# FOUNDATIONS OF SIGNALS AND SYSTEMS
## 18.2 Solved exercises
Prof. T. Erseghe

### Exercises 18.2

Solve the following MatLab problems:

1. Evaluate numerically the Fourier transform of

$$x(t) = 2\,e^{-t}\,\cos(2\pi t)\,1(t)$$

and compare it with its analytical expression

$$X(j\omega) = \frac{1}{1+j(\omega-2\pi)} + \frac{1}{1+j(\omega+2\pi)}\ .$$

2. The file 'ex18_2_2.mat' contains in vector x pancreatic secretion values taken in the interval $[0, 300]$ min with a sampling spacing of $T = 0.1$ min. Plot the signal together with its Fourier transform (absolute values only).

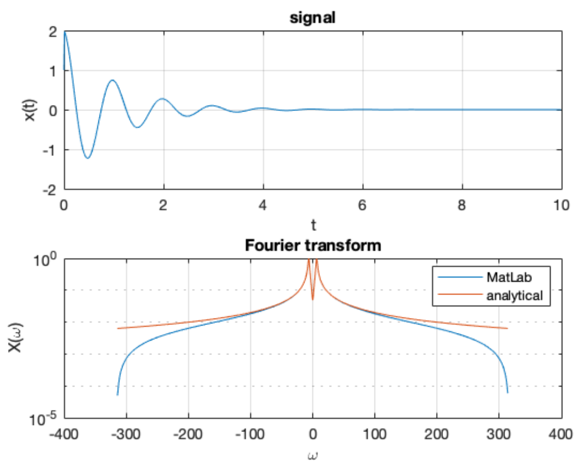
### Solutions.

1. In the code we define a small sampling step $T = 0.01$ and a number of samples $N = 1000$ such that the interval in which we sample the signal is $[0, 10]$, to ensure that the exponential outside the sampled range is small. The derivation of the Fourier transform is standard and it is compared with the analytical expression here called Xref. Note that the plot of the Fourier domain only shows the absolute values, and uses a logarithmic form (through function semilogy, which works as plot) since this is the standard way to correctly observe the Fourier transform behaviour, allowing for a correct interpretation of the result. Always use the logarithmic form! Note that there is full accordance between the MatLab outcome and the analytical expression up to $\omega = 100$, then some aliasing effect (due to the $1/\omega$ nature of the Fourier transform) is visible.

```
T = 0.01;
N = 1000;
t = (0:N-1)*T;
x = ((t>0)+.5*(t==0)).*(2*exp(-t).*cos(2*pi*t));
X = fftshift(T*fft(x));
om = (-round((N-1)/2):round(N/2)-1) *2*pi/(N*T);
Xref = 1./(1+1j*(om-2*pi))+1./(1+1j*(om+2*pi));

figure
subplot(2,1,1)
plot(t,x)
grid
```

```
xlabel('t')
ylabel('x(t)')
title('signal')
subplot(2,1,2)
semilogy(om,abs(X),om,abs(Xref))
grid
xlabel('\omega')
ylabel('X(\omega)')
legend('MatLab','analytical')
title('Fourier transform')
```




2. In this case all the parameters are set so it it simply the case of applying the rules for correct calculation of the Fourier transform. Note that we restricted the Fourier plot to the positive axis, since this is symmetric by nature, and in fact a real-valued signal implies an Hermitian symmetry in the Fourier domain which, in turn, determines an even symmetric absolute value.

```
load('ex18_2_2.mat') % defines t, x, T
N = length(x);
X = fftshift(T*fft(x));
om = (-round((N-1)/2):round(N/2)-1) *2*pi/(N*T);

figure
subplot(2,1,1)
plot(t,x)
grid
xlabel('t')
ylabel('x(t)')
title('signal')
```

```
subplot(2,1,2)
semilogy(om,abs(X))
grid
xlabel('\omega')
ylabel('X(\omega)')
axis([0 max(om) 1e-3 1e4])
title('Fourier transform')
```