# Spectral analyses of digital deterministic signals

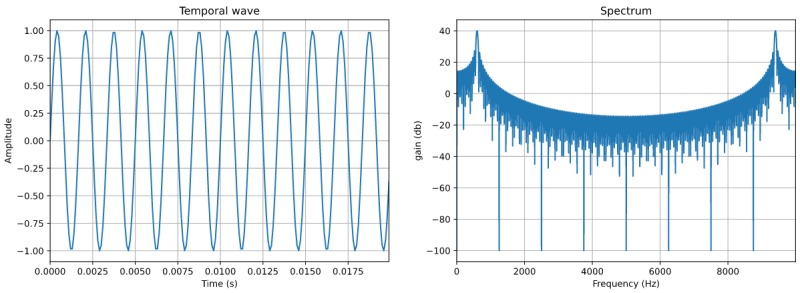
Signal processing

**Dell'Aria Doriano** **Goffaux Lionel**

October 8, 2020
Academic Year 2020-2021
Bachelor's degree in Computer Science

## 1 Influence of the Parameter N

### Question 1

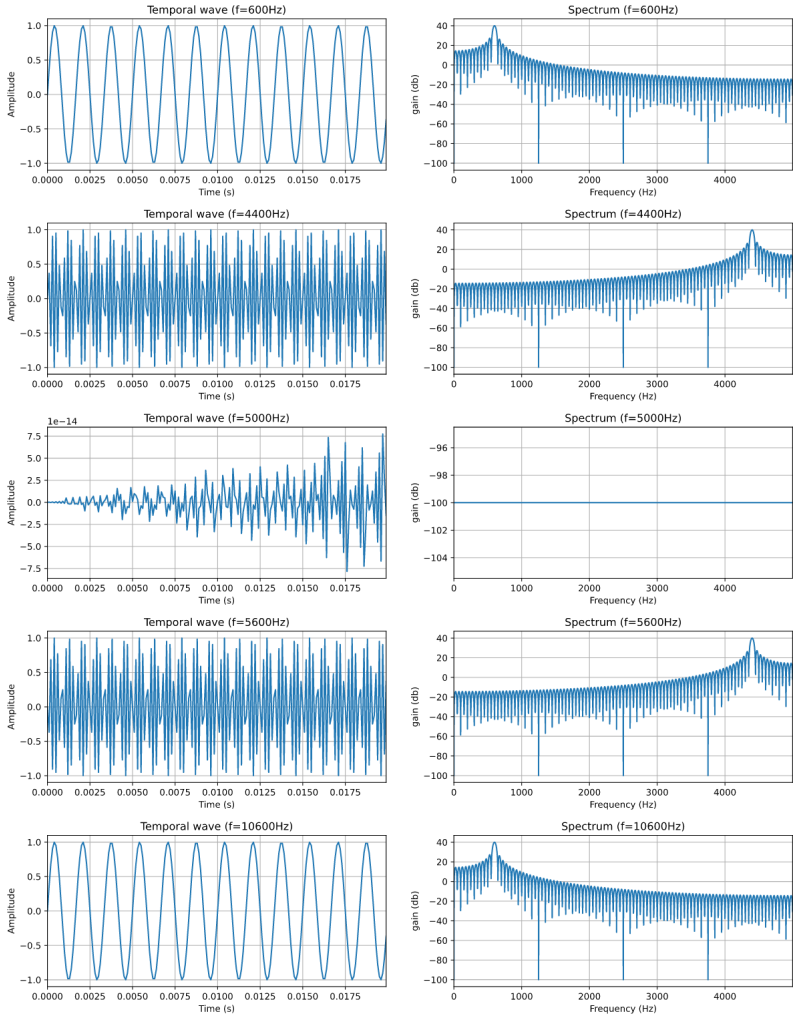



As expected, on the first graph, the maximum value is one and the minimun value is minus one corresponding to the amplitude=1 of the signal. The sine wave also achieves 6 periods in 10 ms meaning that its frequency is $1000\frac{6}{10} = 600$Hz. On the second graph, we observe a spike at $\phi \approx 0.376$ which after computation gives us a frequency of $f = 600$Hz.

