FPGA Auto Correlation Function Simulation Results

Background

I have performed fifteen individual tests comparing the Vivado simulation results of the Auto Correlator implementation containing n(i) of size 100, n(i) of size 1000, and finally n(i) of size 10000 samples.

The simulation results have been compared in MATLAB using the following program:

```
t_int = 125E-6; %Integration time (Adjusted based on the number of samples desired)
fs = 1E6; %Sampling frequency
n_int = fs*t_int; %Size of n(i) vector

mu = 5;         % Mean
sigma = 2;      % Standard deviation

uniformDist = randi([0,10],1,n_int); %Generating uniformly distributed numbers from 0 to 10

p = 5;
xmin=0;
xmax=10;
gaussianDist = round(xmin + (xmax - xmin)*sum(rand(n_int,p),2)/p); %Generates random integers
with Gaussian Distribution

n = gaussianDist; %Generated samples. Can change between uniformDist and gaussianDist

g2 = []
for(delay_time = logspace(log10(1E-6),log10(125E-6),40)) %Computing Auto Correlation function
with logarithmically spaced delay times.

    delta_n = delay_time*fs;
    n_avg = n_int - delta_n;
    numerator = n(1:end-delta_n+1) .* n(delta_n:end);
    numerator_timeAvg = sum(numerator)/n_avg;
    denominator = n.^2;
    denominator_timeAvg = sum(denominator)/n_int;
    g2(end+1) = numerator_timeAvg/denominator_timeAvg;

end
delayt = logspace(log10(1E-6),log10(125E-6),40); %Plotting computed Auto Correlation function
loglog(delayt,g2)
axis([1E-6,1E-4,0,1.1])
```

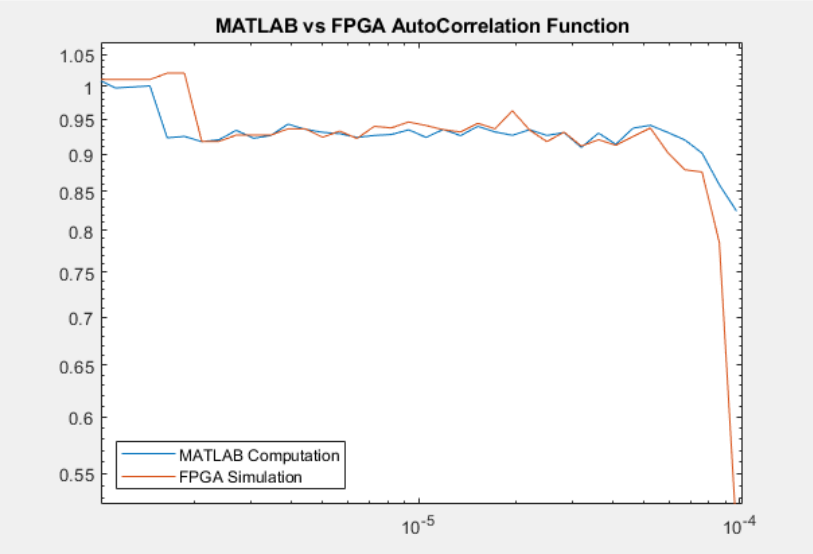
Numbers (integers) for the n(i) vector are generated using a Gaussian distribution using MATLAB's rand() function.

All tests are performed using a 1MHz sampling frequency while varying the integration time to vary the number of samples the n(i) vector will take.

Additionally, the "Observed average percent error" is computed which is the average percent error between the Auto Correlation function computed by MATLAB and the FPGA Simulation for each delay time.

