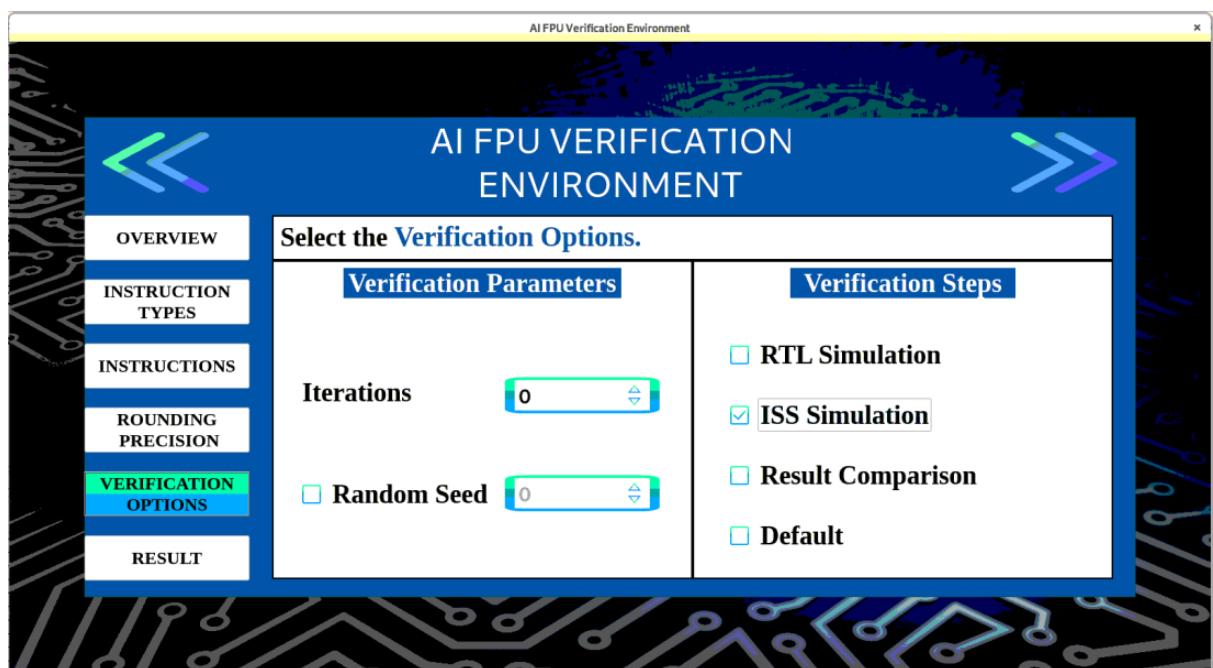


4.8.3 ISS Simulation

An **ISS** is software that emulates a computer's instruction set, allowing developers to test their code without using the actual hardware. An ISS with FPU support emulates FPU instructions, providing results as if the code was executed on actual FPU hardware. This helps developers debug their code efficiently without needing physical access to the FPU hardware.

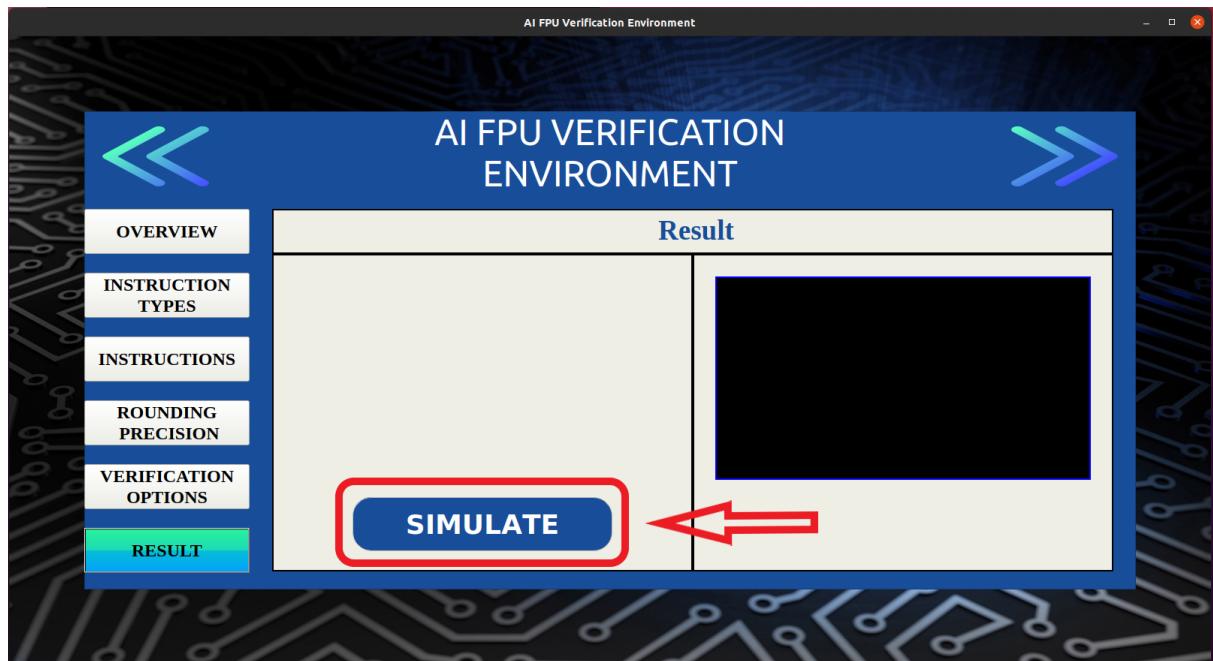
4.8.3.1 Verification Step

If you select the "**ISS**" option, you can skip the setting of **Verification Parameters**. This is because **ISS** runs on its parameters and does not require additional Verification Parameters Values. To select the **ISS** option, simply check the checkbox as shown below.

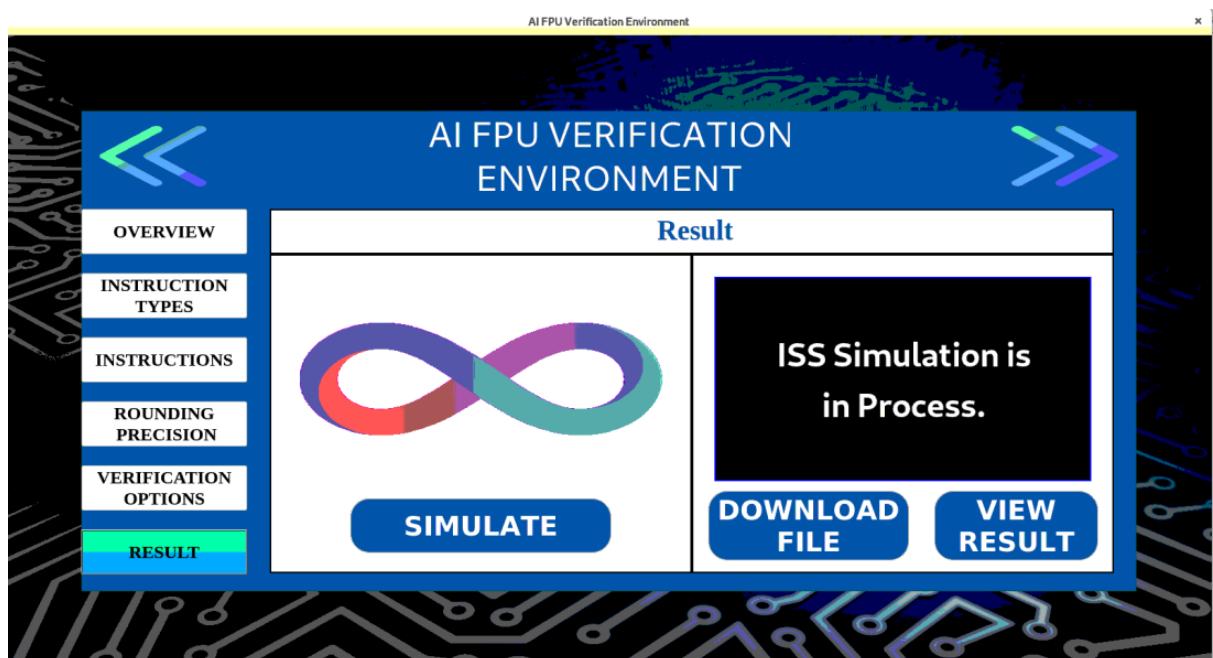


4.8.3.2 Simulation

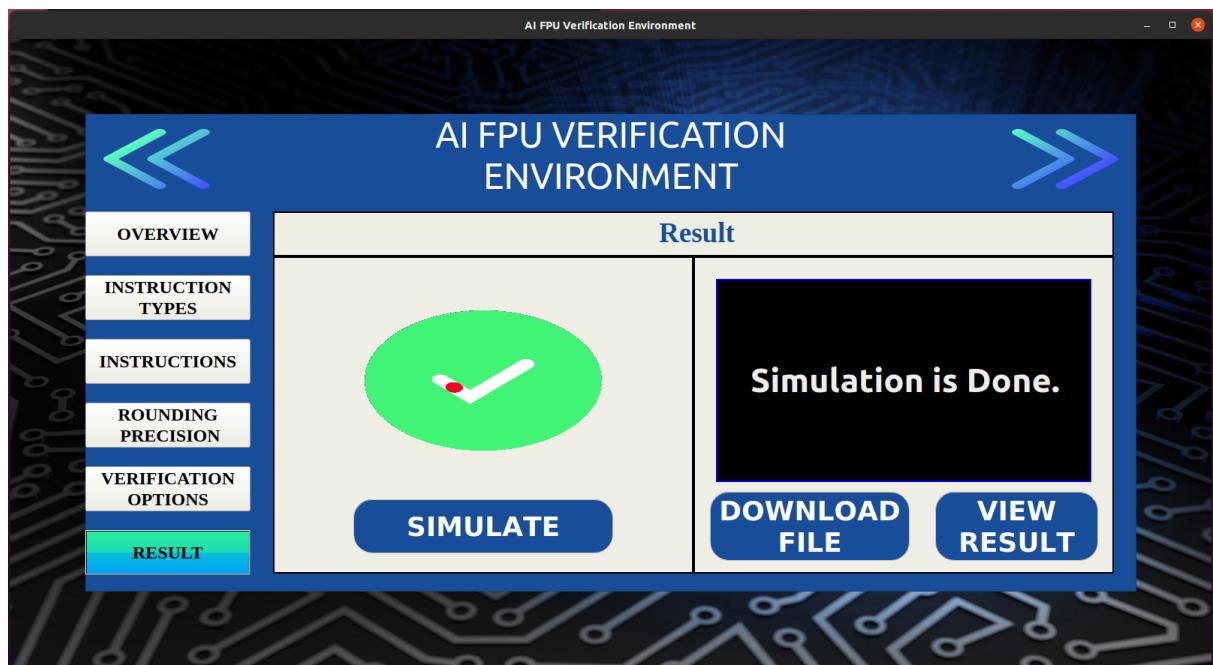
Once you have completed all the steps in the Verification options press the next button. A window similar to the one shown will appear. Press the **SIMULATE** button to initiate the simulation.



Once you click the **SIMULATE** button, a message will appear on the GUI Terminal, indicating that the ISS simulation is in progress.

