EE789
Assignment-3
Design a Gaussian-Elimination System

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1 Question 1 - Floating Point Divider

- The design was verified and accuracy better than 10^6 was achieved.
- Average No. of clock cycles taken by divider to produce result = (Average No. of iterations * Cycles per iteration) + (time taken to compute initial guess)
  Average No. of iterations = 7
  Cycles per iterations = 44
  Time taken to compute initial guess = 4
  Therefore, Average No. of clock cycles taken = 312 cycles
- The values of cycles per iteration and time taken to compute initial guess were calculated using the variables "iteration_duration_indicator" and "initguess_computation_duration" respectively which toggle upon completion of the respective processes.
- The initial guess was made by extracting the exponent part of the denominator and changing its sign (if 'm' is the integer equivalent of the exponent part, then 254-m will give the opposite sign going by the IEEE 754 floating point representation).

1.1 Output Screenshots of FP Divider-

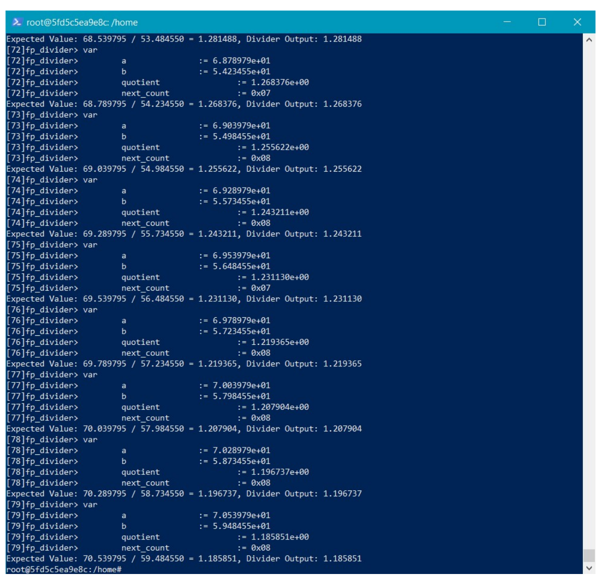

Figure 1: Software simulation of FP divider for test cases in testbench

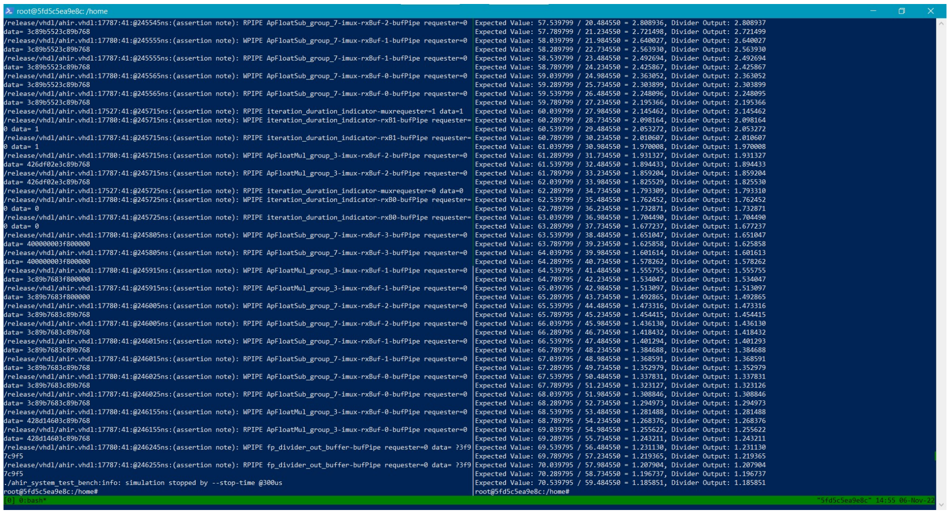

Figure 2: Hardware simulation of FP divider for test cases in testbench

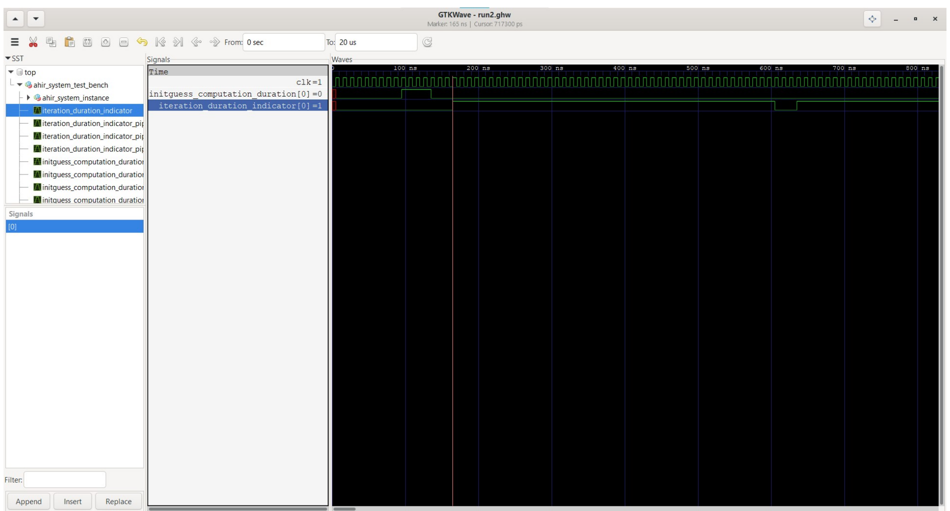

Figure 3: GHDL waveform showing toggling of "iteration_duration_indicator" variable to determine duration of iteration

2 Question 2 - Guassian Elimination

Performance of System = Total No. of FP operations/Total Time Taken
No. of FP division = 152
No. of FP subtractions = 1720
No. of FP multiplications = 1720
