Introduction to Robotics and Mechatronics

GROUP 2.5
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PostLab 03

Q1

The peak-to-peak amplitude of the generated signal is 2,40V.

Q2

The DC offset is 1,76V.

Q3

The frequency is 2,1 kHz.

Q4

To measure a point (a while loop step) it takes a time of 4,167us (=0,004167ms), which translate to an execution speed of 240 kHz.

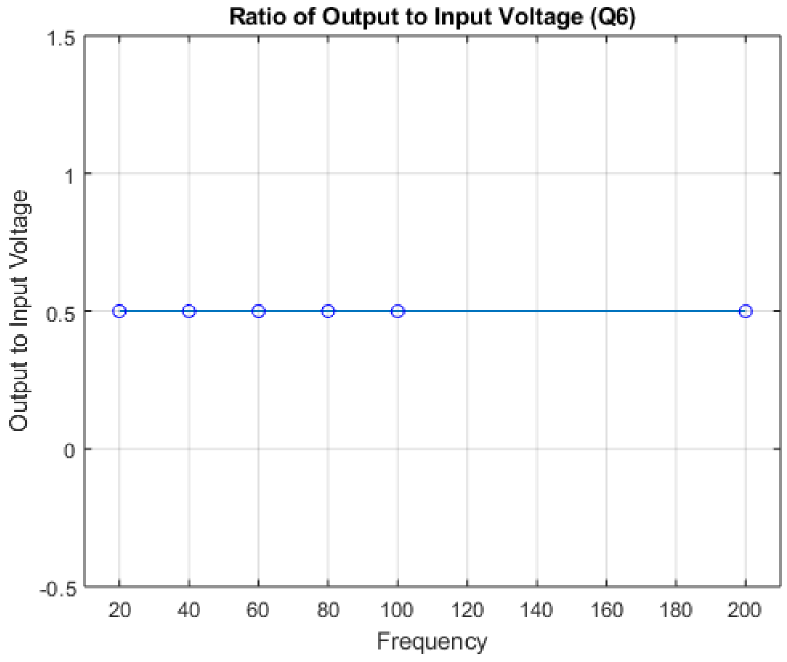
Q5

The minimum is 0,560V and the maximum is about 3V. The voltage range is [0,56 3] and the voltage resolution is 2,4V/4096 = 0,5859 mV.

Q6

Frequency [*Hz*]	**Peak-to-peak voltage** [*V*]
20	1,2
40	1,2
60	1,2
80	1,2
100	1,2
200	1,2

As we expected by how we built the resistive divider circuit, the ratio of output to input voltage remains constant to 1,2V , not varying with the input frequency.



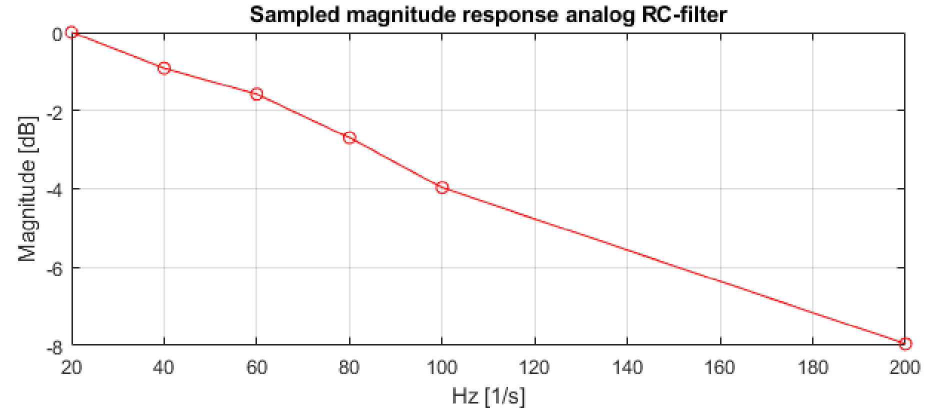
The delay is calculated with the following equation:

