departamento de eletrónica, telecomunicações e informática

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Report

Baseband Simulation – Signal and Noise

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Introduction

This assignment is intended to study a digital broadcast in baseband. The block diagram of what will be studied in this first task is the following:

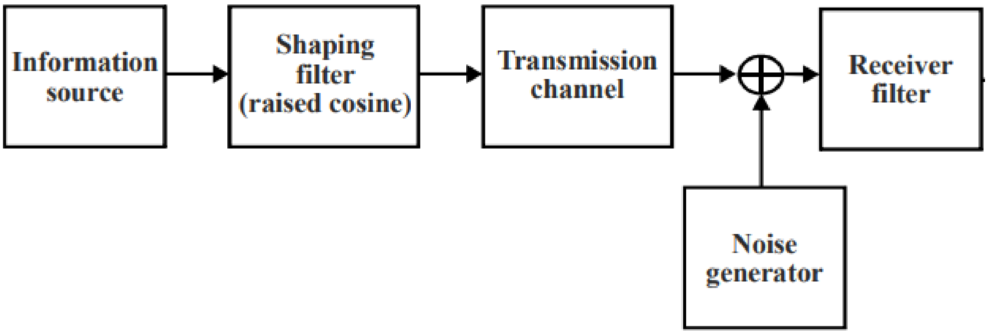

Figure 1 - System Block Diagram

The transmitter generates a Dirac signal whenever it receives a logical '1' (simulated with a random generator to reproduce a true information source where we never know the information that will arrive). The information will pass through a filter, a simple transmission signal and a noise generator (to simulate real cases) until it reaches the receiver.

1ª Part - Transmitter

1. Signal Generator

In this work, we will consider a unipolar signal with a transmission rate of 2.5Gbits/s where the symbol '0' is represented by 0V and the symbol '1' represented by 16V. We also considered a 5% raised cosine roll-off factor.

Finally, a random binary signal with 20k symbols and 16 samples per symbol was generated.

1.1. *Delay* between the 2 signals

The figure obtained was the following:

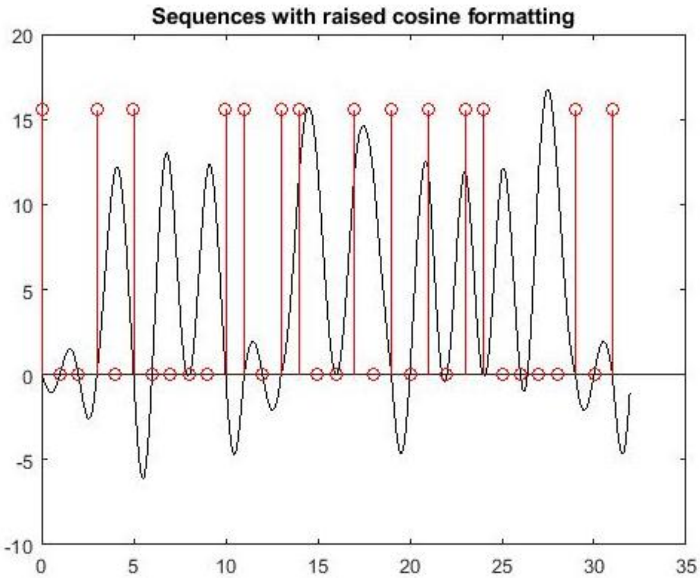

Figure 2 - Delay Between the 2 signals

Through the analysis of the Figure 2 we concluded that the delay between the 2 signals is 4 samples. Each sample is 16 bits that why we have a 64-bit delay.

1.2. Delay Calculation

At this point we used the given function called correlacao() to obtain the delay. This function calculates the correlation between the information signal (inf) and the sampled sequence (s_tx).