## 2 Influence of the Sampling Frequency

### Question 2

For $f = 600Hz$ and $f = 4400Hz$, we see that the Fourier transform corrrespond to the reality, because $2f \leq Fe$ (Shannon's theorem). For $f = 5000Hz$, samples represents the sum of the errors. We should see a graph with 0 everywhere if errors were equals to 0, because $2f = Fe$. For $f = 5600Hz$ and $f = 10600Hz$, we observe a stroboscopic effect because $2f > Fe$. So the Fourier transform doesn't correspond to the reality.



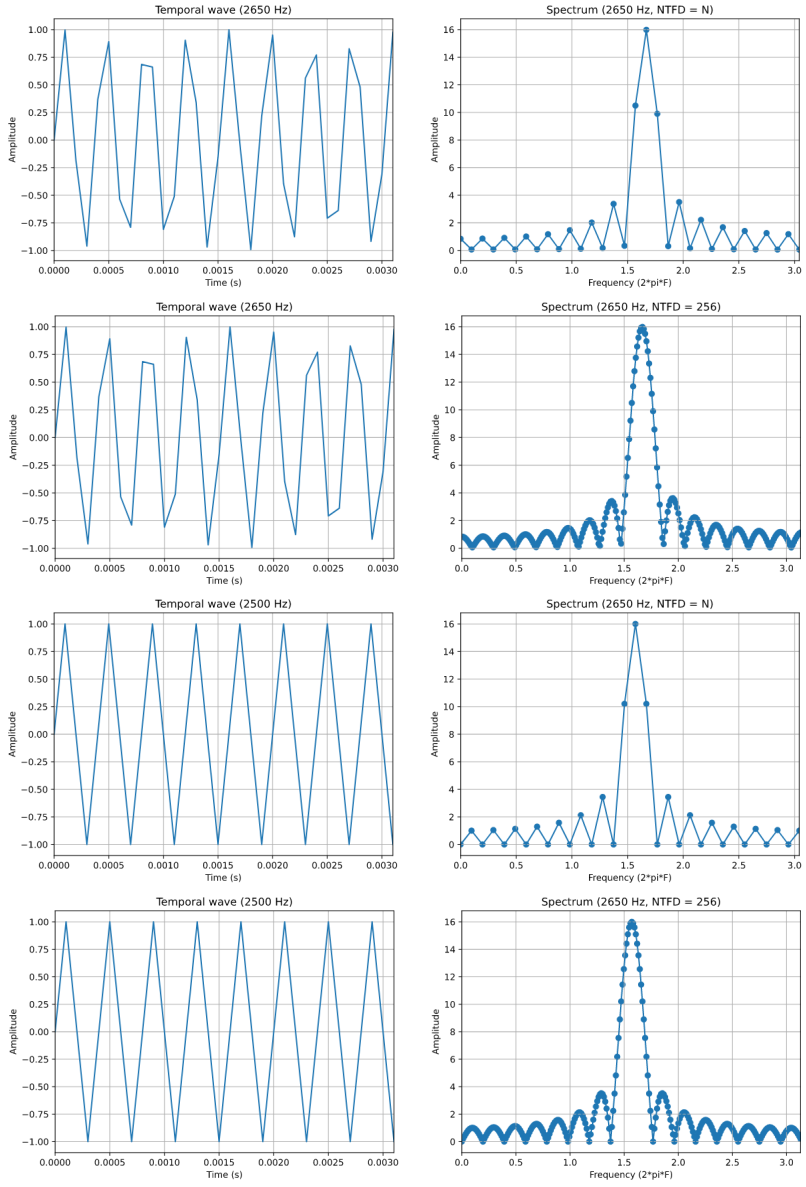

# 3 Influence of the Parameter NTFD

## Question 3

1. (a) The Position of the Fourier spike is at $2\pi * \frac{f}{F_e} = 1.66$.
   (b) The maximum of the Fourier spike is equal to $\frac{N}{2} = 16$.
   (c) There are two frequency samples on each secondary lobe.
2. (a) The position of the Fourier spike is at $2\pi * \frac{f}{F_e} = 1.66$.
   (b) The maximum of the Fourier spike is equal to $\frac{N}{2} = 16$.
   (c) There are sixteen frequency samples on each secondary lobe.
3. (a) The position of the Fourier spike is at $2\pi * \frac{f}{F_e} = 1.57$.
   (b) The maximum of the Fourier spike is equal to $\frac{N}{2} = 16$.
   (c) There are two frequency samples on each secondary lobe.
