Lab 03 Group Tue_3_2

Q1

peak-peak: 3.12 V

Q2

dc (mean): 1.68 V

Q3

frequency: 442 Hz

Q4

ex speed = frequency * samples per cycle = 442 Hz * 120 = 53.04 kHz

Q5

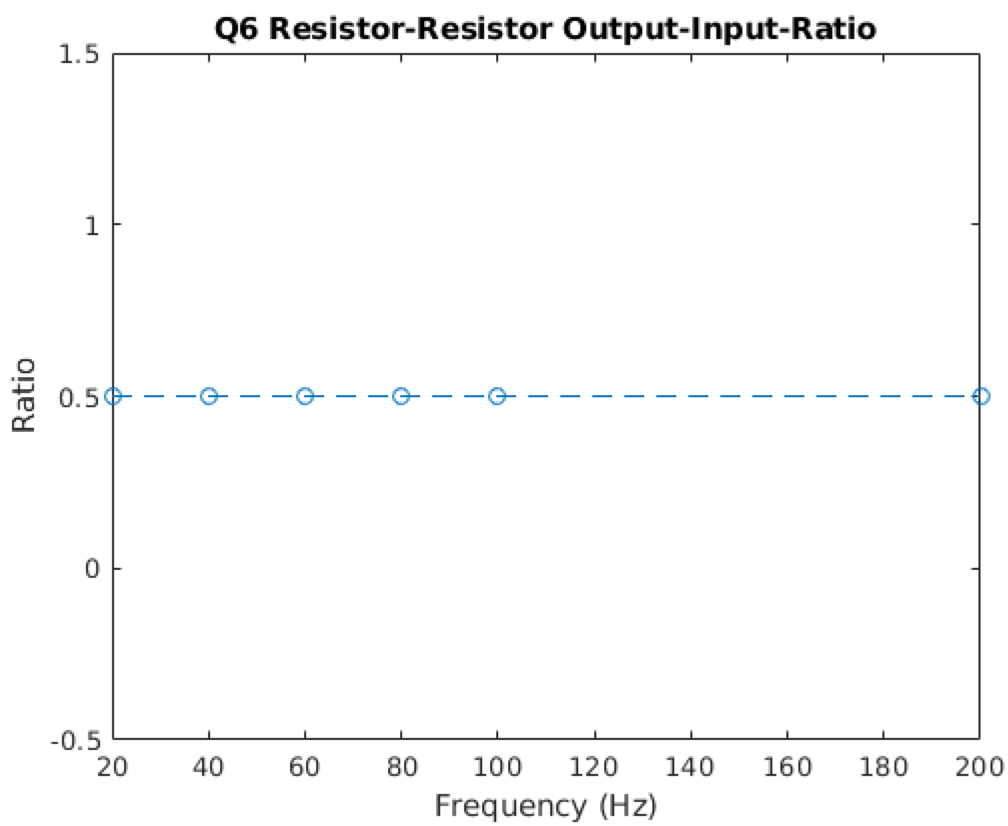
minimum: 0.12 V
maximum: 3.24 V
amp_min = dc - minimum = 1.68 V - 0.12 V = 1.56 V
amp_max = maximum - dc = 3.24 V - 1.68 V = 1.56 V

dac_min: 0 V (gnd, per featherboard specs)
dac_max: 3.3 V (per featherboard specs)
dac_range = dac_max - dac_min = 3.3 V
read: 2^12 bits
resolution = dac_range / read = 3.3 V / 2^12 bits = 0.8 mV / bit

Frequency [Hz]	Input peak-peak [V]	Output peak-peak [V]	Ratio (output to input)
20	3.12	1.56	0.5
40	3.12	1.56	0.5
60	3.12	1.56	0.5
80	3.12	1.56	0.5
100	3.12	1.56	0.5
200	3.12	1.56	0.5

Trend:
No trend can be observed since the resistors are non-frequency related (no impedance). The resistors used were both 50 kOhm, resulting in the expected 0.5 ratio of the voltage divider.