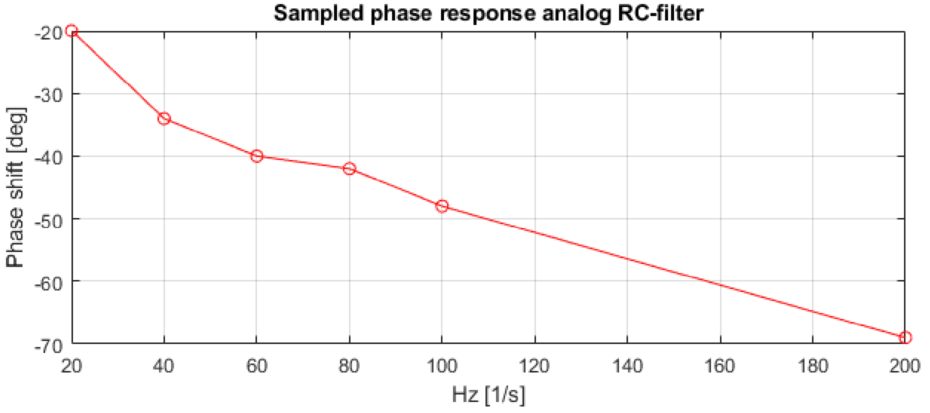
$$delay = \frac{1}{120 * f} - 4{,}167 * 10^{-6}\ [s]$$

Where we consider the number of samples (120) of which one period of the signal gets split off and the execution time needed for one iteration in the while loop (calculated in Q4).

Q7

Frequency [*Hz*]	**Peak-to-peak** [*V*]	**Phase shift** [°]	**Phase shift** [ms]
20	2,4	20	2,778
40	2,16	34	2,362
60	2	40	1,852
80	1,76	42	1,458
100	1,52	48	1,334
200	0,96	69	1,597