4. (a) The position of the Fourier spike is at $2\pi * \frac{f}{F_e} = 1.57$.

(b) The maximum of the Fourier spike is equal to $\frac{N}{2} = 16$.

(c) There are sixteen frequency samples on each secondary lobe.

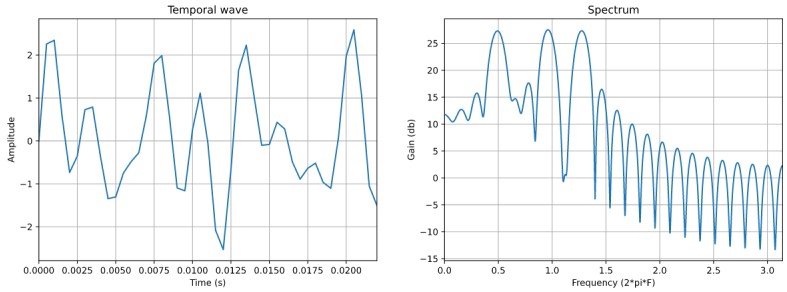



# 4 Spectral Analysis of Several Sine Waves

## Question 4

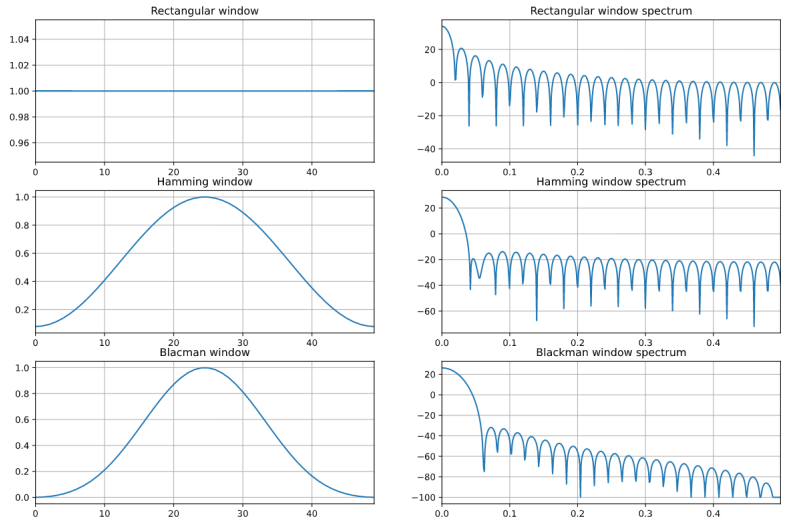
We find that the closer the sample frequency is to twice the higher frequency, the closer the spikes are to pi. So in order to increase the accuracy, it's better to set the sample rate as close as possible to two times the higher frequency that we want to observe. For the NTFD parameter, that only change the space between the frequency samples in the spectrum. So, the higher it is the most continuous the plot seems. We choose N = 45 because N must be greater than 2d where d is difference between the two closest normalized frequency

to avoid lobes overlaping. For the number of samples in the time's space, we observe that the shorter the signal lasts in time the larger the spike corresponding to that signal frequency is and vice versa. There is probably a link with the uncertainty principle in quantum mechanics.




