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Cmpe 362.01

Assignment 1 Report

Question 1:

Part A:

for odd periodic functions (especially for odd sawtooth wave):

$a_0 = 0$

$a_n = 0$ $\quad \cancel{T=5}\ \boxed{T=10} \quad w = \frac{2\pi}{T}$

$b_n = \frac{4}{T} \int_0^{T/2} f(t) \cdot \sin(nwt) dt \qquad f(t) = \frac{2A \cdot t}{T} \quad (A=1)$

$\Rightarrow b_n = \frac{8A}{T^2} \cdot \int_0^{T/2} t \cdot \sin(nwt) dt \qquad \int u \cdot dv = u \cdot v - \int v \cdot du$

$u = t \quad dv = \sin(nwt) dt$

$\Rightarrow b_n = \frac{8A}{T^2} \cdot \left(\frac{t \cdot \cos(nwt)}{-w \cdot n} + \frac{\sin(nwt)}{n^2 w^2} \right) \Big|_0^{T/2}$

$\Rightarrow \quad = \frac{8A}{T^2} \cdot \left(\frac{T/2 \cdot \cos(n \cdot \frac{2\pi}{T} \cdot \frac{T}{2})}{-w \cdot n} + \frac{\sin(\overbrace{n \cdot \frac{2\pi}{T} \cdot \frac{T}{2}}^{\pi n}) \to 0}{n^2 w^2} - 0 \right)$

$= \frac{8A}{T^2} \cdot \frac{T}{2} \cdot \frac{1}{-\frac{2\pi}{T}} \cdot \overbrace{\cos(\pi n)}^{(-1)^n} = \frac{8A}{T^2} \cdot \frac{T^2}{-4\pi} \cdot (-1)^n$

$$\boxed{b_n = -\frac{2A}{\pi \cdot n} \cdot (-1)^n}$$

As a result: $a_0 = 0$ (DC component)

$a_n = 0$

$b_n = \frac{-2A}{\pi n} \cdot (-1)^n \longrightarrow$ $-\frac{2}{\pi n}$ for n even; $+\frac{2}{\pi n}$ for n odd

$x_n = \sum_{n=1}^{\infty} b_n \cdot \sin(nwt)$

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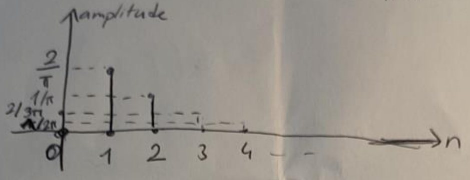
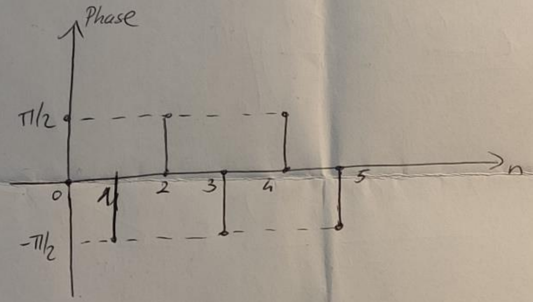
magnitude spectra: $A_n = \sqrt{a_n^2 + b_n^2} = \frac{2}{\pi \cdot n}$



phase spectra: $\phi_n = -\tan^{-1}\left(\frac{b_n}{a_n}\right) = -\tan^{-1}\left(\frac{\frac{2}{\pi n}}{0}\right) = -\frac{\pi}{2}$ ← n odd

$= -\tan^{-1}\left(\frac{-2/\pi n}{0}\right) = \frac{\pi}{2}$ ← n even



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Part B:

We found the Fourier coefficients in the formula we found in Part A.

First 3 harmonics, first 5 harmonics and first 15 harmonics are requested. I have summed up the values for each and I am showing it in a graph.

As expected, the higher the harmony number, the closer it gets to the original signal. Because we represent with more waves. The less harmonics there are, the farther from the original signal.

Question 2:

At first, I read the data and convert it to Fourier Shift. Afterwards, I apply the Fast Fourier Transform (FFT) as indicated in the question, and then I do the Fast Fourier Transform Shift (FFT Shift) in order to shift the waves to the center and reach Figure 2 from the graphic, which was originally Figure 1. From here I reach the frequency of the noise. We select an experimental range where the Noise Frequency is available and use Band Reject Signal to reset every place in this range. After this process, I shift the data back to its original location with Inverse Fast Fourier Transform Shift (IFFT Shift) and transform it into time domain by applying Inverse Fast Fourier Transform (IFFT). Then I saw that the noise in the sound was removed successfully.

Question 3:

I read the voice. I implemented the appropriate Moving Average Filter and applied it to the data. I found that the noise levels decreased a little more, but not as sharply as in question 2. Finding the frequency with the spectrogram requested from us. However, since I could not detect the frequency in Figure 1 with the spectrogram, I reached the Fundamental Frequency in Figure 2 by applying the FFT and FFT Shift processes I applied in the second question. I calculated the NRPM value as 6552 by putting the RPM and f0 values in their place.