Total No. of FP operations = 3592
Total Time Taken (For the test case used) = 713.83 μs (71,383 cycles)
Therefore, Performance = 5.032 * 10^6 = 5.032 MFLOPS

The time taken for computation was determined using the variable "cycle_indicator" in the aa code whose value goes to '1' when the computation starts and goes back to '0' once the computation ends. The duration of this pulse gives the time taken for computation of solution.
The "cycle_indicator" goes to '1' at 22.495us and comes back to '0' at 736.325us. Hence the time taken for computation of solution is (736.325-22.495) = 713.83us = 71383 cycles.

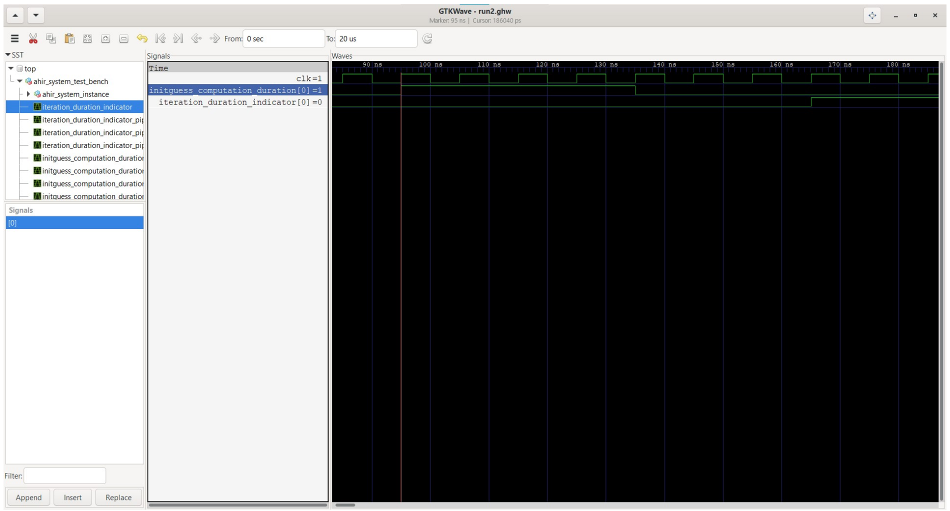

Figure 4: GHDL waveform showing toggling of "initguess_computation_duration" variable to determine duration of initial guess computation

2.1 Pseudo Code of FP Divider

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```
float an[16][17]; \\matrix containing aij (lhs) and bi (rhs) matrix
float x[16]; \\solution (output) matrix

for(f=0;f<16;f++){
    for(g=f;g<17;g++){
        an[f][g]=an[f][g]/an[f][f]; \\making diagonal element equal to 1
        }                            \\FP divider module used for this division
    if(f<15){
        for(h=f+1;h<16;h+=5){
            for(i=16;i>f;i--){
                an[h][i]=an[h][i]-(an[h][f]*an[f][i]); \\converting to row echelon form
                an[h+1][i]=an[h+1][i]-(an[h+1][f]*an[f][i]);
                an[h+2][i]=an[h+2][i]-(an[h+2][f]*an[f][i]); \\unwinding loop for
                an[h+3][i]=an[h+3][i]-(an[h+3][f]*an[f][i]); \\better performance
                an[h+4][i]=an[h+4][i]-(an[h+4][f]*an[f][i]);
            }
        }
    }
}