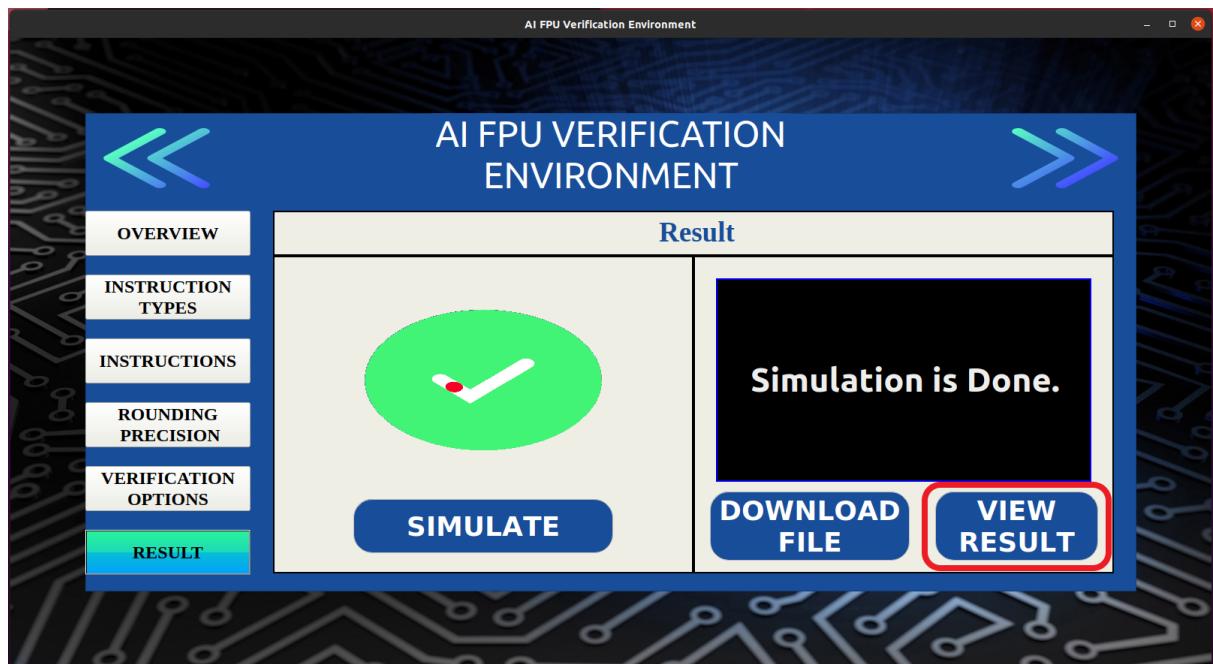


After the successful simulation, a message will appear on the GUI Terminal, indicating that the ISS simulation has been completed.

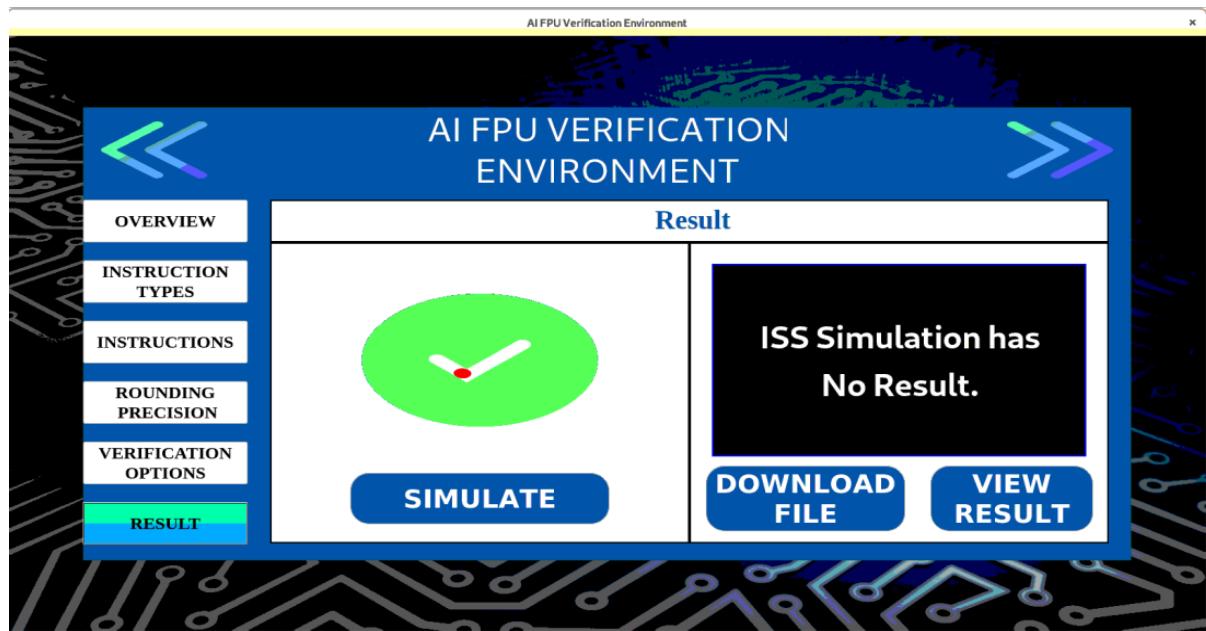


4.8.3.3 View Results

To view the results, click the "VIEW RESULT" button encircled in red.

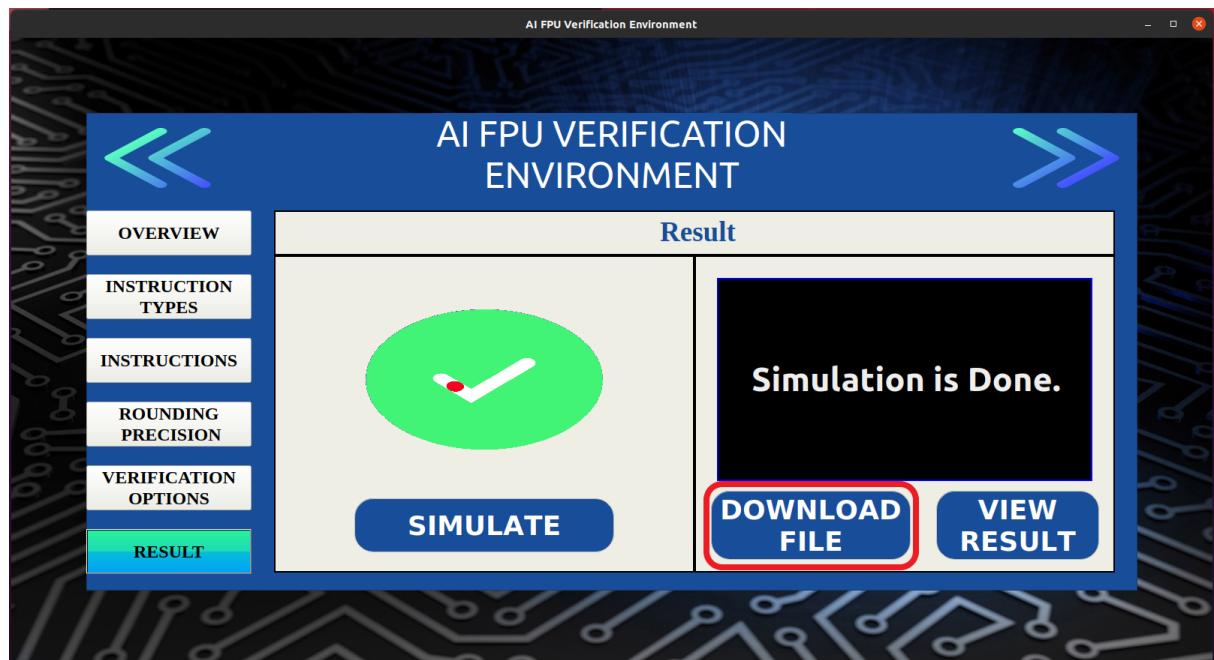


When you click the "VIEW RESULT" button after an ISS simulation, a message will appear indicating that the ISS Simulation has No Result. This is because the ISS Simulation has only generated its own results and has not yet compared them to our design.

