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.
3. Learn how to use Fast Fourier Transform (FFT) [https://www.mathworks.com/help/matlab/ref/fft.html#buuutyt-6](https://www.mathworks.com/help/matlab/ref/fft.html#buuutyt-6)
4. Generate and plot the signal

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

over the time window \(-1 \leq t \leq 5\).

2 Lab assignment

2.1 Fourier series approximation

1. Generate and plot the periodic square wave

\[ x(t) = \begin{cases} 
1 & 0 \leq t \leq 1 \\
0 & 1 \leq t \leq 2 
\end{cases} \quad (1) \]

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

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


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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](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.