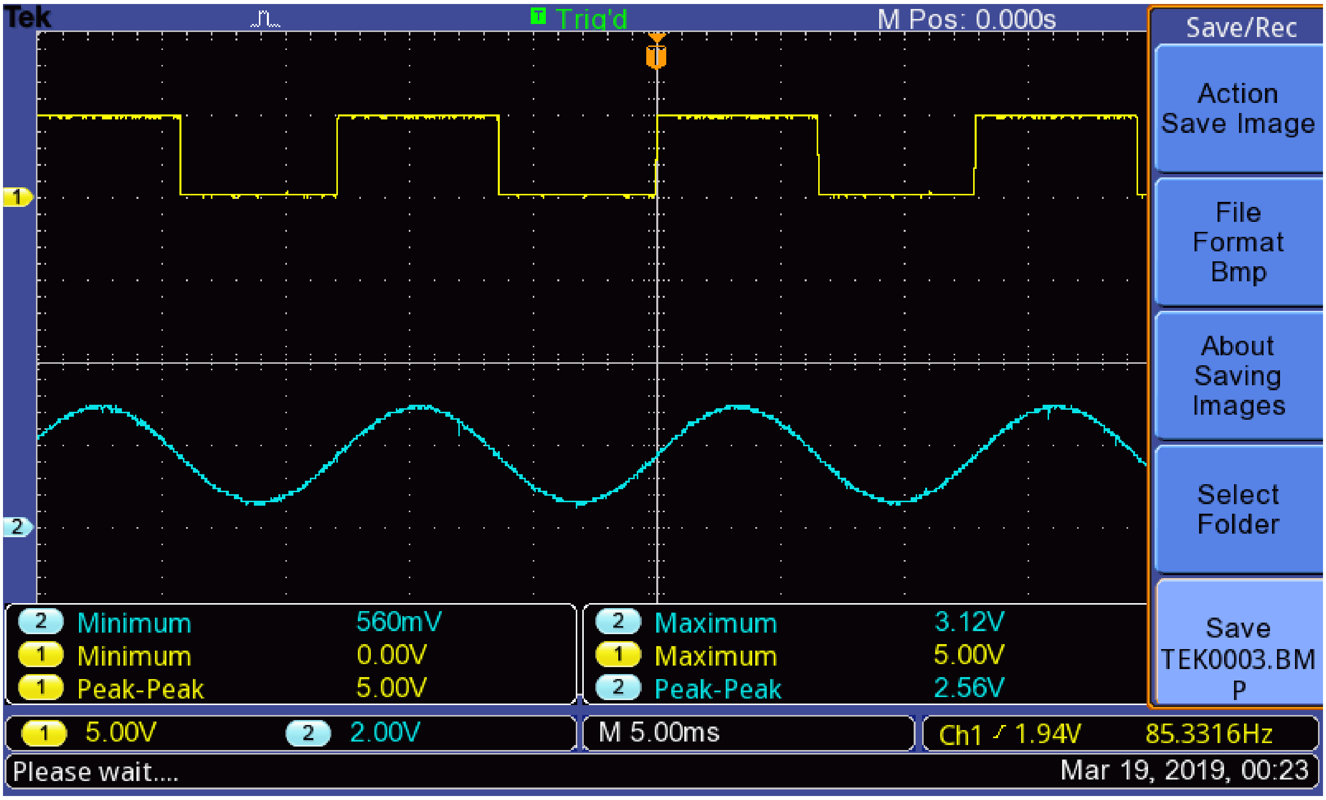


That's a typical low-pass behavior. High frequencies get attenuated, low frequencies passed. Also high frequencies get a phase, they lag more the higher the frequency is.