\\an[][] matrix contains the upper triangular matrix now
\\To obtain output x[]-
x[15]=an[15][16];
for(j=1;j<16;j++){
    x[15-j]=an[15-j][16];
    for(k=0;k<j;k++){
        x[15-j]=x[15-j]-(an[15-j][15-k]*x[15-k]);
    }
}
\\Solution is now present in x[] matrix
```

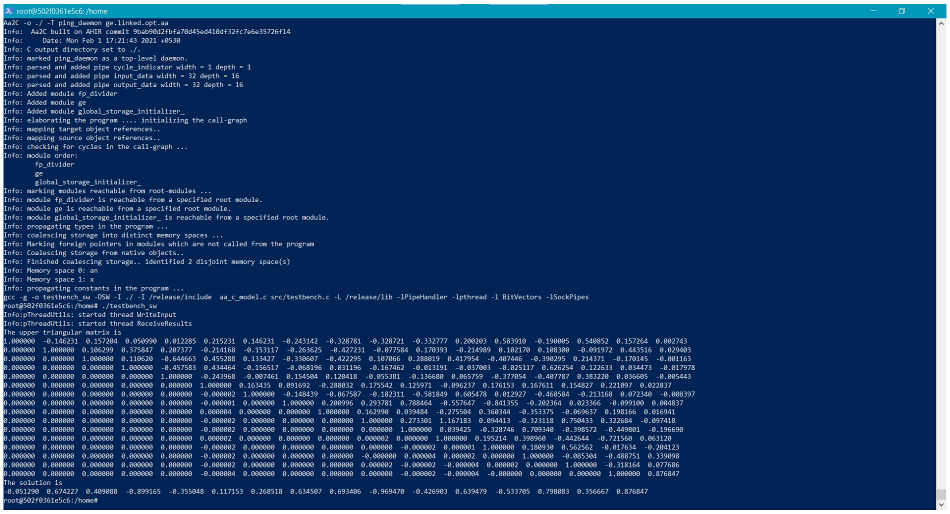

Figure 5: Software Simulation showing upper triangular matrix and Solution to the given input test case

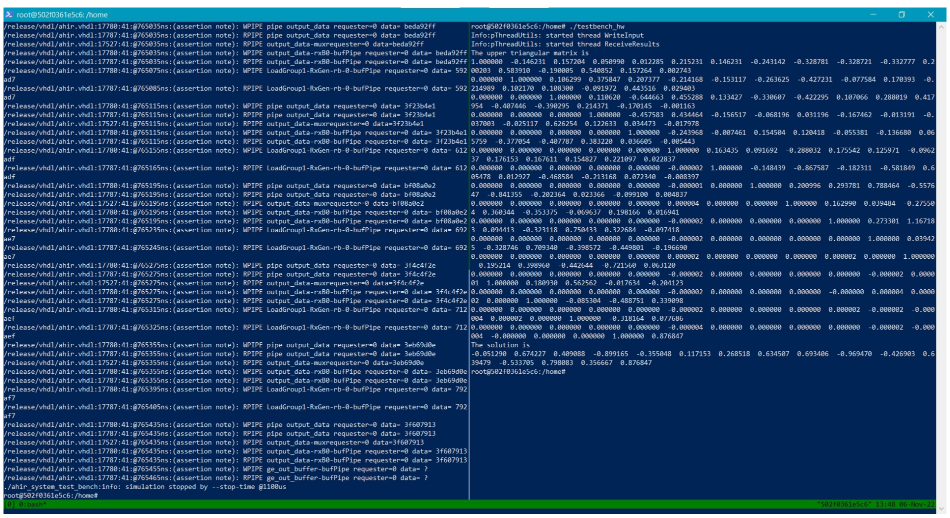