The figure obtained was the following:

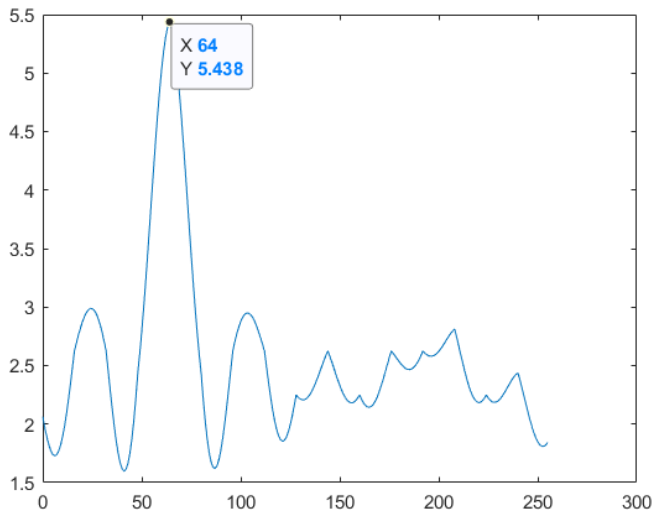

Figure 3 - Correlation

The delay between the 2 signals was 64, which is consistent with the previous result. We also can see, from Figure 3, that 64 is the maximum of the correlation function, witch, once again, is consistent with the previous results.

1.3. Delay Justification

The figure obtained was the following:

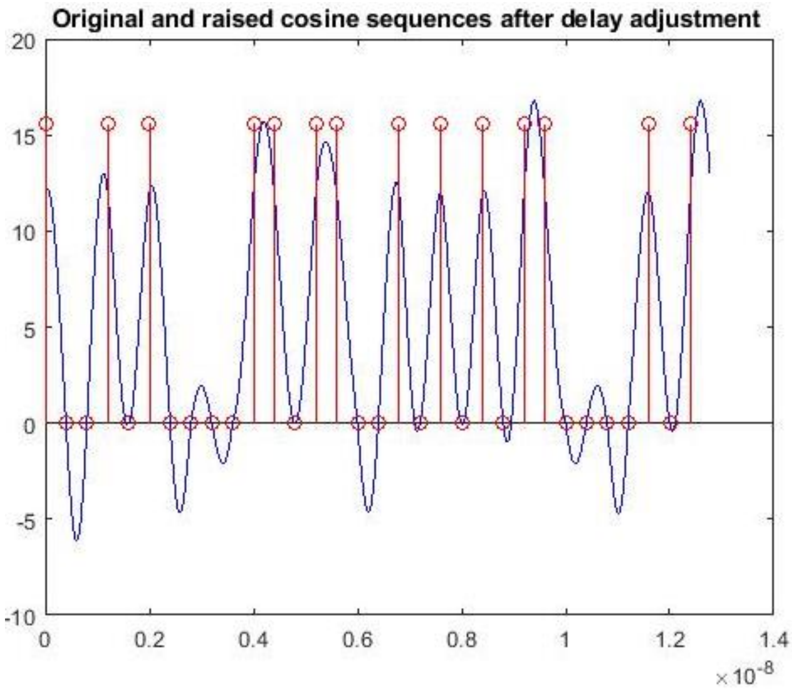

Figure 4 - Sinal after delay adjustment

After adjusting (removing the delay) between the signals, we can see that they are now in phase. When we have a pulse ("1") the raised cosine has a high amplitude. When we don't have a pulse ("0") the raised cosine is 0.

2. Eye Diagram

2.1.

The eye diagram obtained was the following:

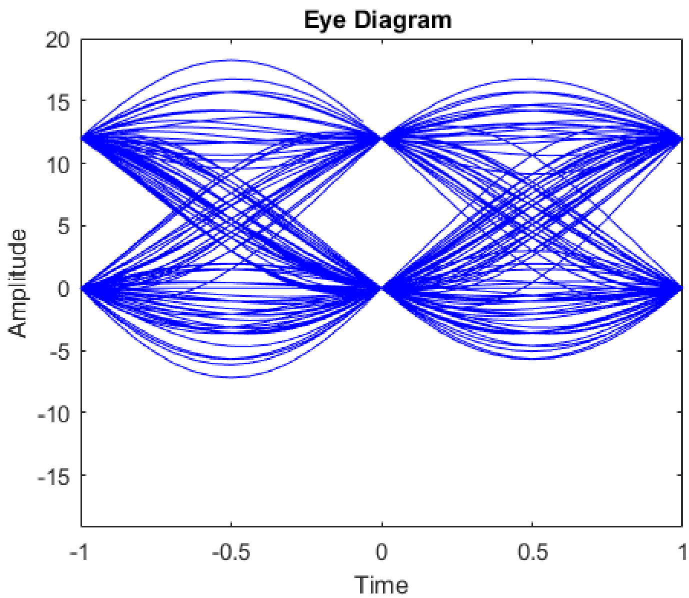

Figure 5 - Eye Diagram

2.2.