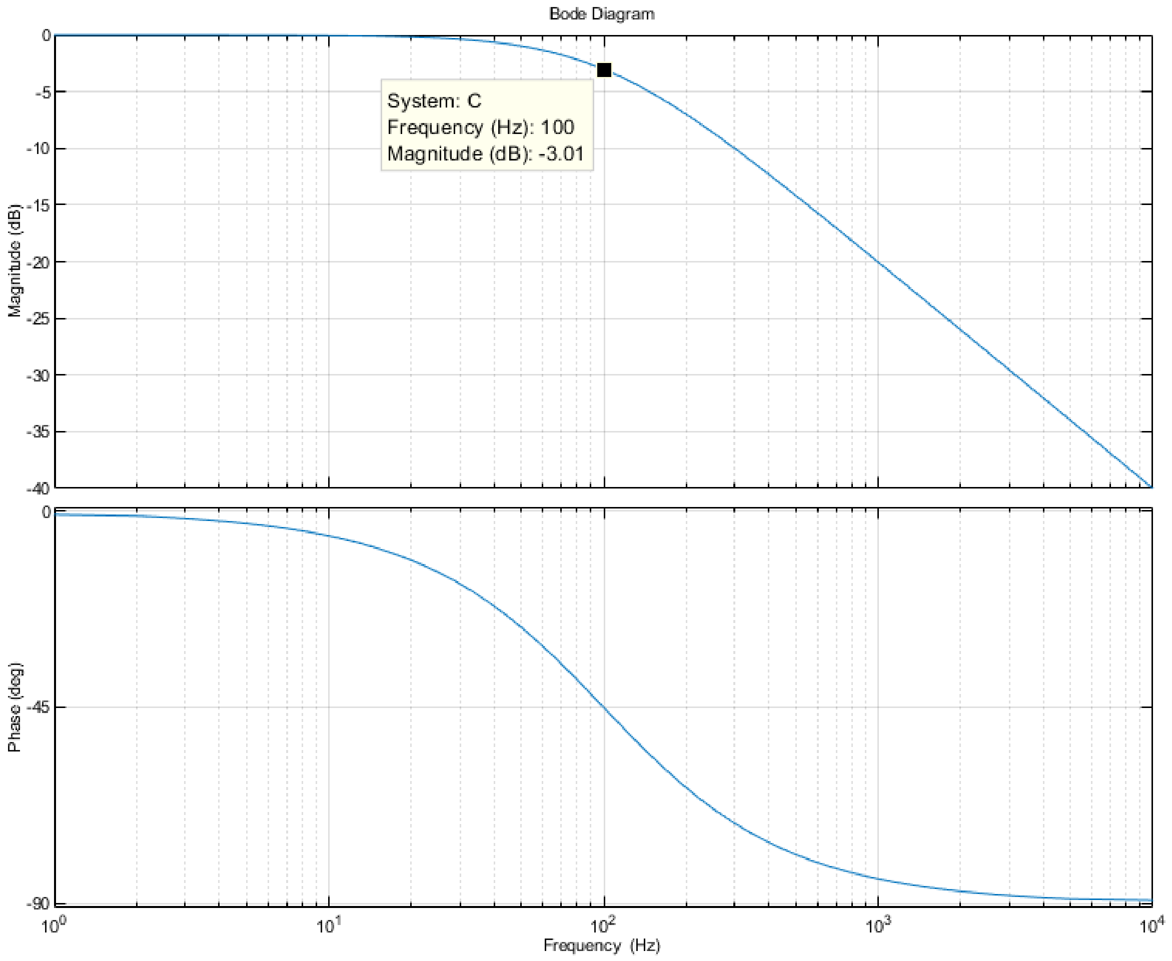
Q8

It will lead to the opposite outcome resulting in Q7. Low frequencies will get attenuated and high frequencies passed. A high-pass filter.