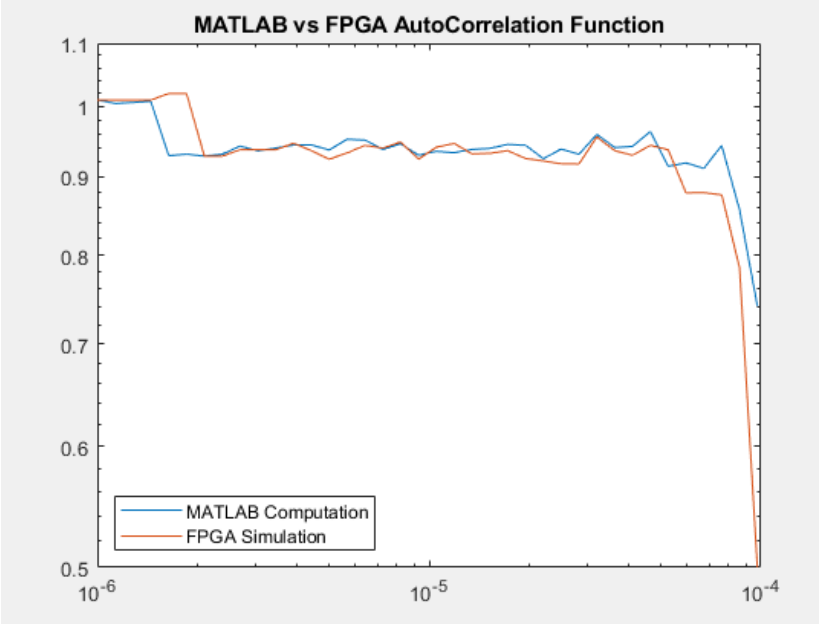
Auto Correlation Results With 100 Samples ($t_{int} = 100\ us$):

Test 1



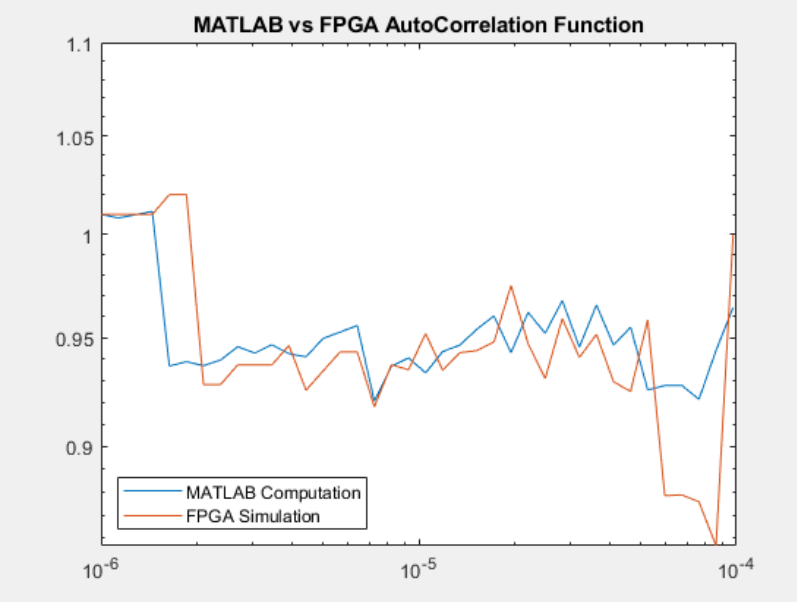
Observed average percent error: -0.74723%

Test 2



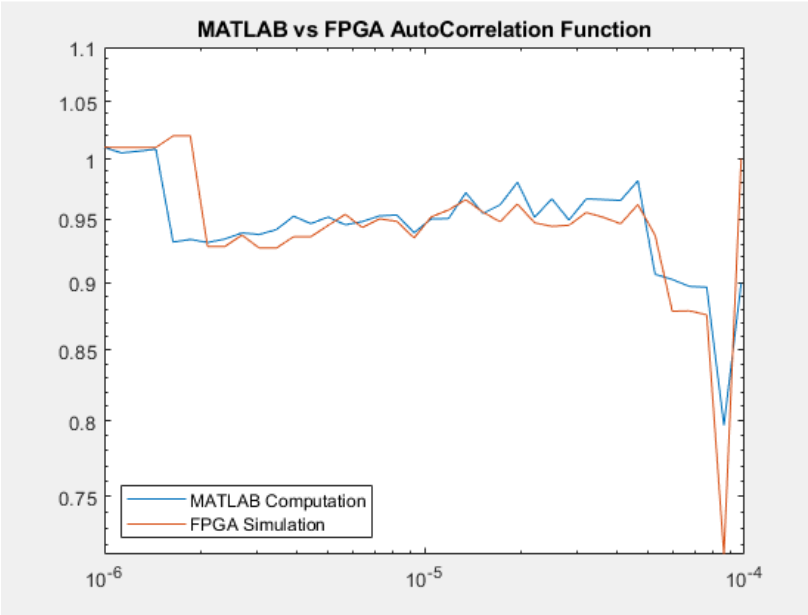
Observed average percent error: -1.3008%