The ODI (Optimum Decision Instant) is where we have the lowest value of ISI the ISI will be 0 at 0s.

The parameters obtained were the following:

- Noise Margin – 6V
- Optimum Decision Level – Time = 0s
- ISI delayed 0.1T – 14.18 – 9.168 = 5.0120V
- Time Jitter at A/2 – 0.5s

To obtain these parameters we did the following:

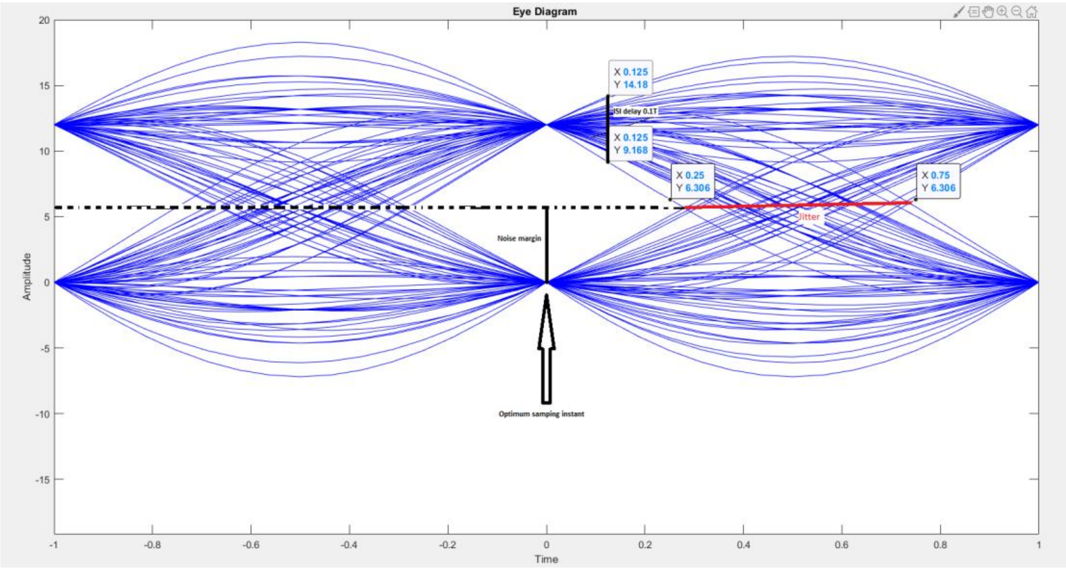

Figure 6- Eye Diagram

2.3.

The ISI in the Optimum Decision Instant is 0. in the Figure 4 the delay was removed, that is, the logical ‘0’ is represented by 0V in the cosine filter and the logical ‘1’ is represented by a high level in the filter. So, the plots are in phase and the optimum decision instant show be, has is, at 0.

3. Power Spectral Density

3.1.

The figure obtained was the following:

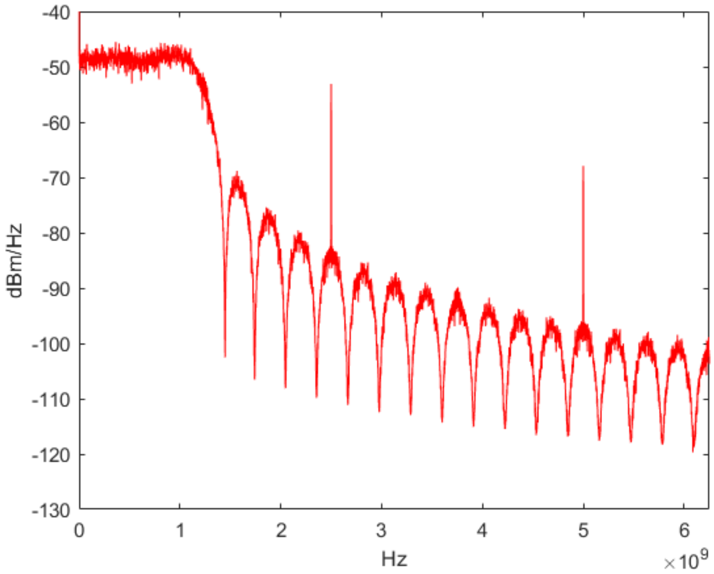

Figure 7 - Power spectral density

The frequency resolution obtained was 1.2495MHz. The theorical value obtained:

$$Frequency\ Resolution\ \approx \frac{fs}{L} = \frac{40\ G}{32012} = 1.2495\ M\ Hz$$

3.2.