Q9



Q10



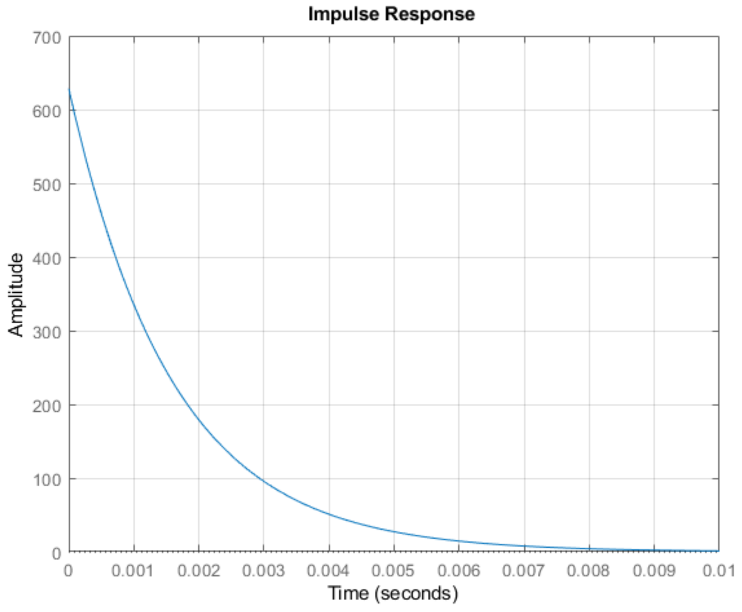
Q12/Q13

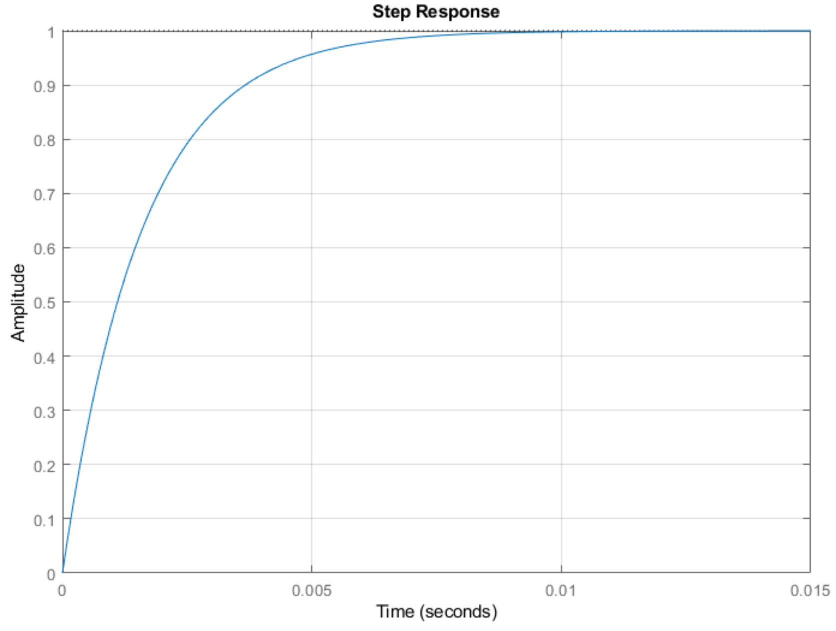
Max phase shift is 90deg.
Gain at cut-off freq is 0.7071 or -3.0103dB.

Q14

No. It’s a **linear** time invariant system. Emphasis on linear, because the system only amplifies the input at its frequency. The frequency wont get modulated hereby.