Test 3



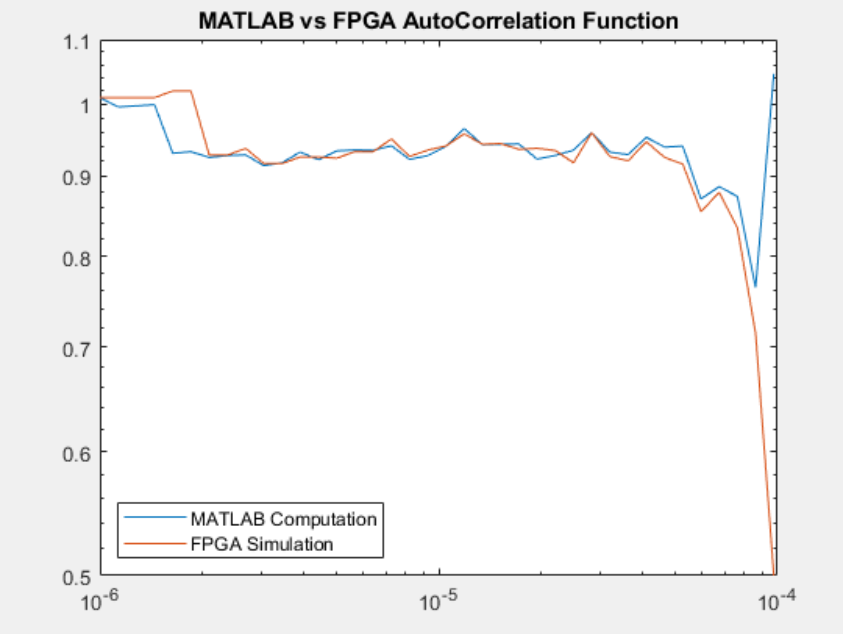
Observed average percent error: -0.53689%

Test 4



Observed average percent error: -0.11439%

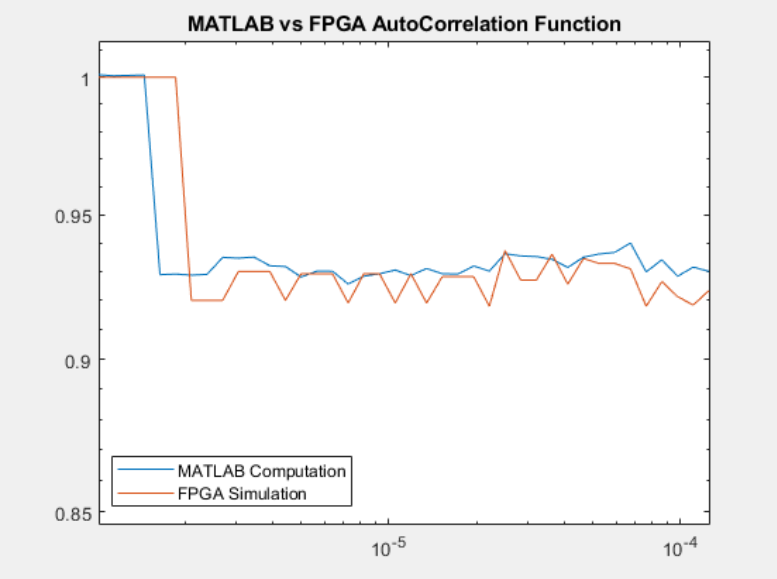
Test 5



Observed average percent error: -1.2799%

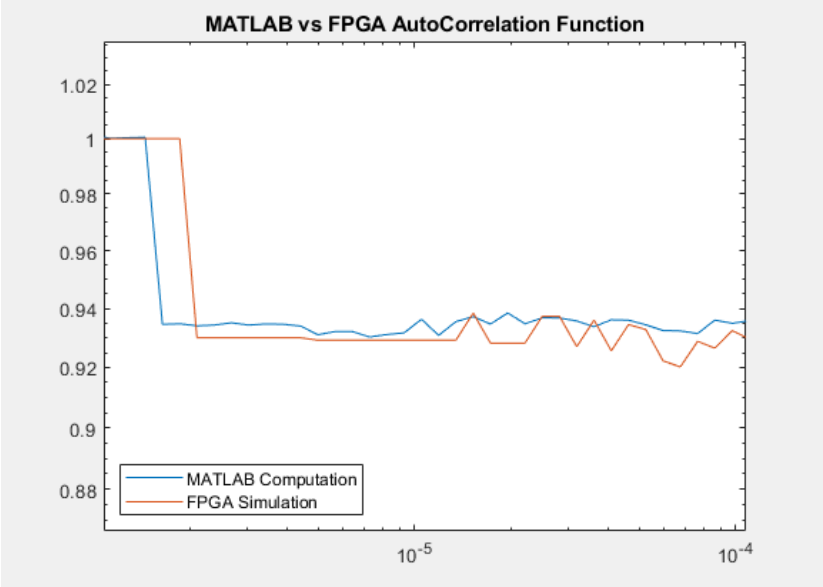
Auto Correlation Results With 1000 Samples ($t_{int} = 1\ ms$):