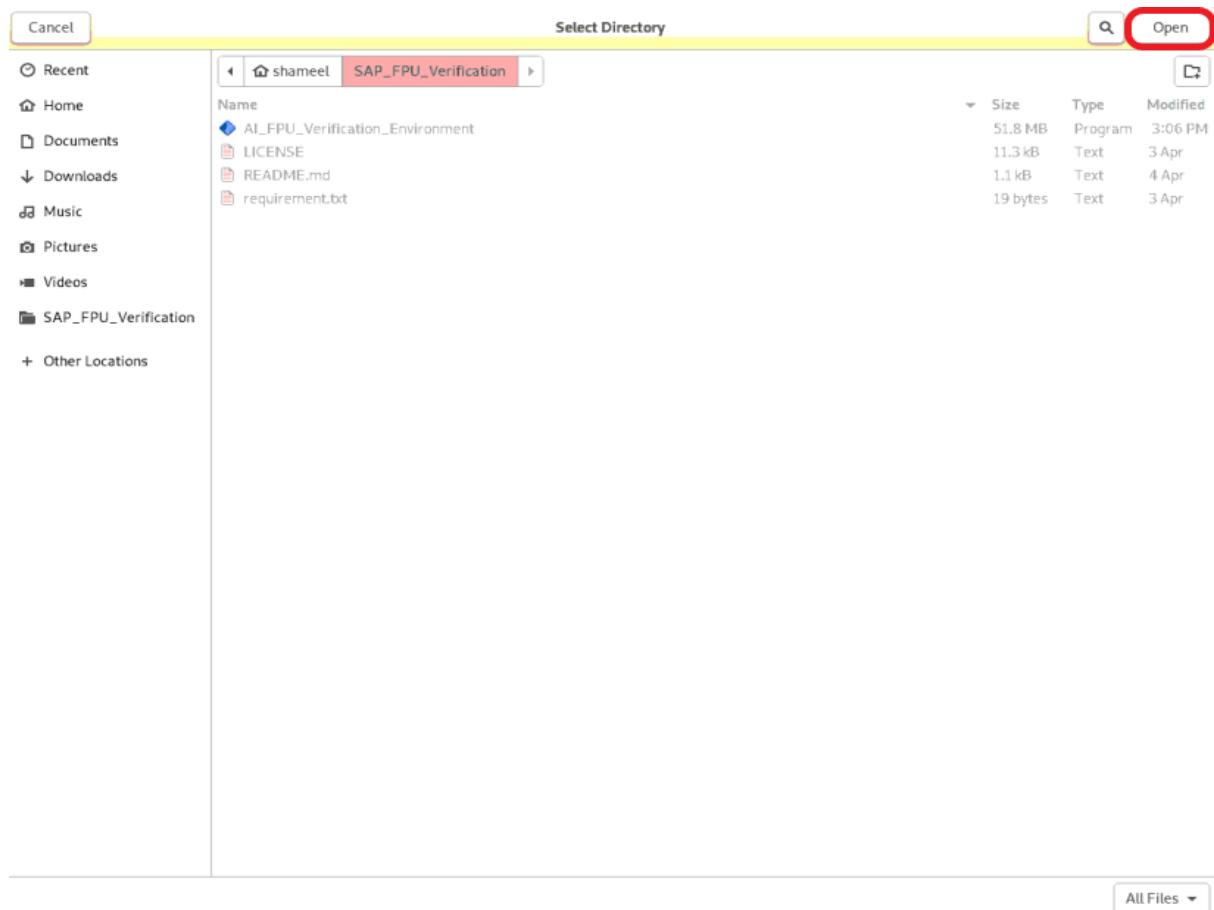


4.8.3.4 Downloading File

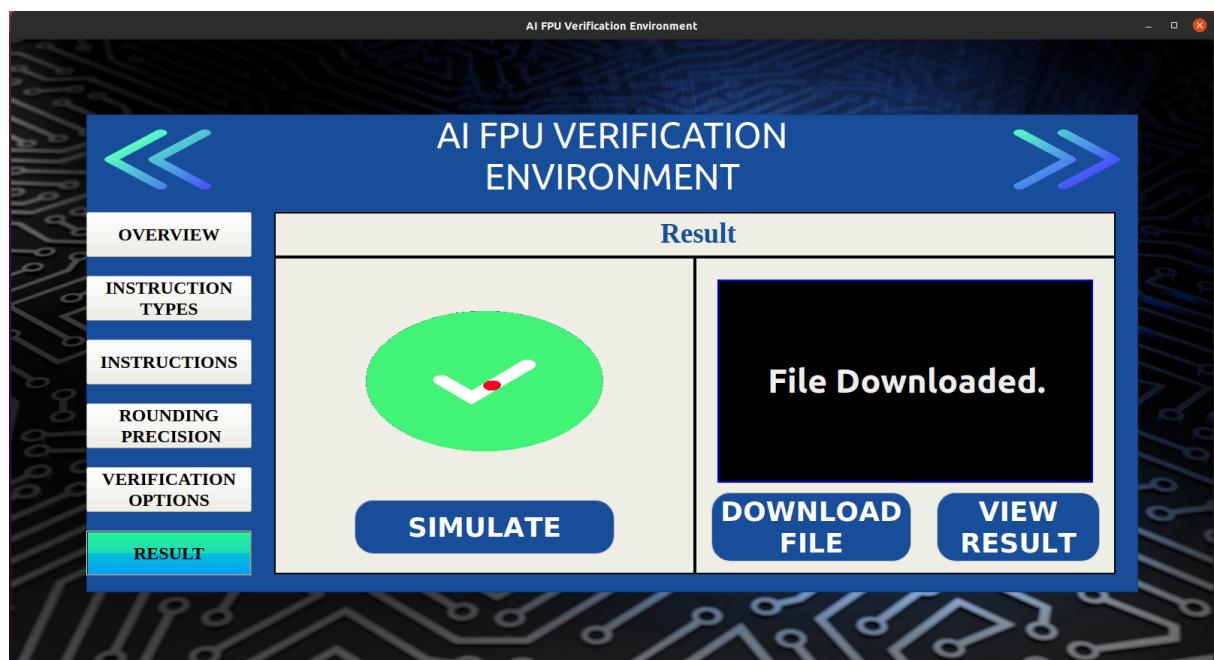
To download the file, click the "DOWNLOAD FILE" button encircled in red.



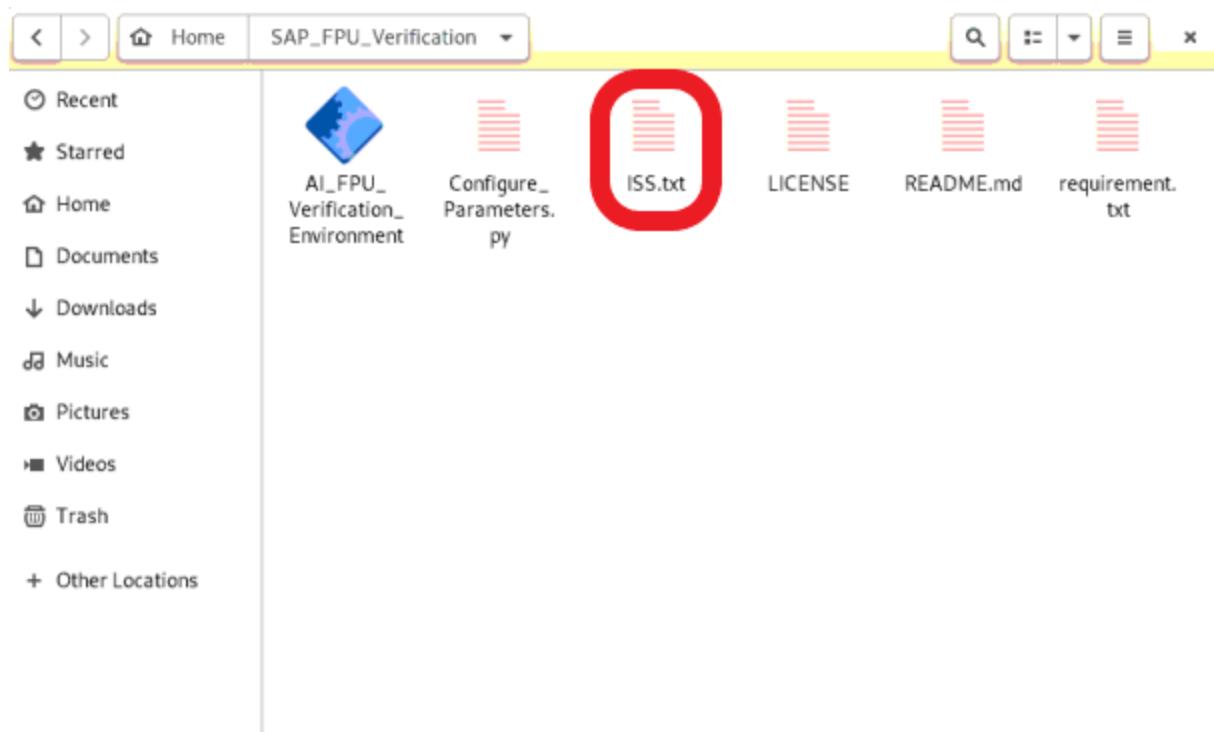
Once you click on the "**DOWNLOAD FILE**" button, a window will pop up asking you to select the directory where you want to save the file. Click on the red indicated button to start the download process.



On successful operation the message will appear on the GUI Terminal, indicating that the file has been downloaded.



ISS simulation only generates the ISS text file as indicated below.

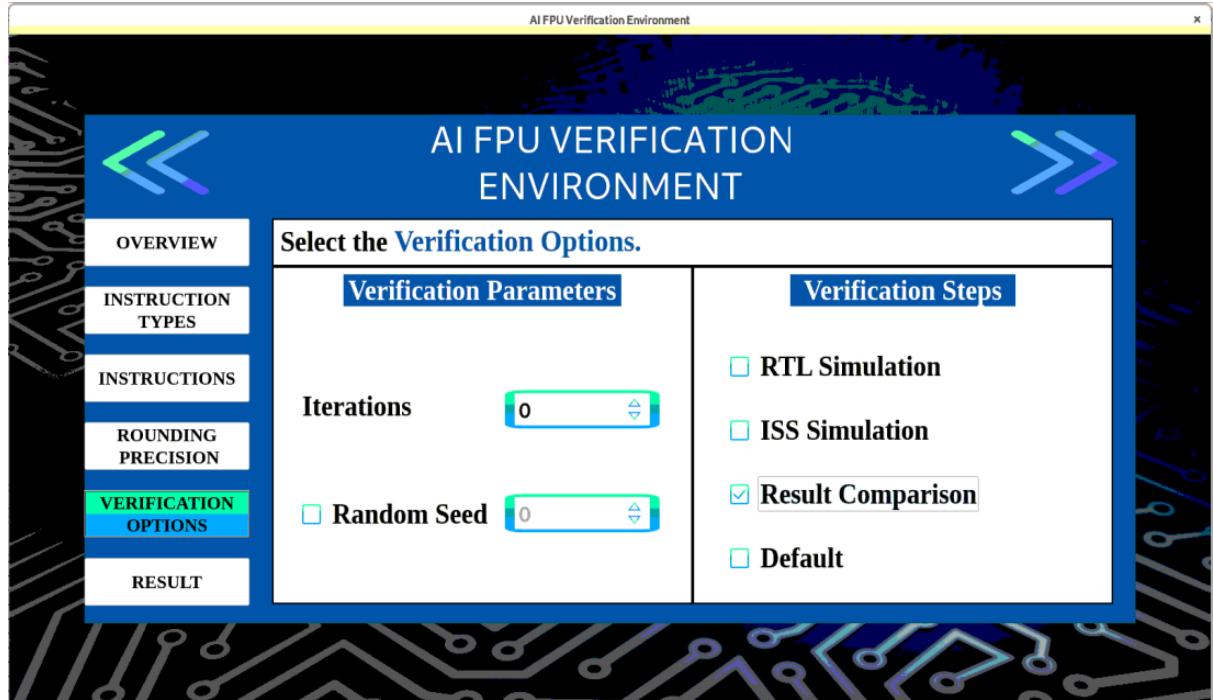


4.8.4 Result Comparison

4.8.4.1 Verification Step

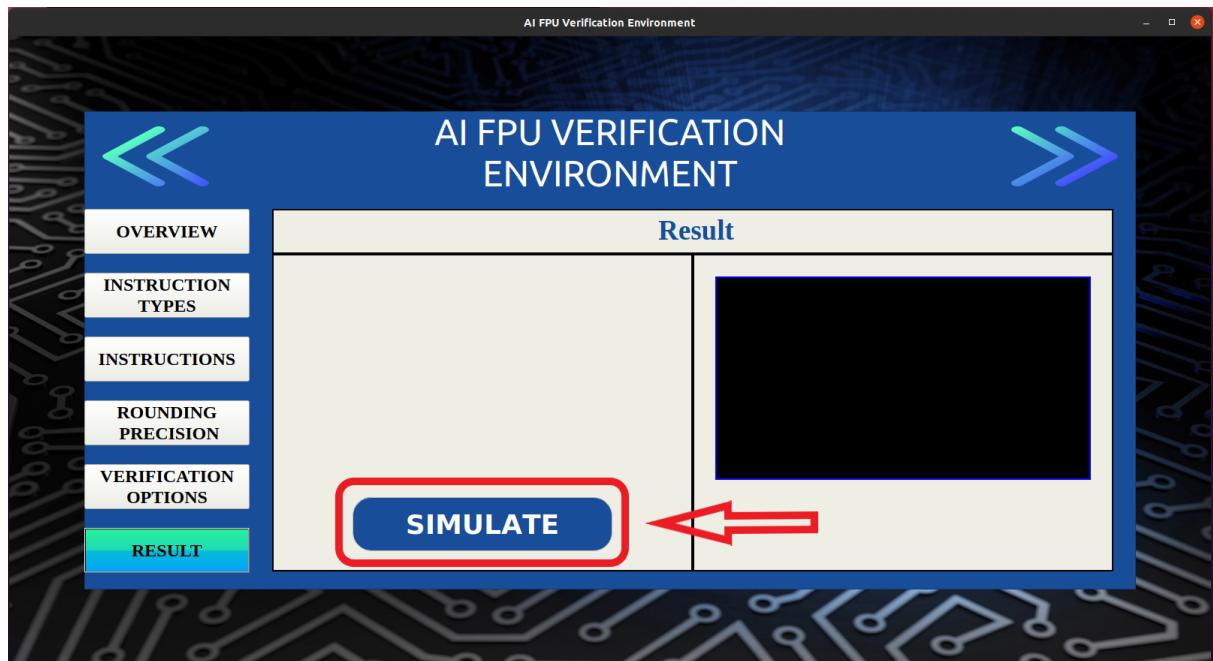
If you select the **Result Comparison** option, you can skip the setting of Verification Parameters. The comparison does not need any parameters as it only compares the design result with ISS results. For comparison, it's essential to run both the **RTL Simulation** and **ISS Simulation** beforehand since this option compares their output.

To select the Result Comparison option, check the checkbox below.