The theorical formula to obtain the corresponding theorical PSD curve was the following:

$$H(f) = \begin{cases} T & ,(0 \le |f| < \frac{1-\beta}{2T}) \\ \frac{T}{2}\left\{1 - \text{sen}\left[\frac{\pi T}{\beta}\left(|f| - \frac{1}{2T}\right)\right]\right\} & ,(\frac{1-\beta}{2T} \le |f| \le \frac{1+\beta}{2T}) \\ 0 & ,(|f| > \frac{1+\beta}{2T}) \end{cases}$$

With this, the figure obtained was the following:

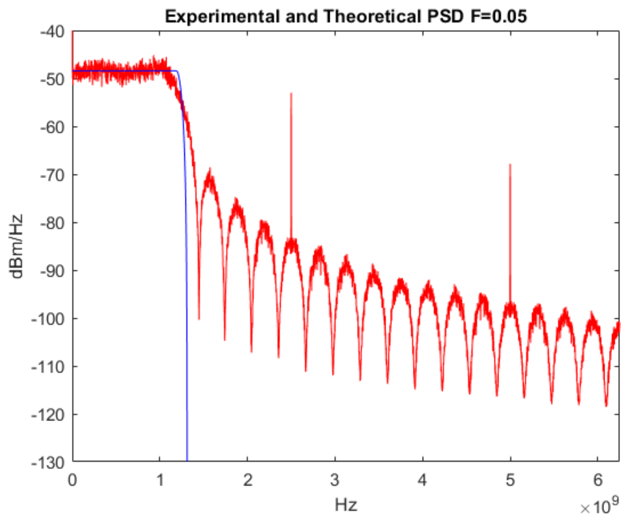

Figure 8 - Power spectral density

3.3.

The bandwidth is given by:

$$B = \frac{1}{2\,T}(1+\beta) = 1.3125\ G\ Hz$$

So, theorical, the PSD curve showed only had spectral until 1.3125 GHz,

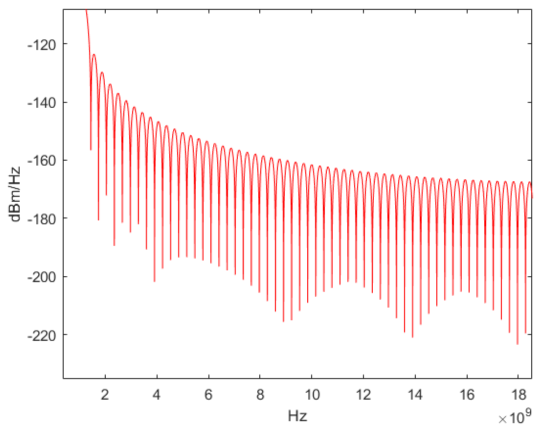

Figure 9 - Power spectral density basic pulse

Theoretically the basic pulse has a finite PSD. But, has we can see in Figure 9, in the simulation the basic pulse isn't finite. If a basic pulse isn't finite If the basic pulse isn't finite, then the signal (which is an agglomeration of basic pulses) won't be finite as expected.

3.4.

The variance ratio expression is:

$$Variance\ Ratio\ \approx \frac{L}{2N}$$

We can change the variance ration by changing the data length (N) or the bandwidth (L), but if we increase bandwidth, we will improve the variance ratio, but we won't maintain the frequency resolution. So, we should change the number of symbols to improve the variance ratio while keeping the frequency resolution intact.

4. Impact of the raised cosine roll-off factor

4.1.