Test 1



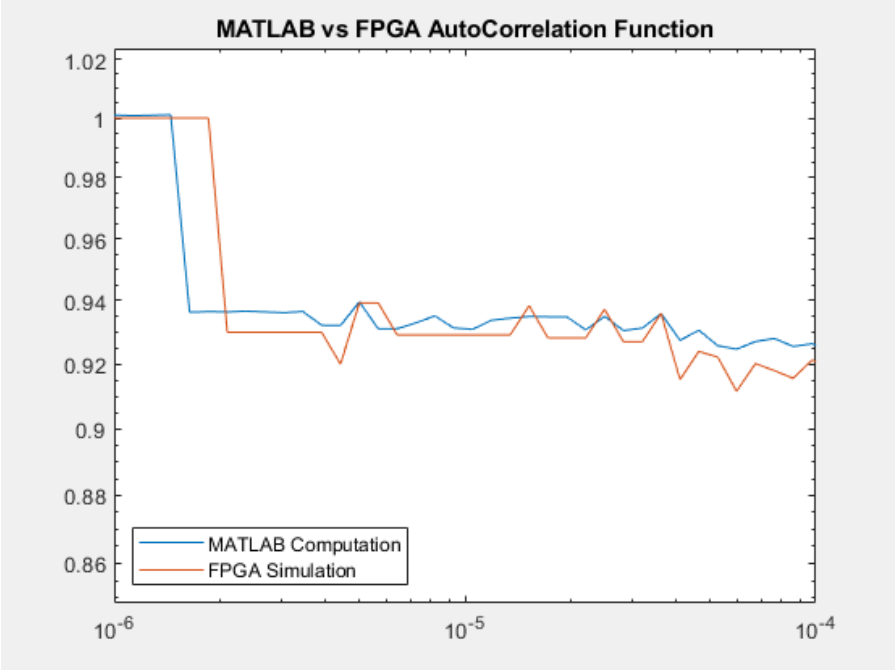
Observed average percent error: - 0.12241%

Test 2



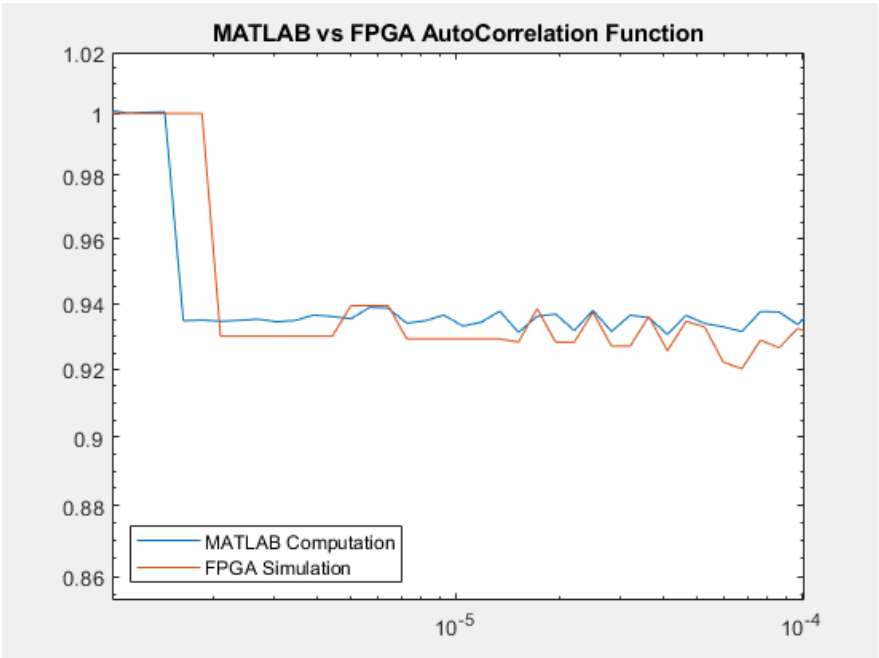
Observed average percent error: - 0.061677%