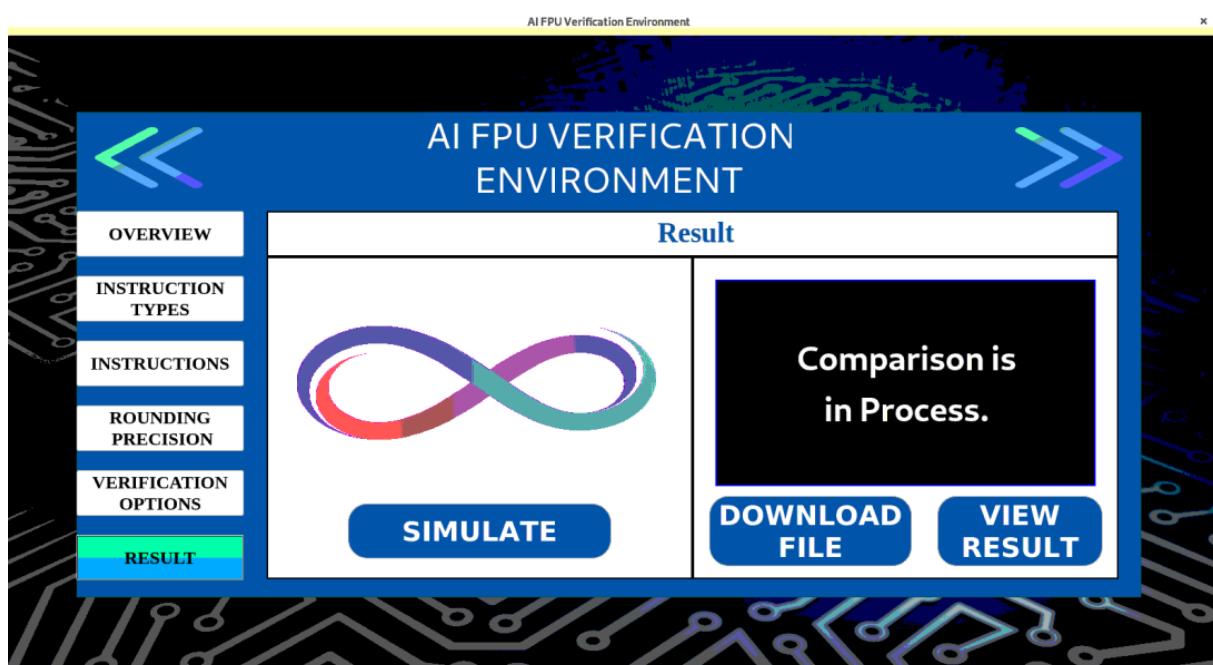


4.8.4.2 Simulation

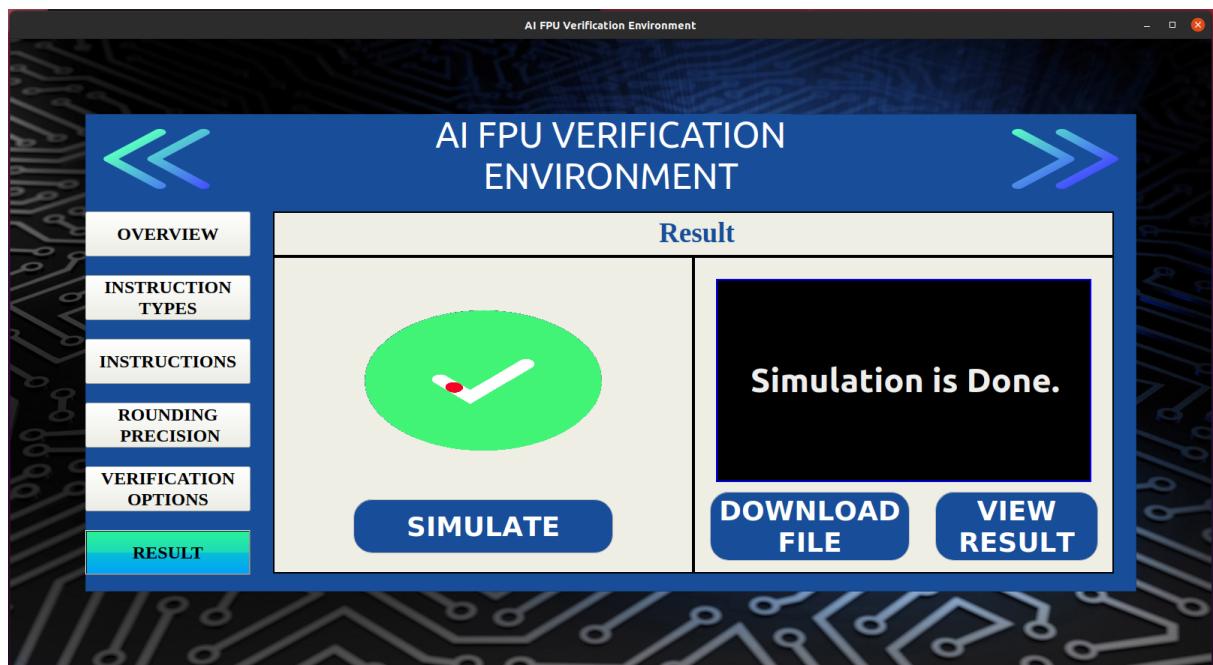
Once you have completed all the steps in the Verification options press the next button. A window similar to the one shown will appear. Press the **SIMULATE** button to initiate the simulation.



Once you click the **SIMULATE** button, a message will appear on the GUI Terminal, indicating that the Comparison is in progress.

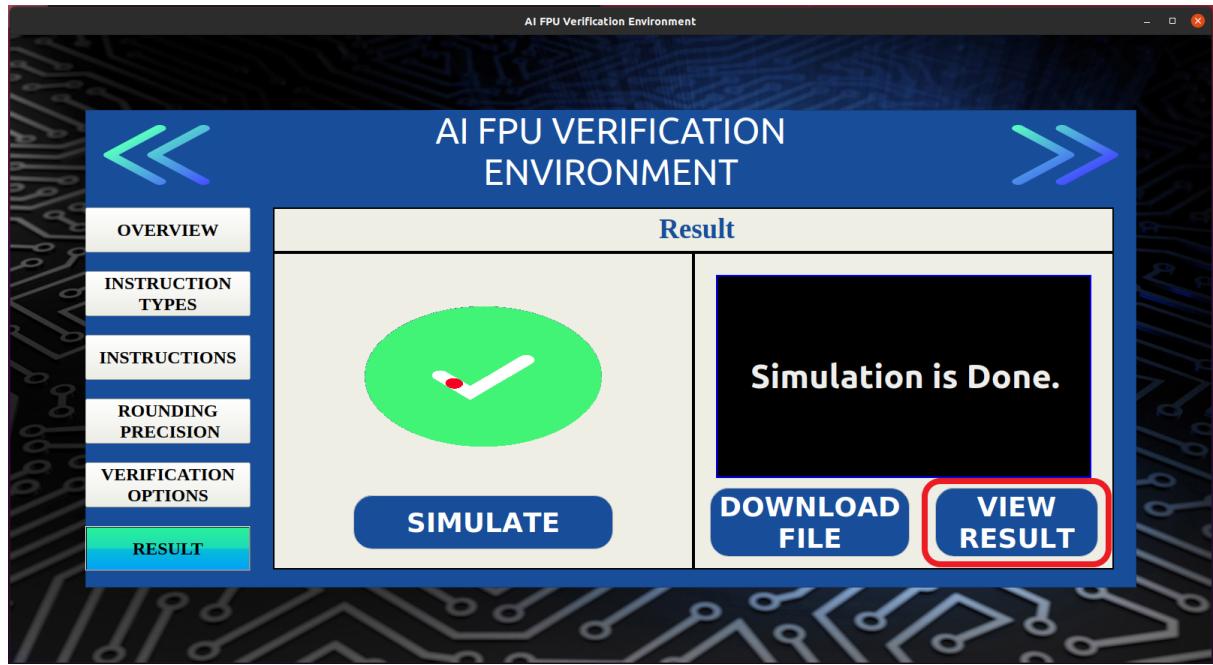


After the successful simulation, a message will appear on the GUI Terminal, indicating that the Comparison has been Done.

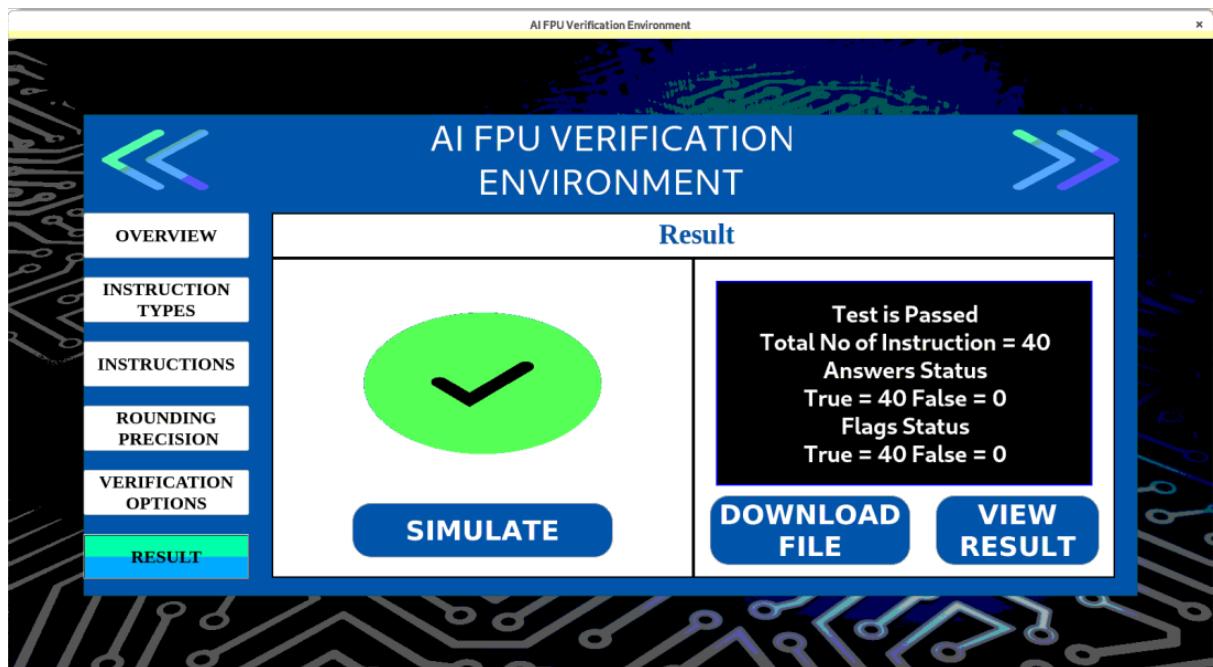


4.8.4.3 View Results

To view the results, click the "VIEW RESULT" button encircled in red.

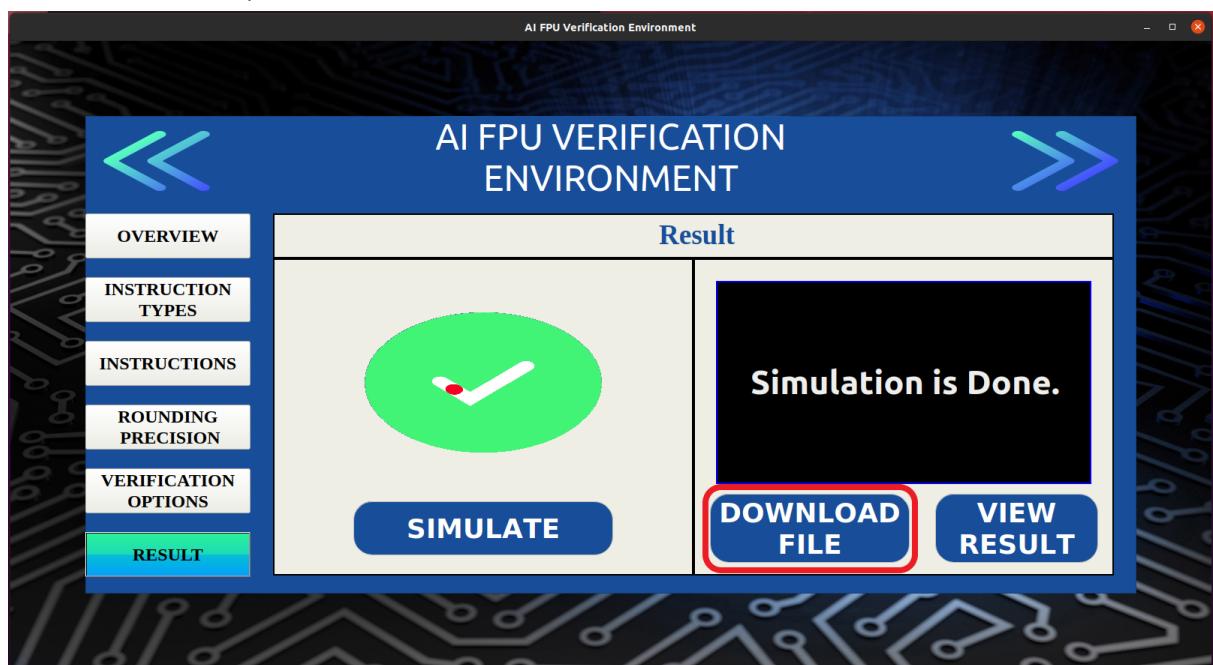


After clicking on the "**VIEW RESULT**" button, a message will appear on the GUI terminal that displays the results of the comparison. It will show the statistics of whether the test is passed or failed, What is the total number of instructions that have been verified, and how many answers and flags are exactly matching with the Golden Model, which allows you to determine the overall performance of the design. This information can be used to make improvements and optimizations to the design.