Figure 6: Hardware Simulation showing upper triangular matrix and Solution to the given input test case

2.2 Output Screenshots of Guassian Elimination Design-

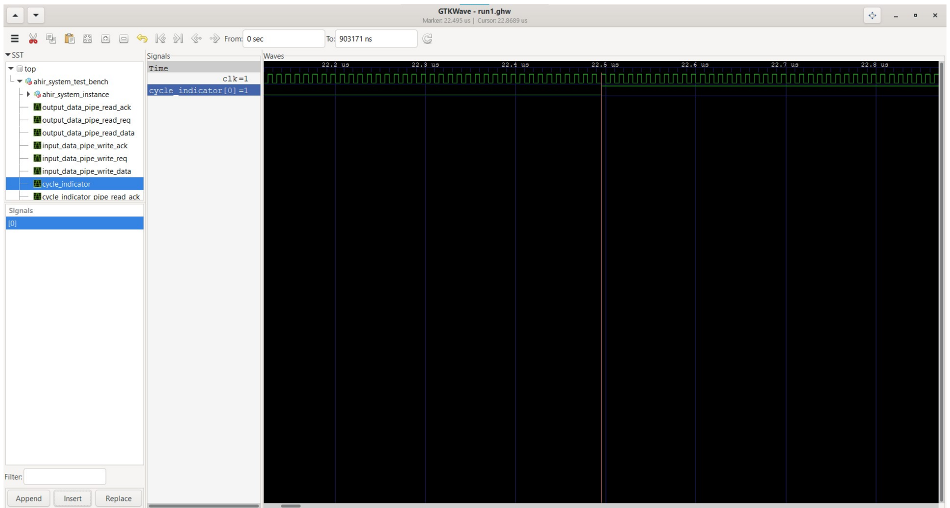

Figure 7: GHDL waveform showing the variable "cycle_indicator" going to '1' at 22.495us

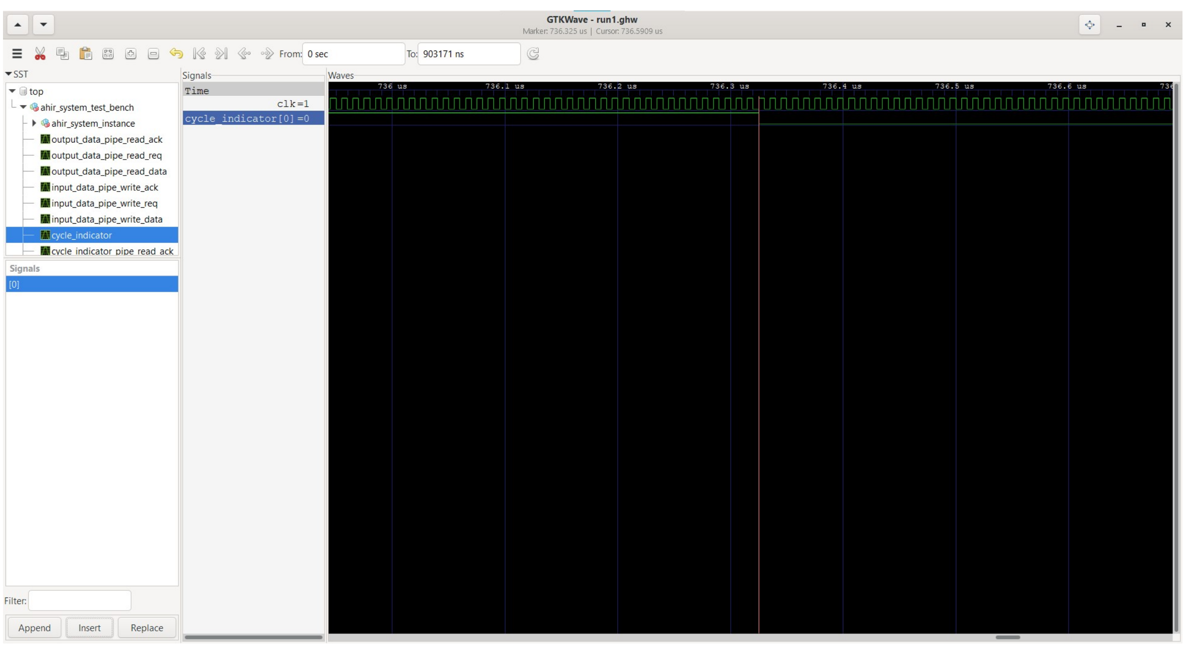

Figure 8: GHDL waveform showing the variable "cycle_indicator" going to '0' at 736.325us