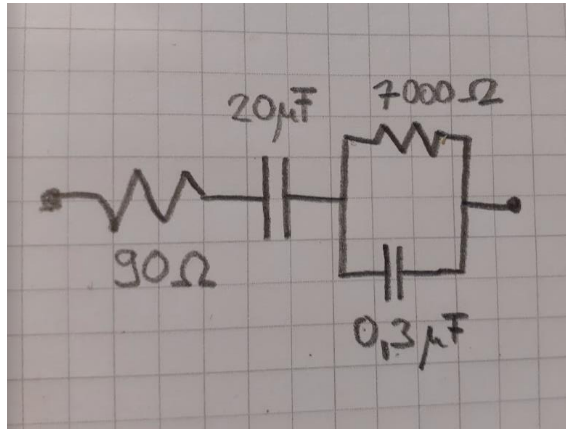
Exercise 2: Komplex Numbers, Impedances and a more difficult fitting example

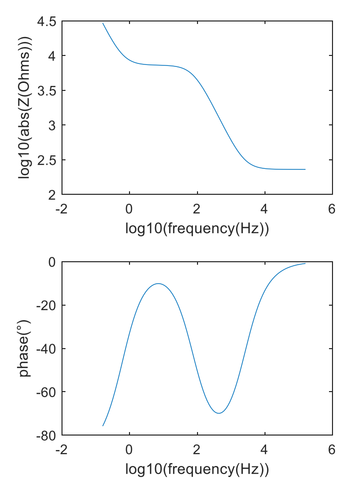
Exercise 2.1: Calculate the total impedance of the shown circuit in the frequency range from 1 Hz to 1 MHz. Plot the modulus and the phase of the impedance in a Bode Plot.



Exercise 2.2: Plot the thermal voltage noise spectra of the circuit measured at room temperature. Use the same frequency range as in 2.1. The general Johnson Nyquist Noise formula is:

$$S_v(f) = 4k_B T \mathrm{Re}[Z(f)]$$

Bonus Exercise 2.3: The plot shows a measured impedance as a function of frequency. Assume that the same equivalent circuit shown in 2.1 is valid. Find the values of the passive circuit elements that fit the data. You can download the impedance data file from Virtual.



Help for exercise 2.3:

a) Build a function that takes a frequency vector as input and the 4 parameters of the circuit elements. As an ouput the function produces a vector with the complex impedances.

b) Build a second function that takes as input the measured data (frequency vector and complex impedance vector) and the 4 parameters of the circuit elements. As an ouput the function produces a single number that represents the error E describing the difference between the measured data and the calculated impedance.

c) Some thought on how to precisely define the error E is necessary. Here are some examples:

$$E = \sum_i \left| Z_{mea,i} - Z_{calc,i} \right|$$

$$E = \sum_i Re\{Z_{mea,i} - Z_{calc,i}\} + Im\{Z_{mea,i} - Z_{calc,i}\}$$

$$E = \sum_i \frac{Re\{Z_{mea,i} - Z_{calc,i}\}}{Re\{Z_{mea,i}\}} + \frac{Im\{Z_{mea,i} - Z_{calc,i}\}}{Im\{Z_{mea,i}\}}$$

d) Use the function fminsearch to find the 4 parameters that minimize the error E.