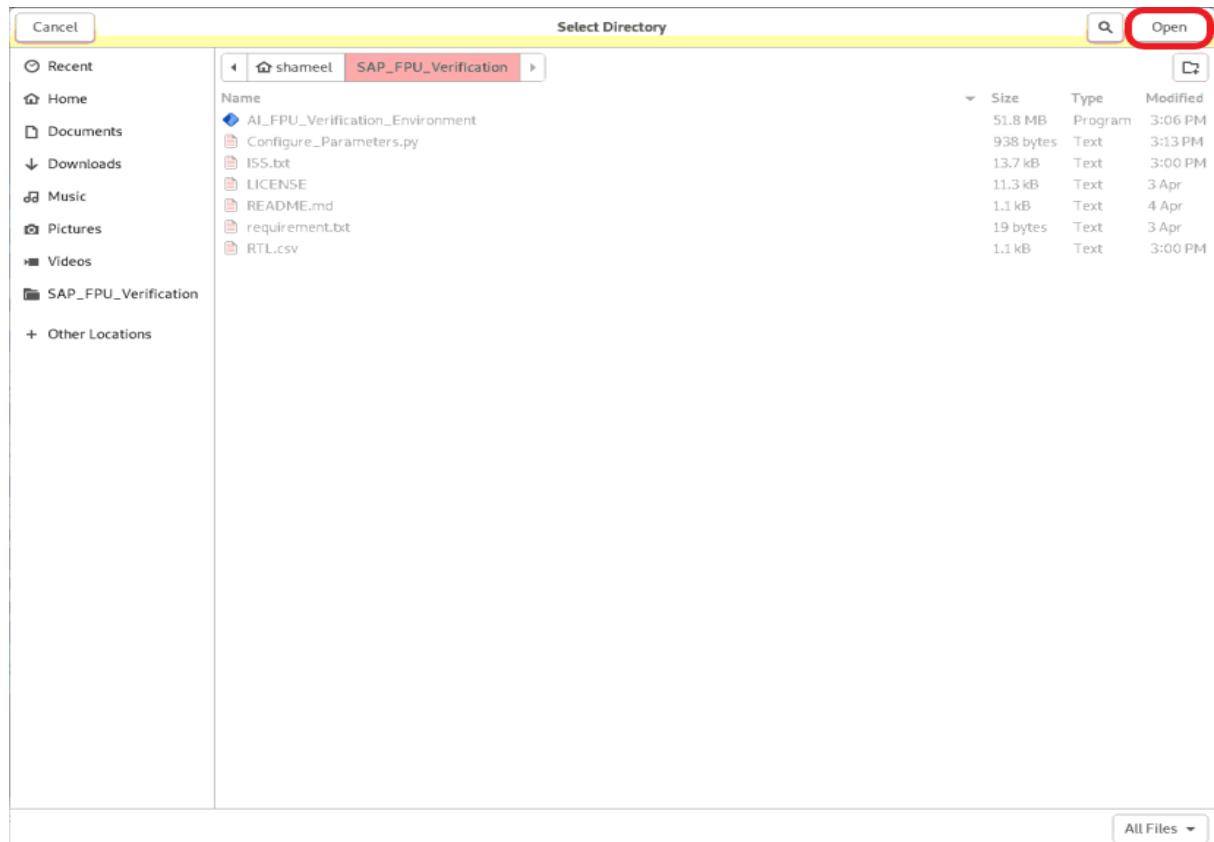


4.8.4.4 Downloading File

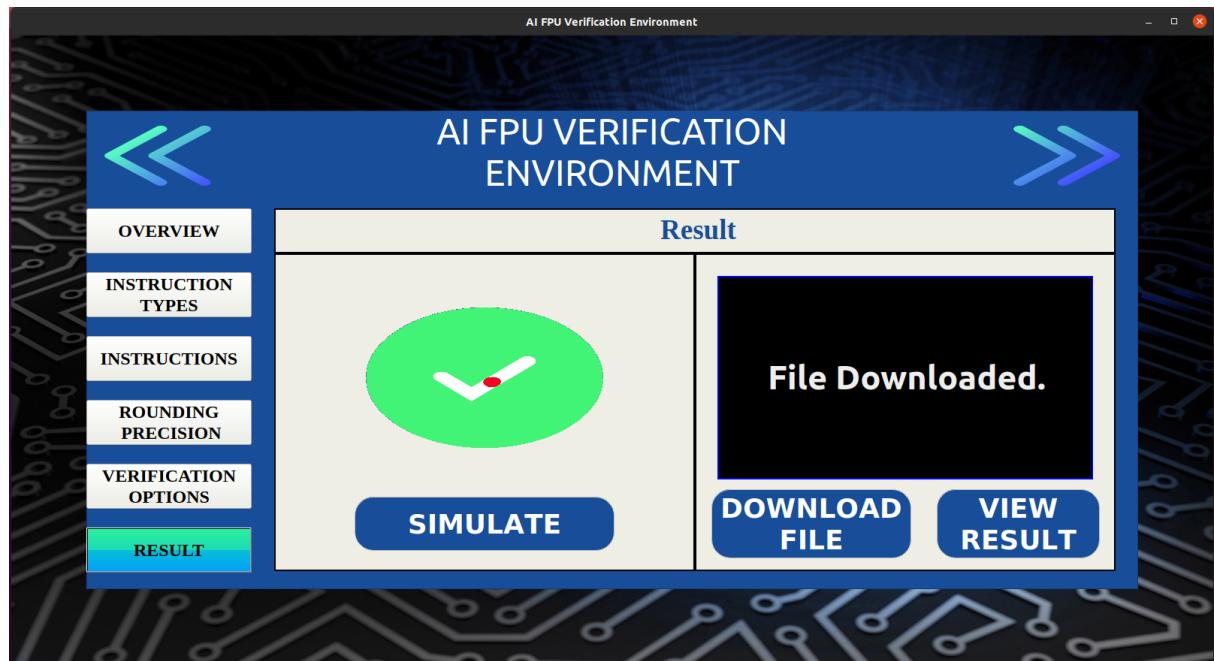
To download the file, click the "**DOWNLOAD FILE**" button encircled in red.



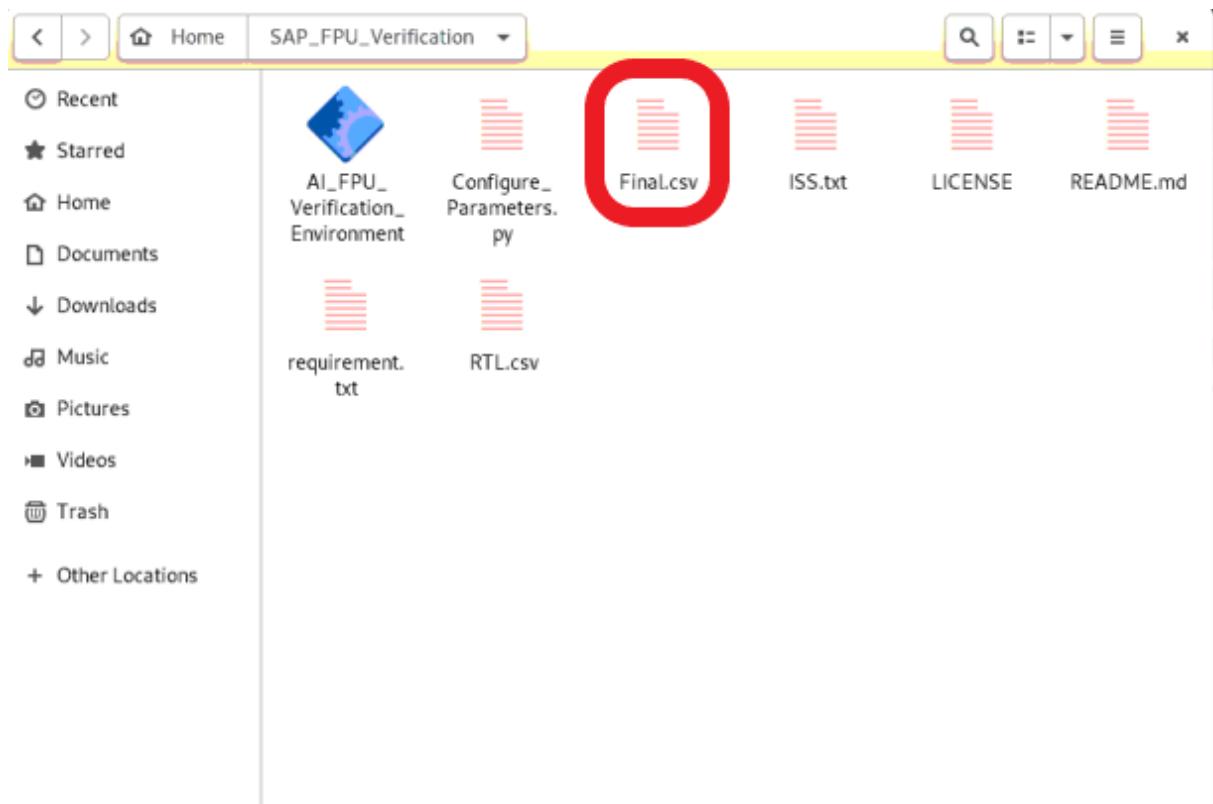
Once you click on the "**DOWNLOAD FILE**" button, a window will pop up asking you to select the directory where you want to save the file. Click on the red indicated button to start the download process.



On successful operation the message will appear on the GUI Terminal, indicating that the file has been downloaded.