Plot Ratio-Frequency:



Explanation of time delay calculation:

n : samples per cycle
f : desired frequency
s : execution speed
s_0 : execution speed w/o delay
d : delay
d_0 : baseline delay with $d=0$

$$s = \frac{1}{d_0 + d} \qquad s_0 = \frac{1}{d_0} = 53.04\,\text{kHz} \Rightarrow d_0 = 18.85\,\mu s$$

$$f = \frac{s}{n} = \frac{1}{n \cdot (d_0 + d)}$$

$$\Rightarrow \quad d_0 + d = \frac{1}{n \cdot f}$$

$$\Rightarrow \quad d(f) = \frac{1}{n \cdot f} - d_0 = \underline{\underline{\frac{1}{120 \cdot f} - 18.85\,\mu s}}$$

Q7

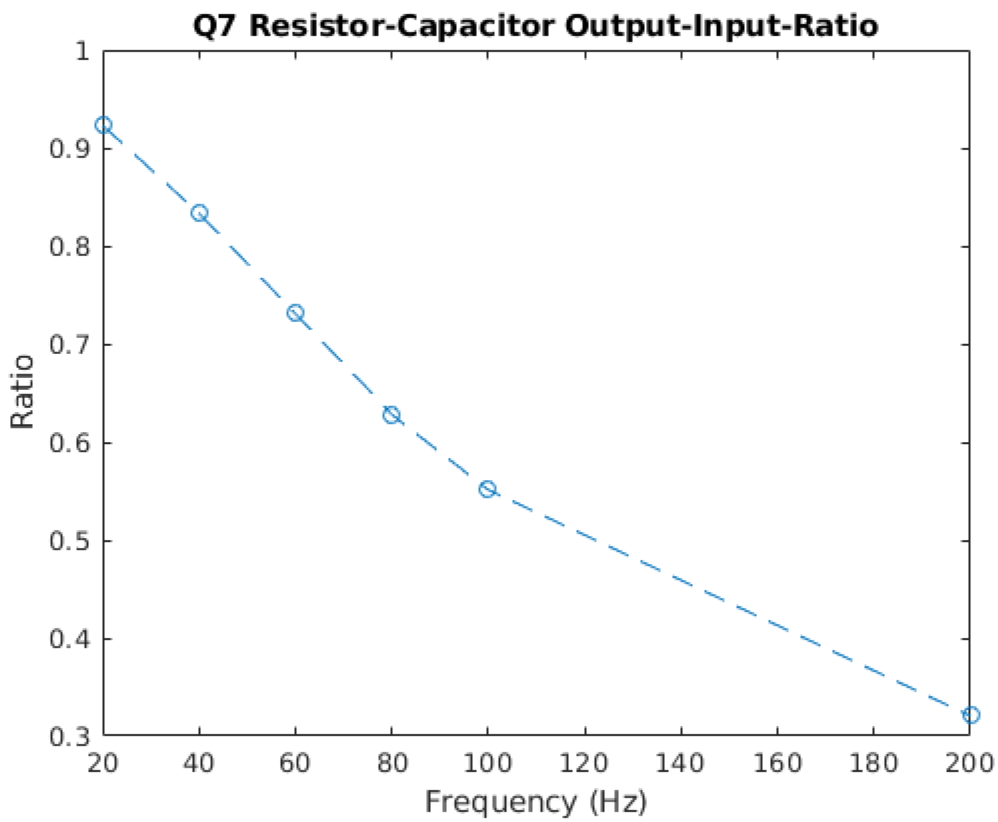
Frequency [Hz]	Input peak-peak [V]	Output peak-peak [V]	Ratio (output to input)	Phase shift (input to output) [degrees]	Phase shift (input to output) [ms]
20	3.12	2.88	0.923	-13.5	2.60
40	3.12	2.60	0.833	-28.0	2.30
60	3.12	2.28	0.731	-37.0	2.00
80	3.12	1.96	0.628	-54.0	1.80
100	3.12	1.72	0.551	-60.0	1.60
200	3.12	1.00	0.321	-72.0	1.00

Trend:

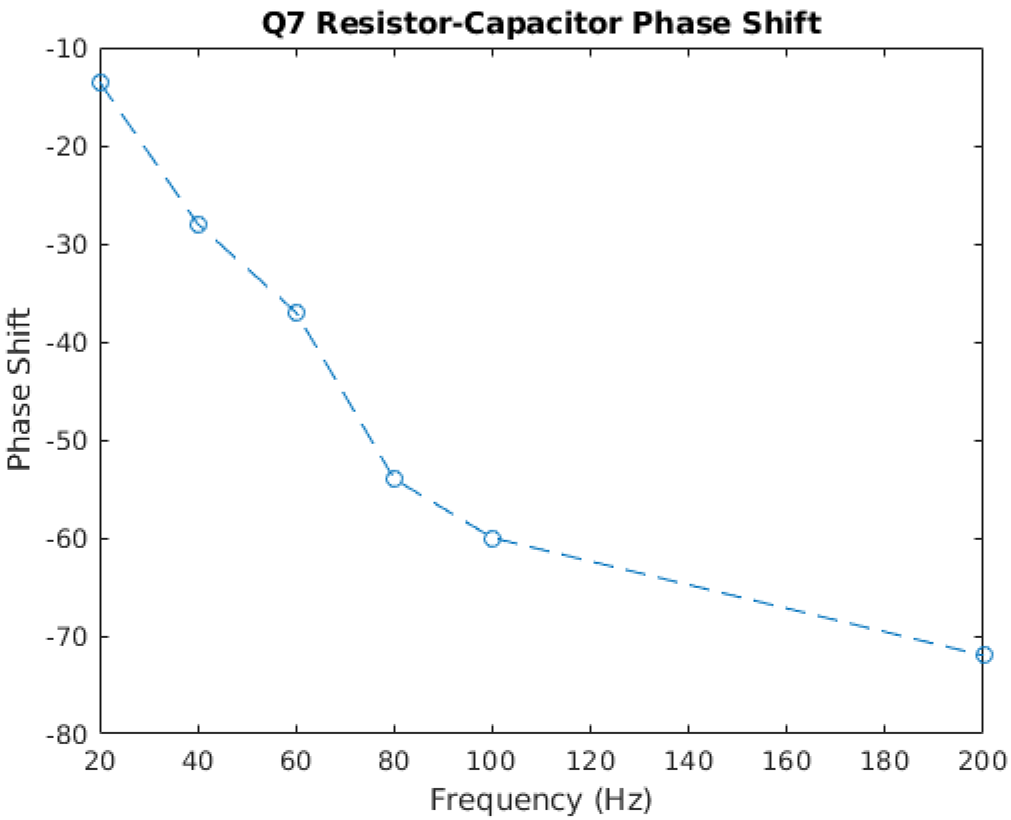
- Behavior of a lowpass filter can be observed. Signals with a high frequency are attenuated while signals at low frequencies can pass the filter with little to no attenuation. This can also be seen in the plot shown below. It can be seen that the ratio of input to output decreases the higher the input frequency.

- In addition to attenuating the frequency of the input signal at high frequencies, the output signal also shows a phase shift with respect to the input signal of the filter. The higher the frequency of the input signal the higher the (absolute) phase shift of the output signal measured in degrees.
- When looking at the phase shift measured in ms (measured in delta_t from peak_input to peak_output) we see that the timedelay increases the lower the frequency. This can be understood by taking the frequency into account that the measurement was taken. At lower frequencies, the timeperiod of the signals are much larger and therefore also the timedelay measured in ms.

Plot Ratio-Frequency:



Plot Phase-Shift-Frequency:



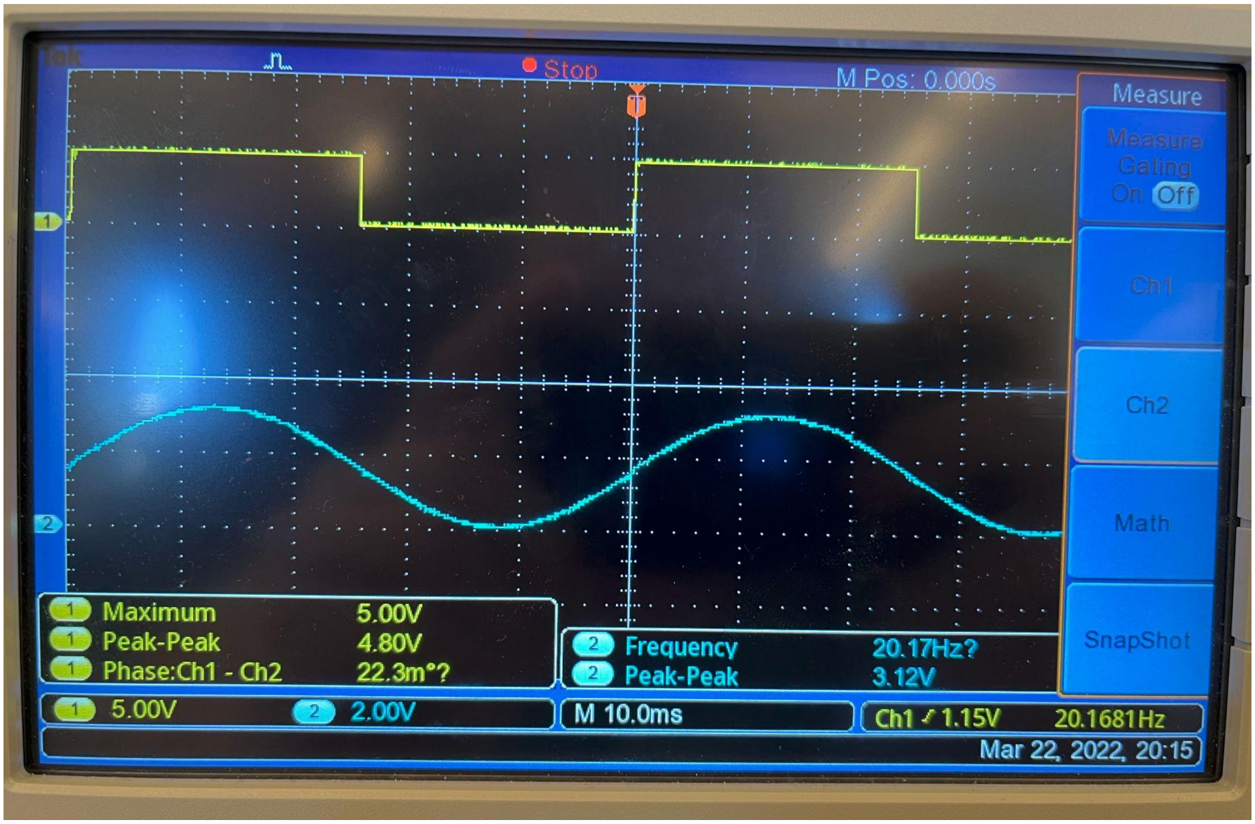
Measure Resistor specs:
The three resistors we had were very close to the specs they had and which we calculated from the colorcoding to be 51 kOhm:
50.92 kOhm
50.89 kOhm
50.94 kOhm
No worries here…

The capacitor specs are 47 nF - The capacitor was measured to have 48.6 nF.
No worries here as well…

Q8

Would be a high-pass filter which lets through high frequencies whilst diminishing the signals of low frequency inputs.

Q9



Matlab Code for Q6 and Q7 Visualization

```
freq = [20 40 60 80 100 200];

%% Q6 Resistor-Resistor
ratio_q6 = [0.5 0.5 0.5 0.5 0.5 0.5];
plot(freq, ratio_q6, '--o');
title('Q6 Resistor-Resistor Output-Input-Ratio'); xlabel('Frequency (Hz)'); ylabel('Ratio');

%% Q7 Resistor-Capacitor Output-Input-Ratio
input_q7 = [3.12 3.12 3.12 3.12 3.12 3.12];
output_q7 = [2.88 2.6 2.28 1.96 1.72 1.00];
ratio_q7 = output_q7./input_q7
plot(freq, ratio_q7, '--o');
title('Q7 Resistor-Capacitor Output-Input-Ratio'); xlabel('Frequency (Hz)'); ylabel('Ratio');

%% Q7 Resistor-Capacitor Phase Shift
phase_shift_q7 = [-13.5 -28.0 -37.0 -54.0 -60.0 -72.0];
plot(freq, phase_shift_q7, '--o');
```

```
title('Q7 Resistor-Capacitor Phase Shift'); xlabel('Frequency (Hz)'); ylabel('Phase Shift');
```