# 5 Weighting Window Effect

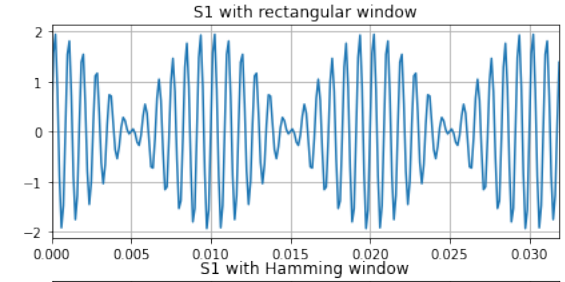
## Question 5

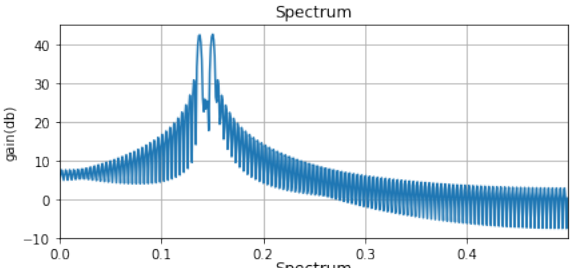


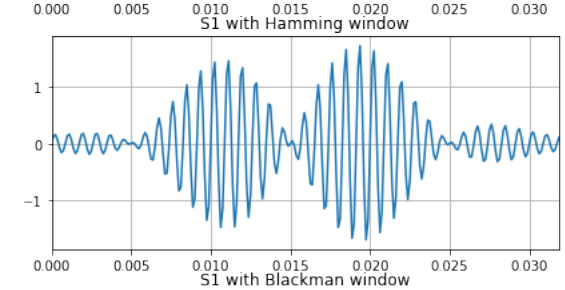

We observe that the main lobe is getting larger and larger and the other lobes are getting lower and lower from one window to another. That fits well with the given table.

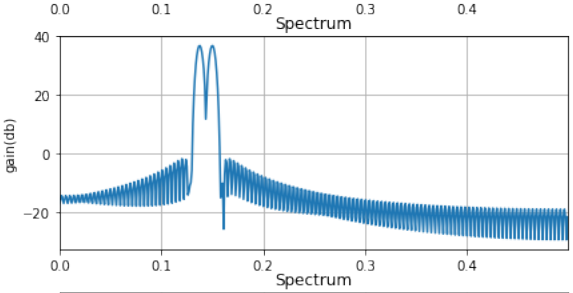
## Question 6

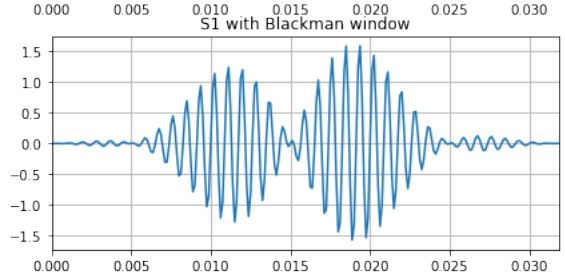
For the first graph, we observe that the rectangular window is the best beacuse the size of the main lobe is smaller than the other ones. For the second graph the difference between the two frequency is bigger, so the main lobe of the smallest frequency is drowned into the secondary lobes of the biggest one. So we choose the Blackman window because the secondary lobes of this window are smaller.