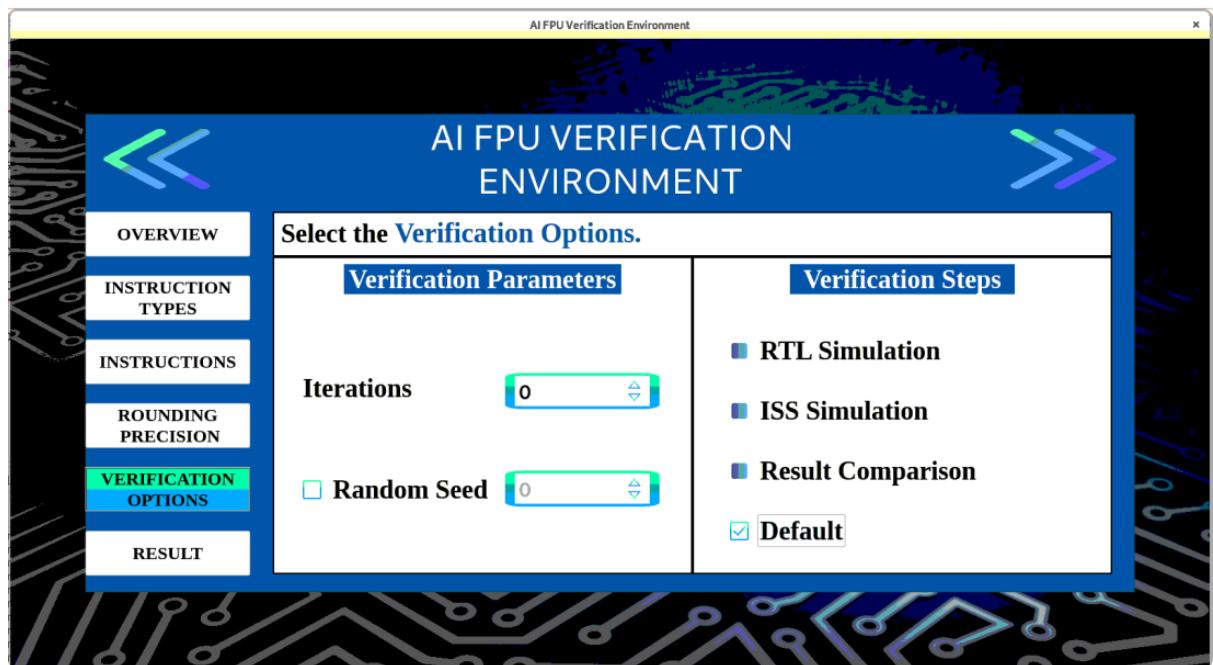
Result Comparison only generates the Final CSV file as indicated below.



4.8.5 Default

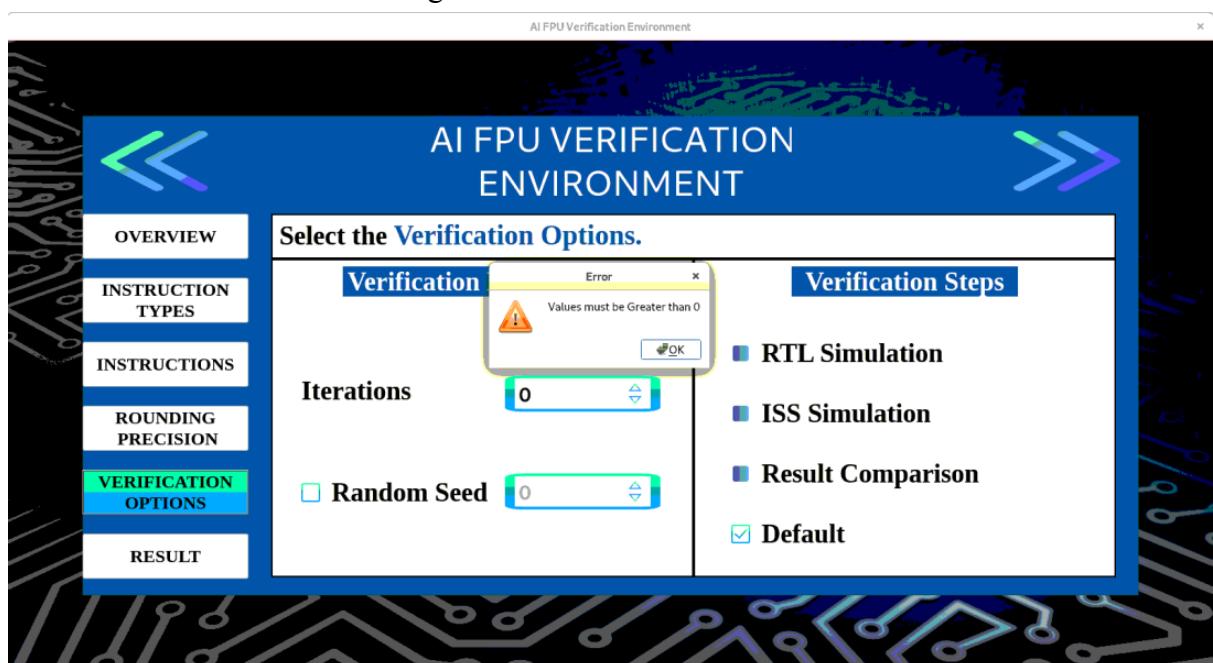
4.8.5.1 Verification Step

If you want to perform all the Verification Steps simply select the Default option as shown below.



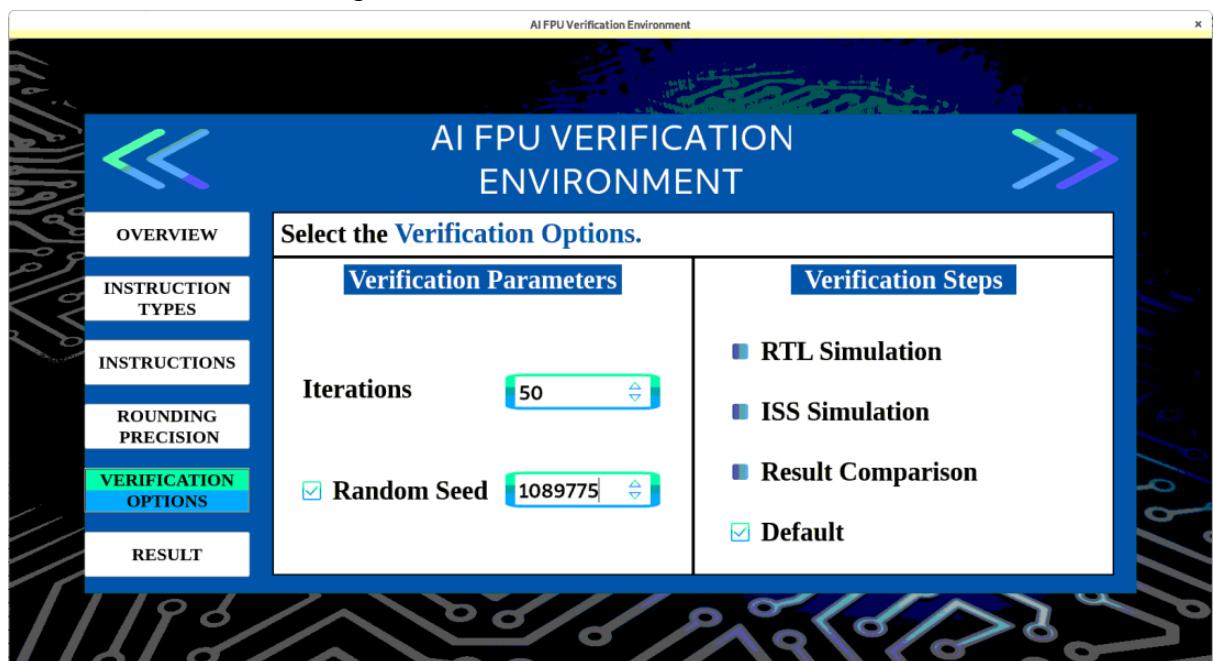
4.8.5.2 Error Generation

When choosing **Default**, it is necessary to set the **Verification Parameters**. Otherwise, an error message will appear when clicking the "next button" instructing the user to set the iteration value greater than zero.



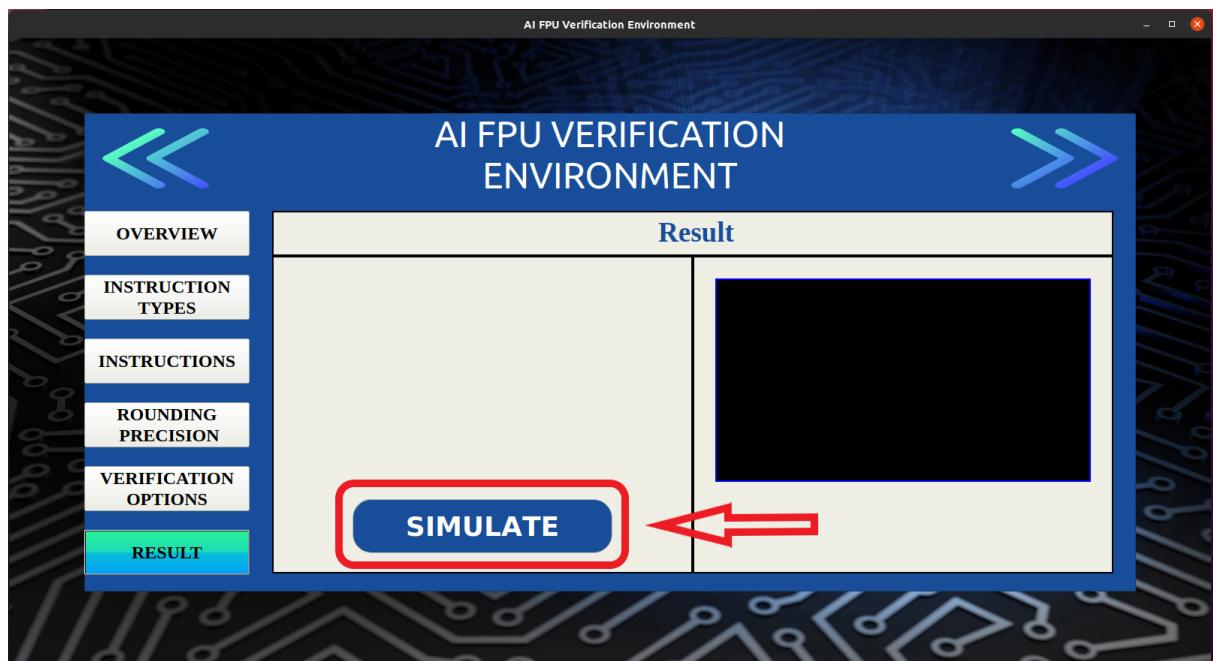
4.8.5.3 Iteration & Random Seed

The description of the Iteration value and Random Seed is the same as mentioned in the RTL Simulation heading.