In this part, we changed the F variable from 0.05 to 1. With this the eye diagram obtained was the following:

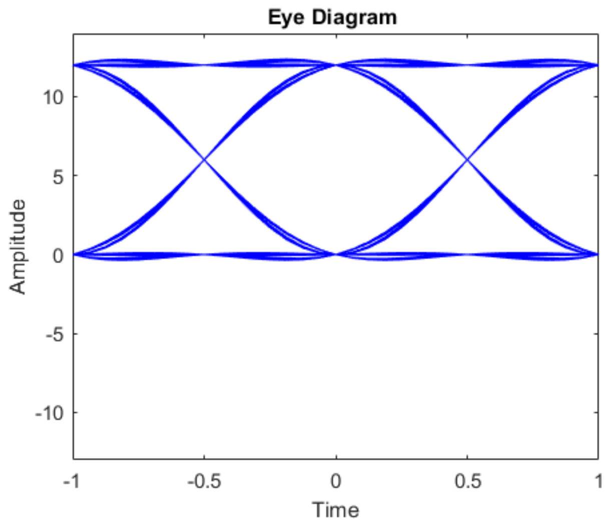

Figure 10 - Eye Diagram

The parameters obtained were the following:

- Noise Margin – 6V
- Optimum Decision Level – 0s
- ISI delayed 0.1T – 12.34 – 11.5 = 0.84V
- Time Jitter at A/2 – 0V

To obtain these parameters we did the following:

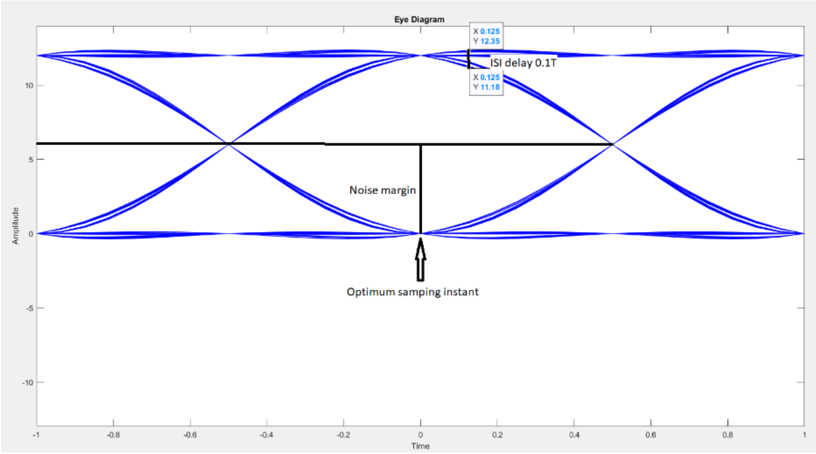

Figure 11 - Eye Diagram

4.2.

With raised cosine roll-off factor at 100%, we are in the ideal case so the ISI is 0s, like it should. The jitter, once there are no delays. With a lower roll-off factor, this ideal numbers would not happen, we won't have delays, the jitter and ISI delayed by 0.1T will increase significantly. The basic pulse obtained was the following:

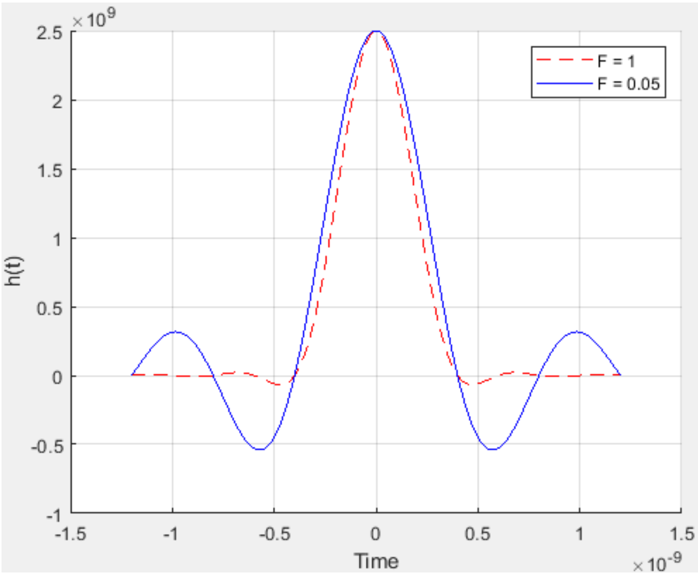

Figure 12 - Basic Impulse

We can see that when we increase the roll-off factor the basic pulse will have less variation between the zeros.

4.3.