Test 3



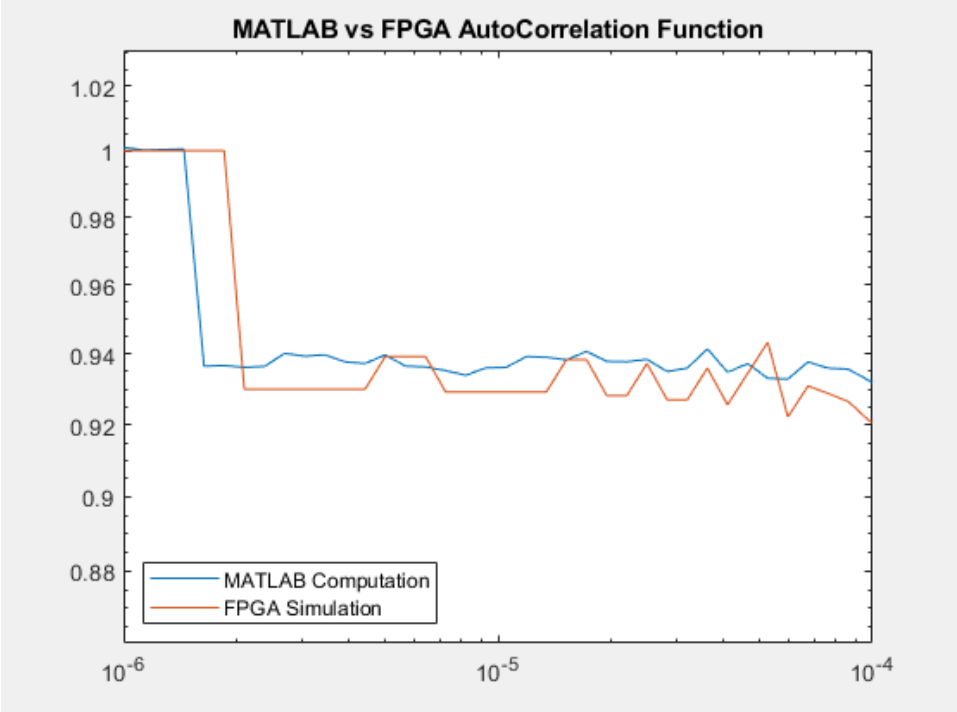
Observed average percent error: -0.12108%