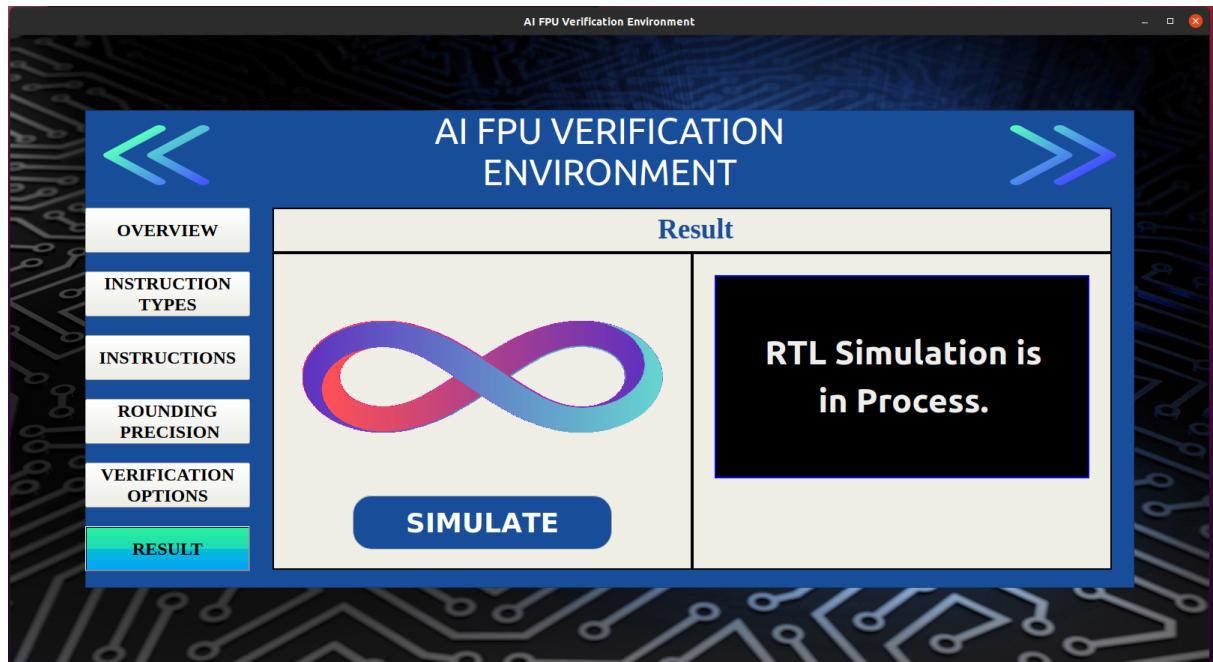


4.8.5.4 Simulation

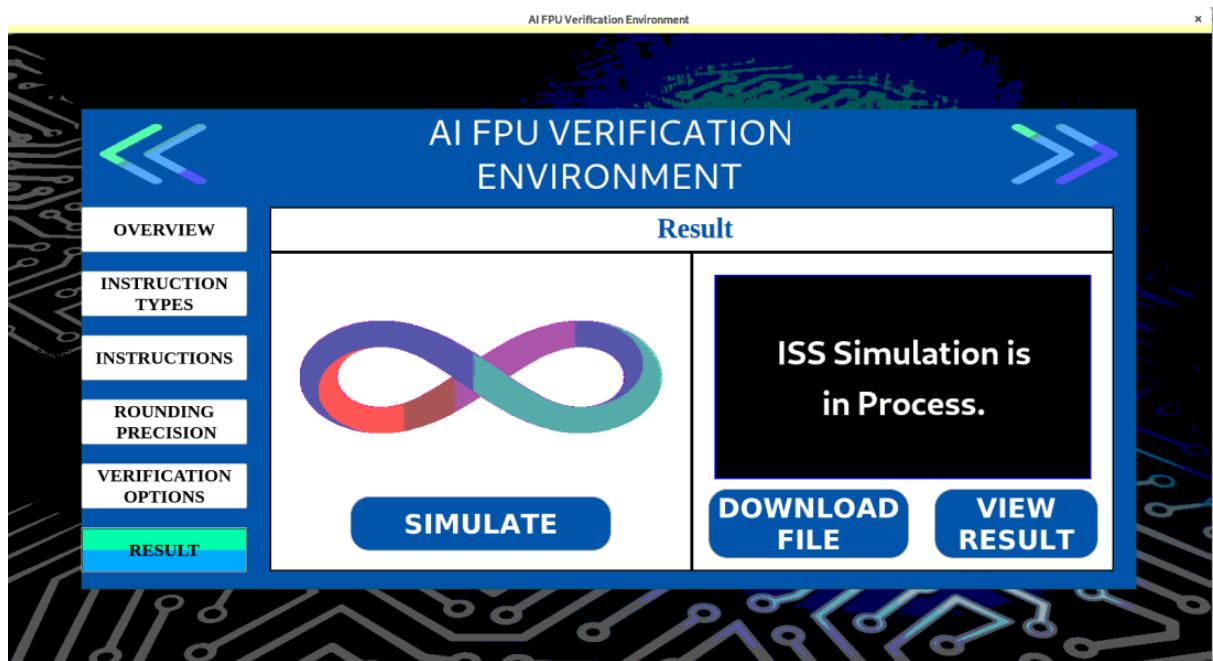
Once you have completed all the steps in the Verification options and pressed the next button, a display similar to the one shown will appear. Press the **SIMULATE** button indicated in red to initiate the simulation.



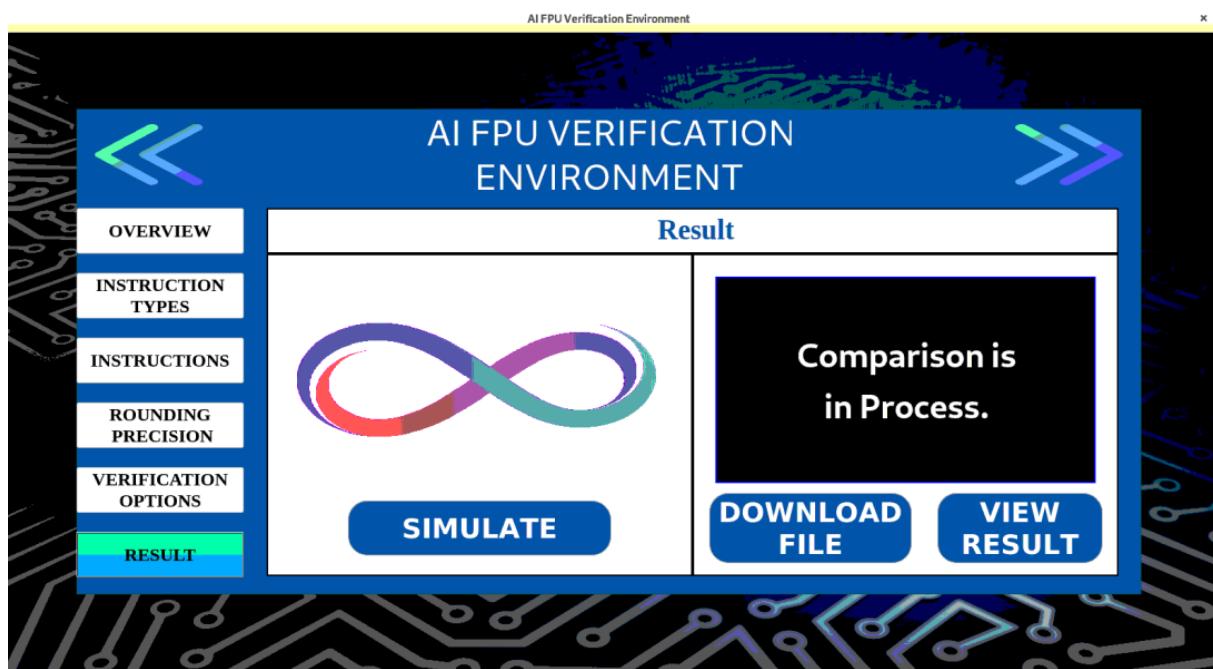
Once you click the **SIMULATE** button, a message will appear on the GUI Terminal, indicating that the RTL simulation is in progress.



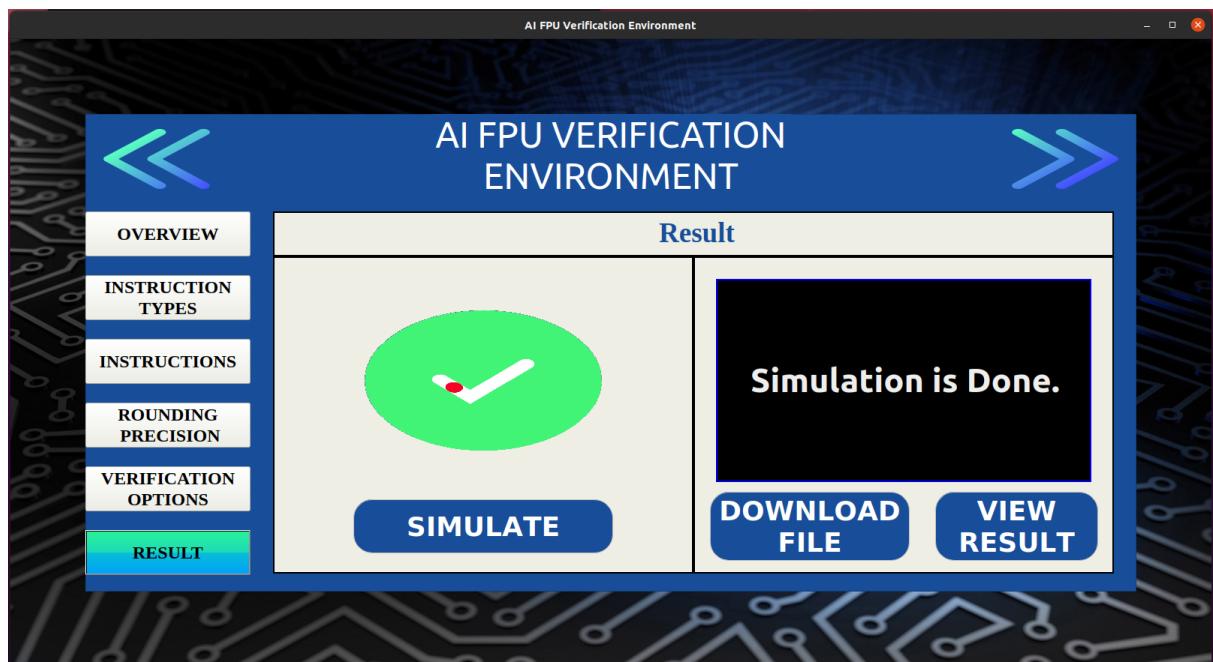
On successful **RTL Simulation**, a message will appear on the GUI Terminal, indicating that the ISS simulation is in progress.



On successful **ISS Simulation**, a message will appear on the GUI Terminal, indicating that the Comparison is in progress.

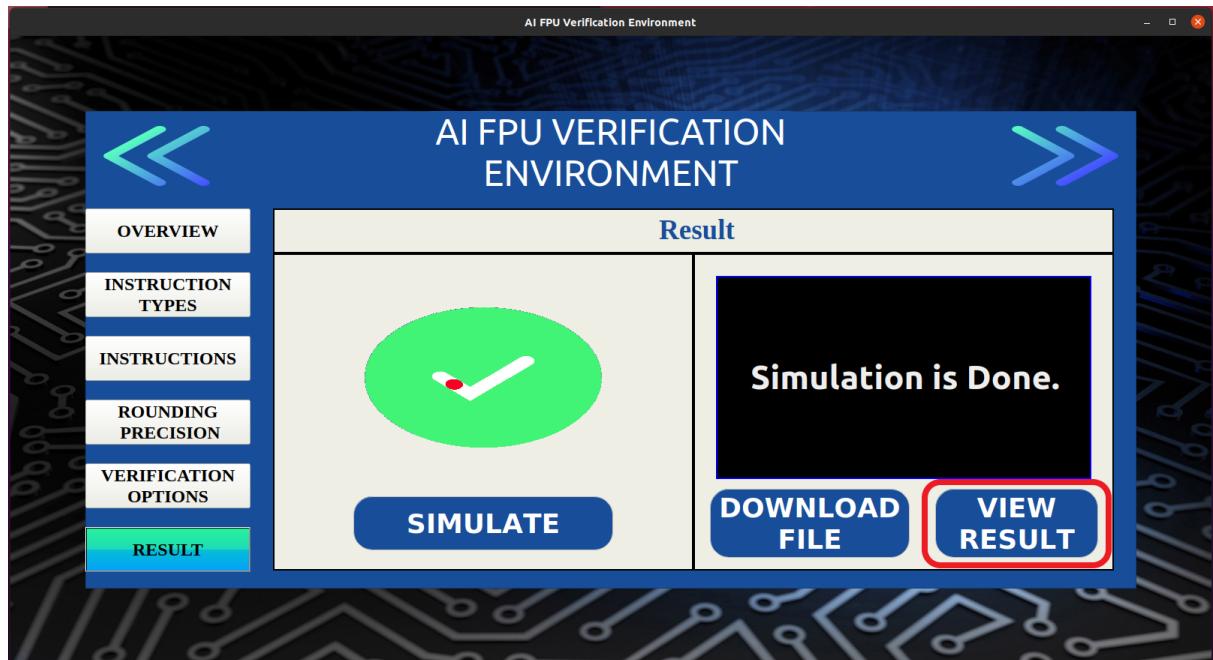


After the successful simulation, a message will appear on the GUI Terminal, indicating that all the Simulations have been Done.