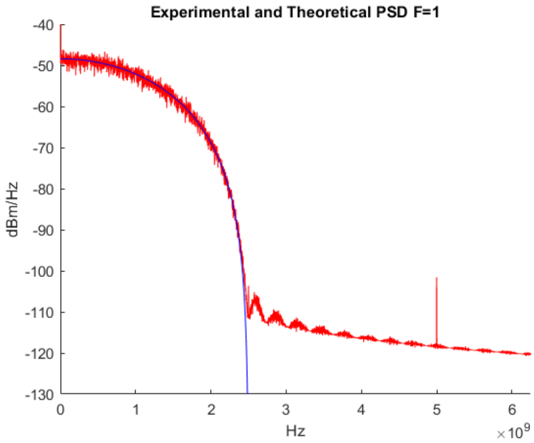

Figure 13 - Power spectral density

There are some differences between Figure 13 and Figure 8 and the only change made was in the roll-off factor. The Figure 13 as a larger bandwidth and the secondary lobes are smaller.

2ª Part - Noise

1. Gaussian Noise Generator

To obtain the Gaussian Noise, we just had to convert W to dBW, to do this we did the following:

$$dBW = 10 * \log_{10}(W)$$

And then apply the given code.

2. Spectral Characterization of Noise

2.1.

The figure obtained was the following:

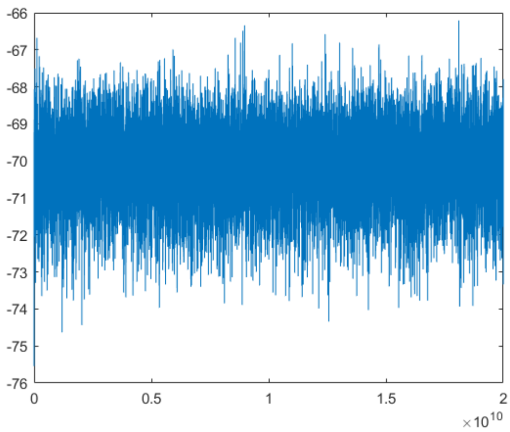

Figure 12 - PSD of the noise

The average obtained was 2.0020×10^{-10}, the variance obtained was

2.3429×10^{-21} and the frequency resolution value obtained was 1.2495 MHz.

2.2.

We can calculate the theorical value for the average by:

$$\sigma^2 = \frac{n_0}{2} f_s \quad \Rightarrow n_0 = 2 \times 10^{-10}$$

The practical value for the average is 2.0064×10^{-10}. The theorical and practical values obtained are basically the same as expected.

2.3.

The ratio obtained between the variance and the average was the following:

$$Ratio = \frac{Variance}{Average} = \frac{2.3429 \times 10^{-21}}{2.0020 \times 10^{-10}} = 1.1590 \times 10^{-11}$$

2.4.

Now we change the NSYM to 10000. The figure obtained was the following:

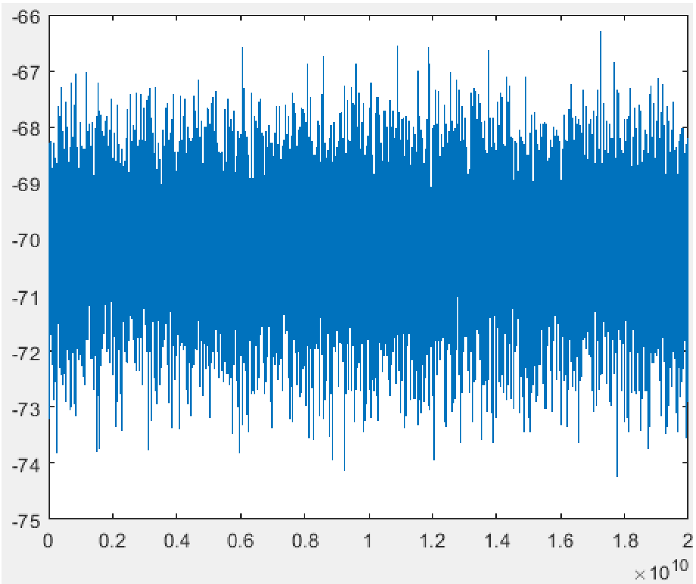

Figure 13 - Noise with NSYM = 10000

The average obtained was 2.0088×10^{-10}, the variance obtained was 5.0575×10^{-21} and the frequency resolution value obtained was 1.2495 MHz.

The ratio obtained between the variance and the average was the following:

$$Ratio = \frac{Variance}{Average} = \frac{5.0575 \times 10^{-21}}{2.0088 \times 10^{-10}} = 2.4133 \times 10^{-11}$$

We can see that with a lower number of simulated symbols we obtain a bigger variance.