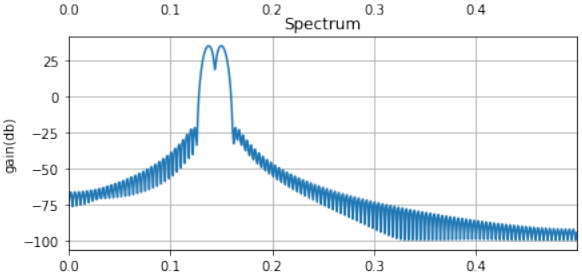

S1 with rectangular window

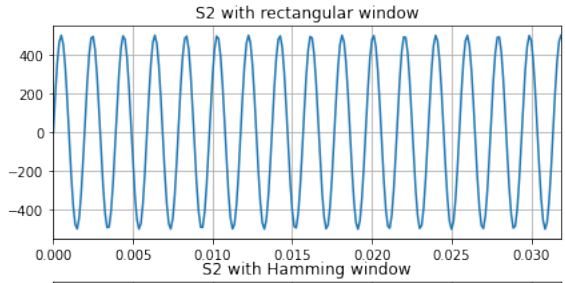

Spectrum
gain(db)

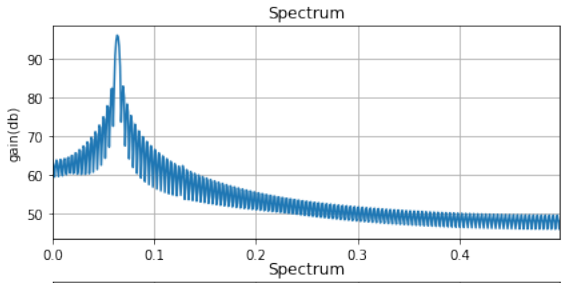

S1 with Hamming window

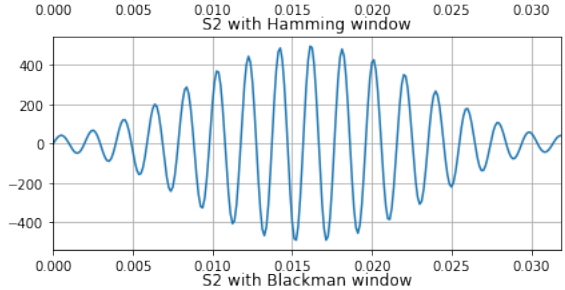

Spectrum
gain(db)

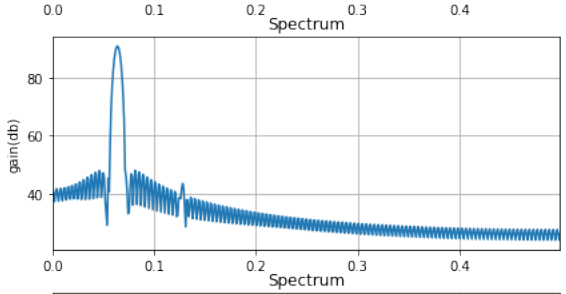

S1 with Blackman window

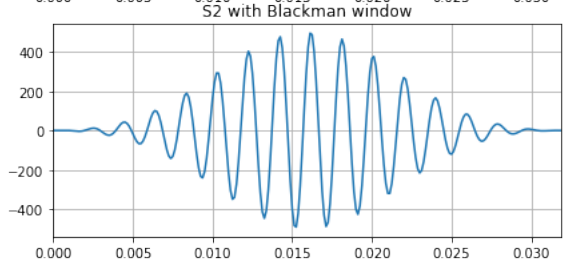

Spectrum
gain(db)

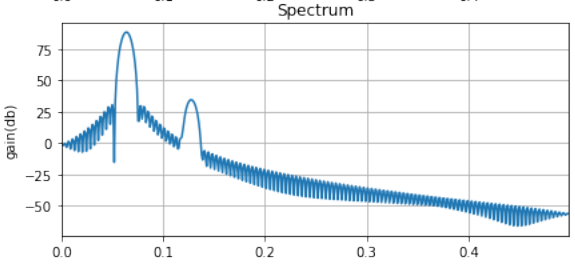

S2 with rectangular window


Spectrum
gain(db)


S2 with Hamming window


Spectrum
gain(db)


S2 with Blackman window


Spectrum
gain(db)