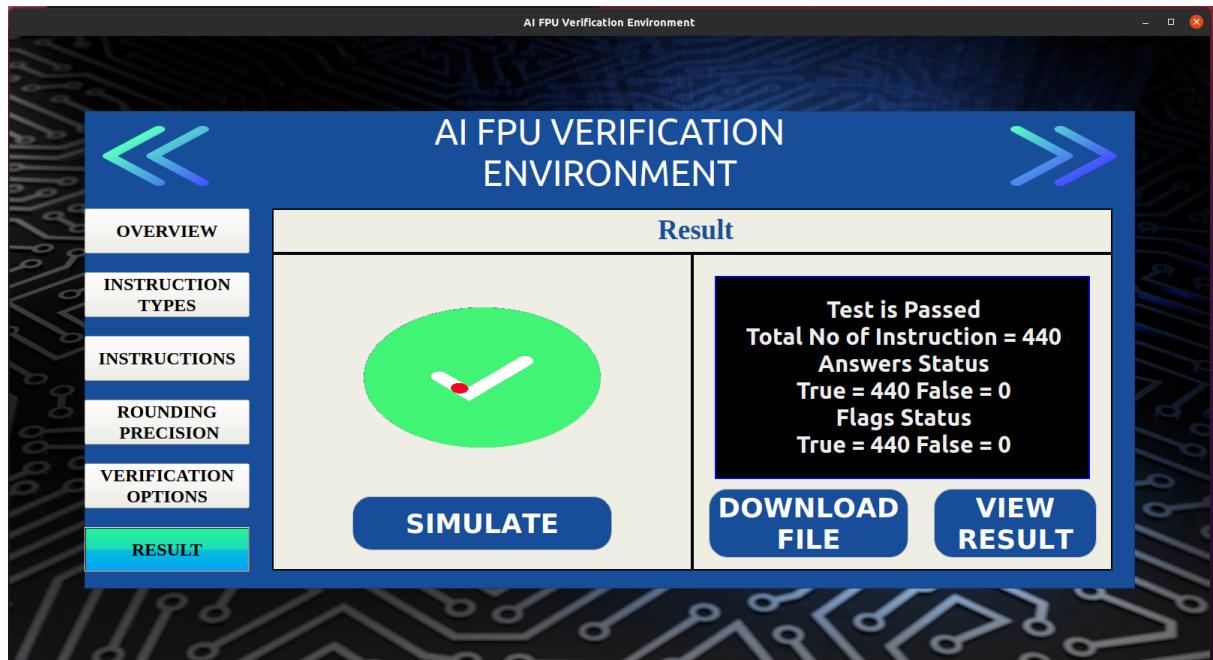


4.8.5.5 View Results

To view the results, click the "VIEW RESULT" button encircled in red.

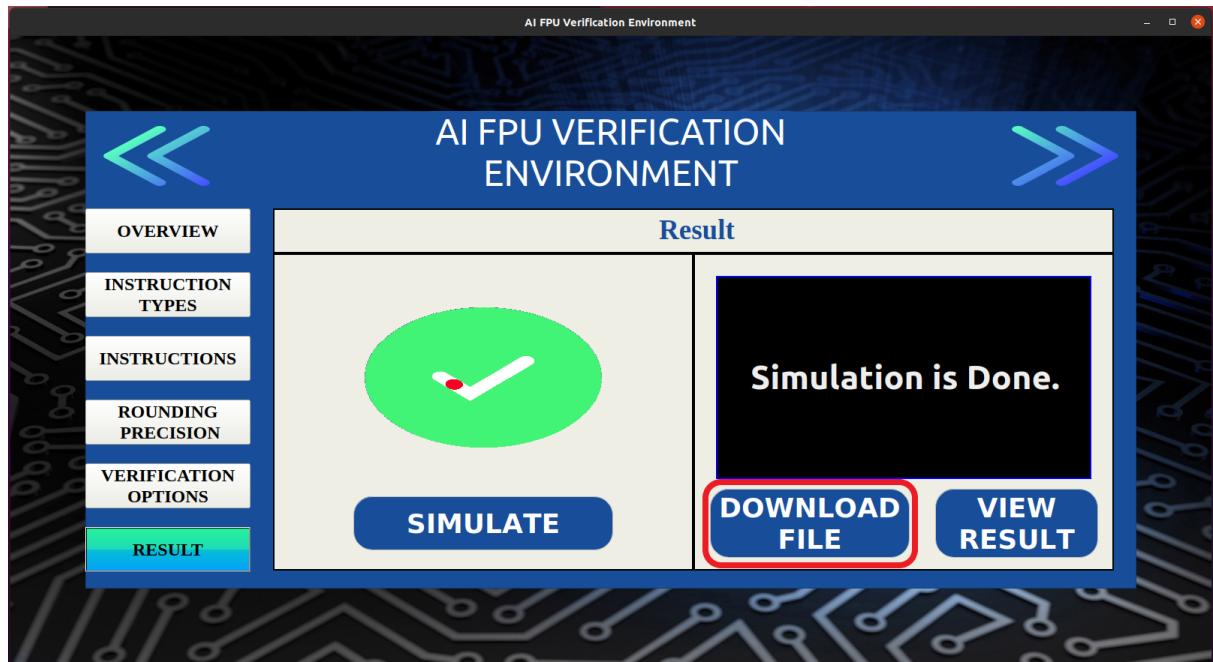


After clicking on the "VIEW RESULT" button, a window will appear that displays the results of the simulation. It will display the same statistics as mentioned in the Result Comparison heading.

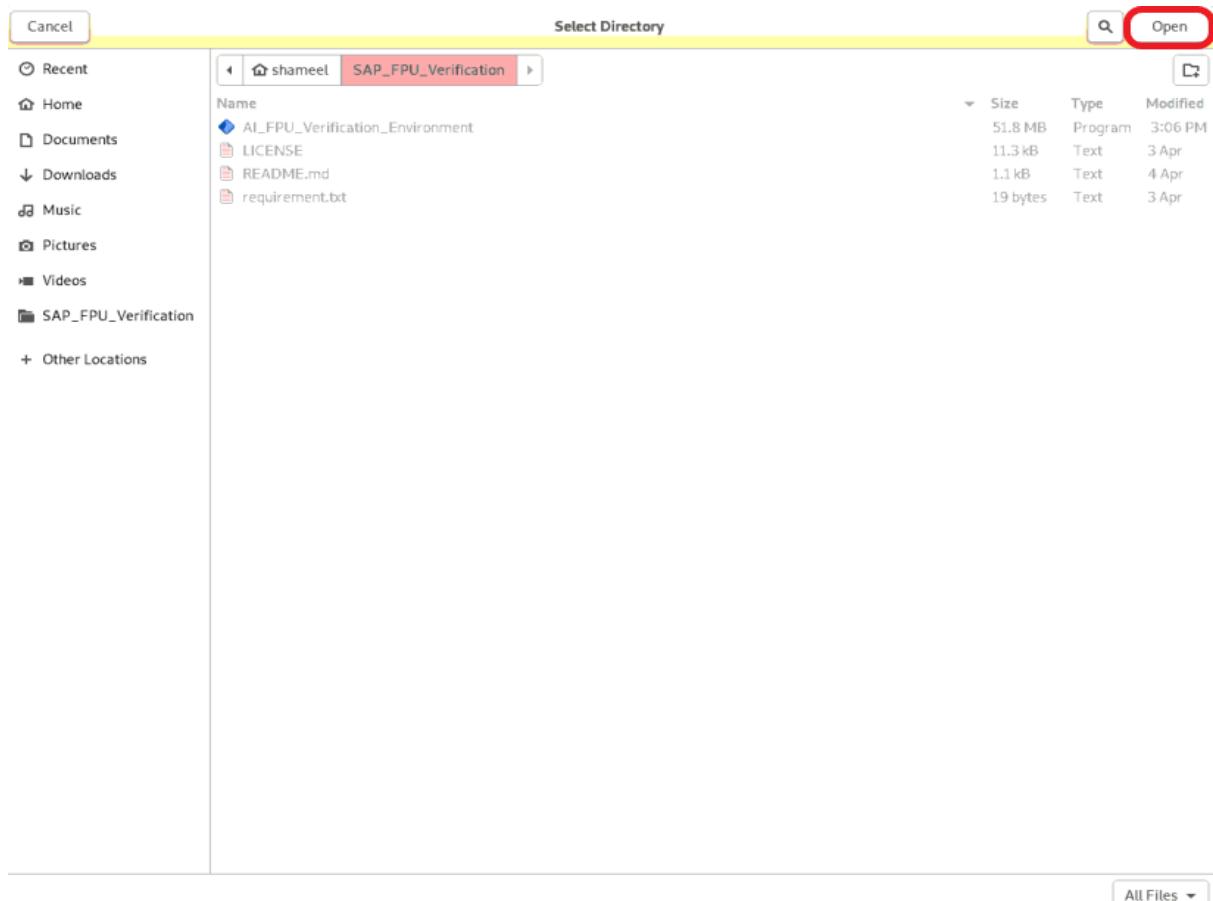


4.8.5.6 Downloading File

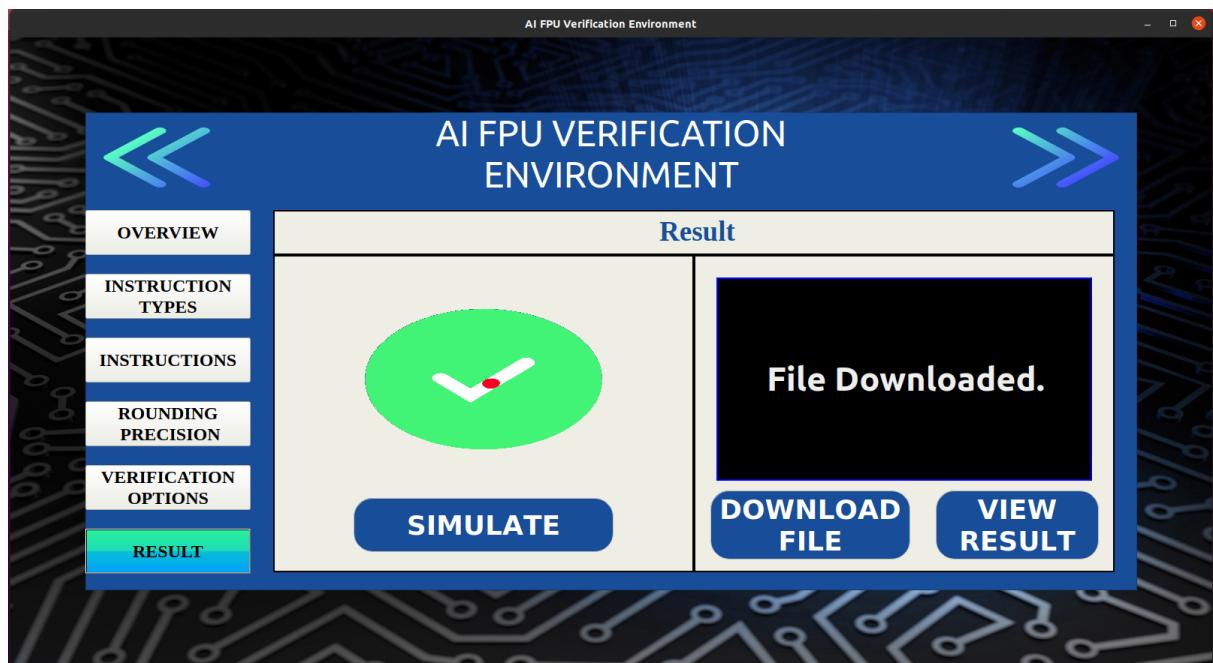
To download the file, click the "DOWNLOAD FILE" button encircled in red.



Once you click on the "DOWNLOAD FILE" button, a window will pop up asking you to select the directory where you want to save the file. Click on the red indicated button to start the download process.



On successful operation the message will appear on the GUI Terminal, indicating that the file has been downloaded.



The Default option only generates the Final CSV file as indicated below.

