Lab 1

EE 324: Signals and Systems II

The task of this lab section is revisiting basic matlab and simulink tools on signals and systems to get ready for future study.

1 Prelab assignment

1. Make sure you remember how to use matlab.
2. Go through the tutorials on simulink `https://www.mathworks.com/help/simulink/getting-started-with-simulink.html`.
3. Learn how to use Fast Fourier Transform (FFT) `https://www.mathworks.com/help/matlab/ref/fft.html#buuutyt-6`
4. Generate and plot the signal

$$x(t) = \begin{cases} \sin(\pi t) & 0 \le t \le 4 \\ e^{-t}\cos(2\pi t) & \text{otherwise} \end{cases}$$

over the time window $-1 \le t \le 5$.

2 Lab assignment

2.1 Fourier series approximation

1. Generate and plot the periodic square wave

$$x(t) = \begin{cases} 1 & 0 \le t \le 1 \\ 0 & 1 \le t \le 2 \end{cases} \tag{1}$$

with period $T = 2$.
2. Calculate its Fourier series

$$X(k) = \frac{1}{T}\int_0^T x(t)e^{-j\frac{2\pi}{T}kt}dt.$$

3. Approximate $x(t)$ using

$$x_K(t) = \sum_{k=-K}^{K} X(k)e^{j\frac{2\pi}{T}kt}$$

with different K value. Show $x(t), x_1(t), x_2(t), x_3(t), x_4(t), x_5(t)$ on the same plot and discuss your observation.

2.2 Fourier analysis

1. Discretize $x(t)$ in (1) with N points through

$$x[n] = x(\frac{nT}{N}) = x(\frac{2n}{N})$$

with $0 \leq n \leq N-1$.
2. Apply FFT to $x[n]$ with (say $N = 20$).
3. Plot the absolute value of the Fourier transform with the correct frequency values (follow the example on `https://www.mathworks.com/help/matlab/ref/fft.html#buuutyt-6`)
4. Compare the result with the Fourier series calculated in 2.2. They should be more or less the same.
5. Generate white noise using

$$x[n] = \text{randn}(N, 1).$$

6. Apply FFT to $x[n]$ with $N = 20$ and plot the result. Discuss your observation.

2.3 Simple filters

1. Use Simulink blocks to generate signal

$$x(t) = \sin(t) + \sin(40t) + n(t).$$

Use the block "Band-Limited white noise" to generate the noise term $n(t)$. Take the noise power to be 0.01.
2. Use a transfer function block to filter the noisy signal. Take the parameter to be

$$\frac{1}{0.5s + 1}.$$

This is a simple low pass filter.
3. Compare the original noisy signal with filtered signal. Discuss your observation.