Test 4



Observed average percent error: -0.10069%

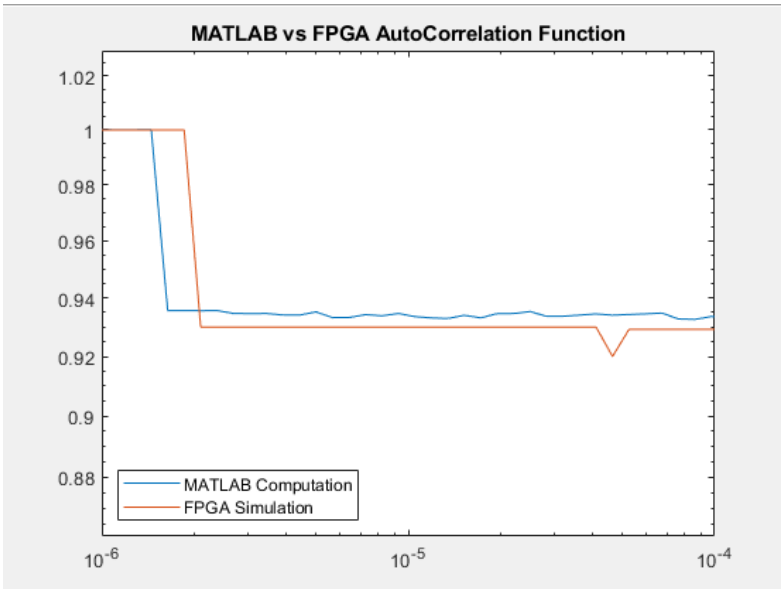
Test 5



Observed average percent error: -0.22629%

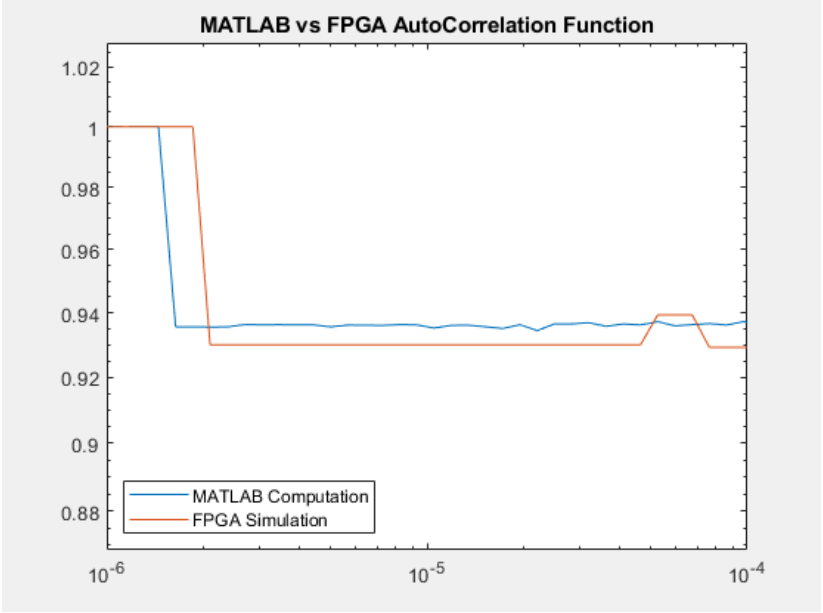
Auto Correlation Results With 10000 Samples ($t_{int} = 10\ ms$):

Test 1



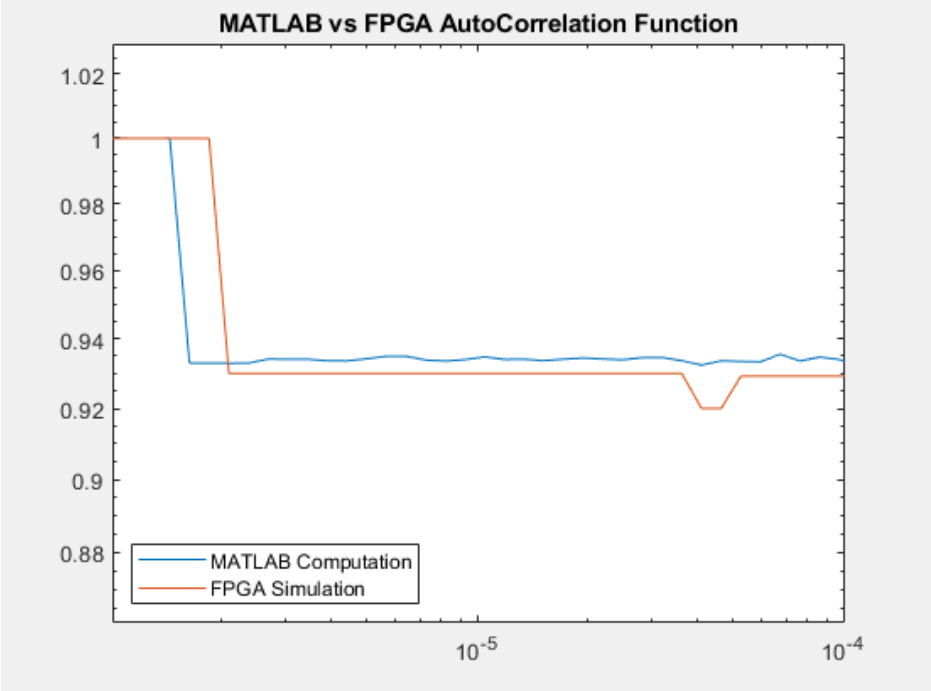
Observed average percent error: -0.077251%