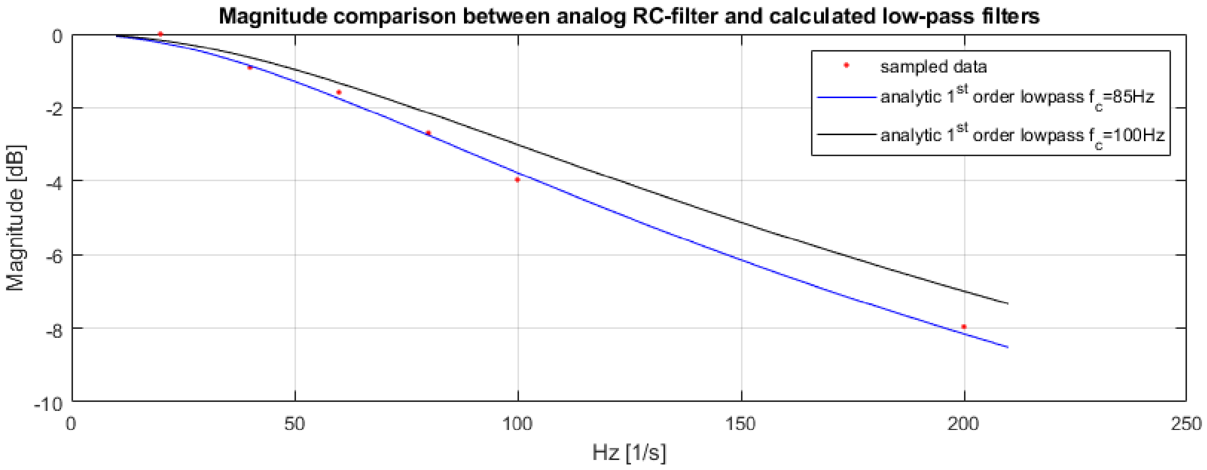
Q11

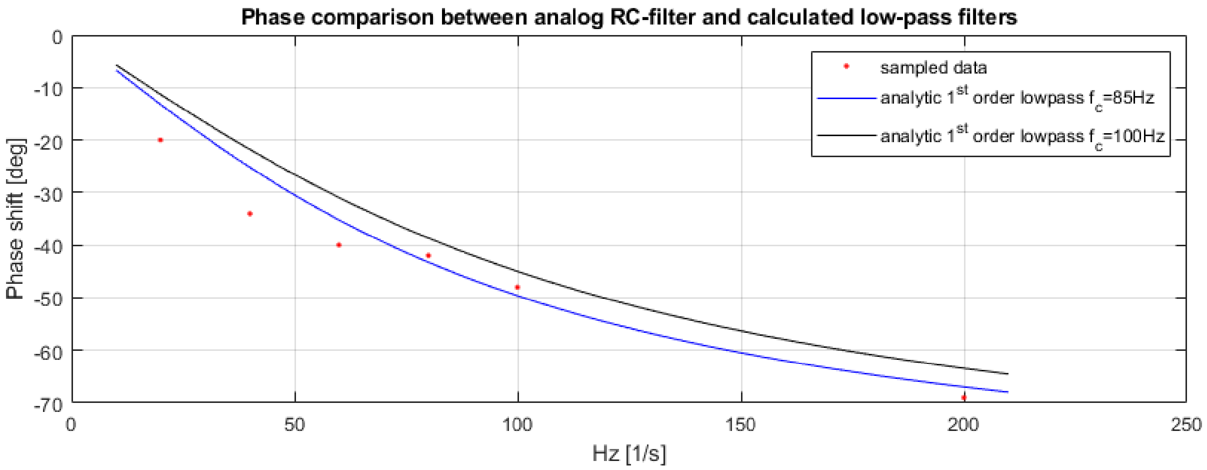




The system clearly responds like a 1st order system. 1st order systems have a very distinct linear slope around t=0s.

Q15





We can see that the cut-off frequency of our analog filter lies around 85Hz. It's where the phase is -45deg and magnitude around -3dB.

```
clc; close all; clear all;
%% 1st order low pass:
f = 100;
f2 = 85;
wc = 2*pi*f;
wc2 = 2*pi*f2;


s= tf('s');
C = wc/(wc + s);
C2 = wc2/(wc2 + s);

options = bodeoptions;
options.FreqUnits = 'Hz'; % or 'rad/second', 'rpm', etc.
figure(1)
bode(C,options);
grid on

figure(2)
impulse(C);
grid on

figure(3)
step(C);
grid on

%%
mag = abs(wc/(wc+j*wc))
magdb = 20*log10(mag)
phase = angle(wc/(wc+j*wc));
phased = radtodeg(phase);
%%
fs = [20 40 60 80 100 200];
ws = 2*pi*fs;
p2p = [2.4 2.16 2 1.76 1.52 0.96]/2.4;
p2pdb = 20*log10(p2p);
ps = [20 34 40 42 48 69]*-1;

figure(4)
subplot(2,1,1)
plot(fs,p2pdb,'r-o')
title('Sampled magnitude response analog RC-filter')
xlabel('Hz [1/s]')
ylabel('Magnitude [dB]')
grid on
subplot(2,1,2)
plot(fs,ps,'r-o')
title('Sampled phase response analog RC-filter')
xlabel('Hz [1/s]')
ylabel('Phase shift [deg]')
grid on
%%

flin = linspace(10,210,201);
C2 = wc2./(wc2 + 1i*flin*2*pi);
```

```
C1 = wc./(wc + 1i*flin*2*pi);
%%

figure(5)

subplot(2,1,1)
plot(fs,p2pdb,'r.')
grid on
hold on
plot(flin,20*log10(abs(C2)),'b')
plot(flin,20*log10(abs(C1)),'k')
title('Magnitude comparison between analog RC-filter and calculated low-pass filters')
xlabel('Hz [1/s]')
ylabel('Magnitude [dB]')
legend('sampled data','analytic 1^{st} order lowpass f_c=85Hz','analytic 1^{st} order↙
lowpass f_c=100Hz')

subplot(2,1,2)
plot(fs,ps,'r.')
grid on
hold on
plot(flin,rad2deg(angle(C2)),'b')
plot(flin,rad2deg(angle(C1)),'k')
title('Phase comparison between analog RC-filter and calculated low-pass filters')
xlabel('Hz [1/s]')
ylabel('Phase shift [deg]')
legend('sampled data','analytic 1^{st} order lowpass f_c=85Hz','analytic 1^{st} order↙
lowpass f_c=100Hz')
```