EC3400: Computer Assignment 1

In this project we address the problem of sampling sinusoidal signals to understand analog frequencies, digital frequencies and aliasing.

**Problem 1.** (pencil and paper)

Consider the signal \( x(t) = 5 \cos(4000\pi t + 0.1) \).

Q1. Determine its Fourier Transform \( X(F) = FT\{x(t)\} \) and sketch it;

Q2. Let \( F_s = 5kHz \) be the sampling frequency and call \( x[n] = x(nT_s) \) the sampled sequence. Determine \( X(\omega) = DTFT\{x[n]\} \) and sketch it for \(-\pi \leq \omega \leq \pi\). Determine the digital frequencies of this signal.

Q3. Same as Q2 with \( F_s = 3kHz \). Which other frequency \( F \) (in Hz) has the same samples?

**Problem 2 (Matlab)**

In this problem we make use of the FFT, as an approximation of the DTFT. In particular we use the following fact:

**FACT:** Let \( x[n], n = 0, \ldots, N-1 \) be a sequence of length \( N \), and \( X[k] = FFT\{x[n]\}, k = 0, \ldots, N-1 \) be its \( N \)-point FFT. Then, if \( N \) is “large enough”,

\[
X[k] = X(\omega)\big|_{\omega=k\frac{2\pi}{N}}, \quad k = 0, \ldots, N-1
\]

with \( X(\omega) = DTFT\{x[n]\} \).

Consider the same signal \( x(t) = 5 \cos(4000\pi t + 0.1) \).

Q1. Generate \( N = 1024 \) samples \( x[n] = x(nT_s), n = 0, \ldots, 1023 \) with sampling frequency \( F_s = 5kHz \).

Plot the magnitude of the FFT in the range \( 0 \leq k < N/2 \) and verify that it has a peak at \( \omega = \omega_0 \) as from Problem 1, Q2;

Q2. Same, for \( F_s = 3kHz \) and compare with Problem 1, Q3.

**Matlab Commands:**

\[
n=0:N-1; \quad x=A*\cos(w0*n+alpha); \quad \text{to generate a vector of cos. with digital frequency } \ w_0;
\]

\[
X=fft(x); \quad \text{yields the fft of the vector } x
\]

Note: Matlab has no zero or negative indexes

\[
k=0:N/2-1; \quad \text{plot(k, abs(X(1:N/2)))} \quad \text{to plot the FFT as a function of the index "k".}
\]