Test 2



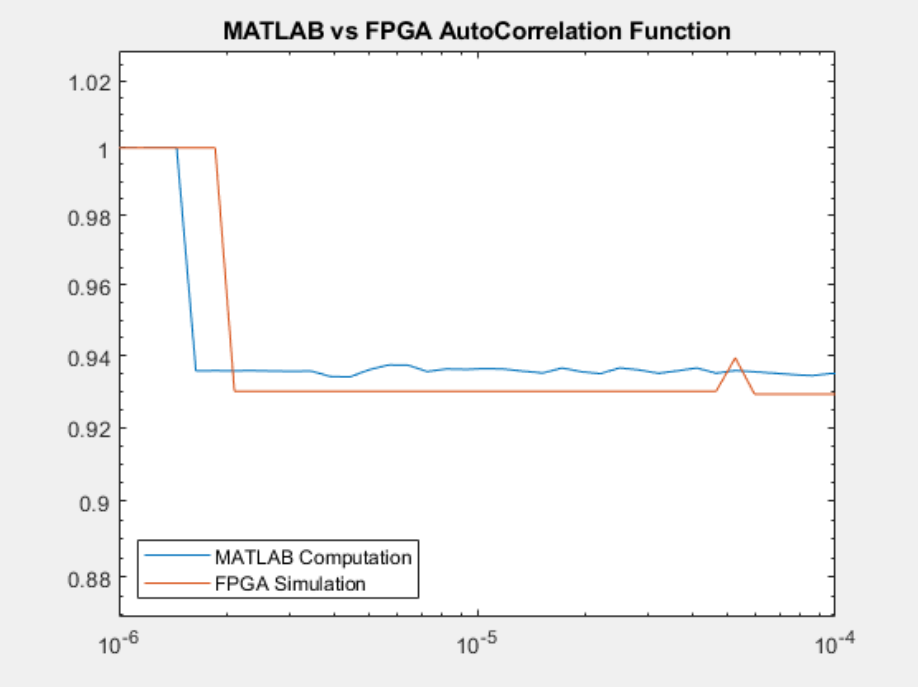
Observed average percent error: -0.14337%

Test 3



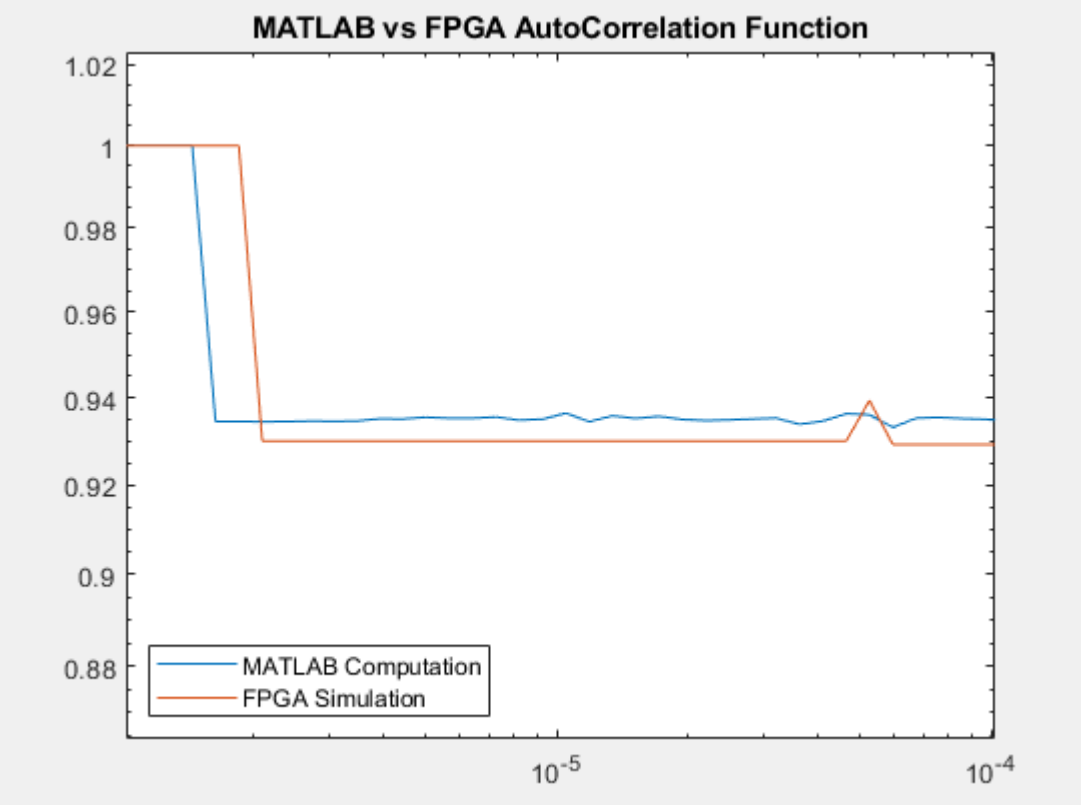
Observed average percent error: -0.070782%

Test 4



Observed average percent error: -0.15419%

Test 5



Observed average percent error: -0.094946%