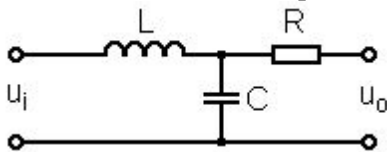


**Measurement Methods in Physics I**  
**Fall 2016**  
**Exercise 4**  
**5 – 7.10.**

**Hand-in assignments. You have to return an answer sheet, even if it would be empty.**  
 Return by 29.9.2016 16:00.

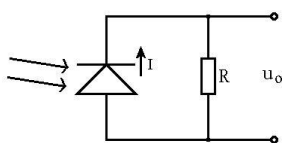
1. An ideal cable has no impedance, which is a good approximation if the cable is short ( $<1\text{m}$ ) and it is protected from external disturbances. In practice the cable has resistance, serial inductance and capacitance between the wires. The impedance of a coaxial cable can be modelled as a four-point network:



A typical coaxial cable (e.g. RG 58) of 20 m has  $C = 1760 \text{ pF}$ ,  $L = 5.2 \text{ }\mu\text{H}$ , and  $R = 0.2\Omega$ . The signal source can be thought to be ideal. The cable is connected to a circuit with an input impedance of  $1\text{k}\Omega$ . What is the highest signal frequency that can propagate through the cable without being dampened more than one percent?

2. a) A voltage amplifier's output voltage has been noted to dampen by 20 % when a load of  $1 \text{ k}\Omega$  resistance is connected to it. What is the output impedance of the amplifier?
- b) A  $1 \text{ k}\Omega$  load is driven with the amplifier, whose open-loop gain is 60 dB. The amplifier's input impedance is  $20 \text{ k}\Omega$  and the output impedance is  $1 \text{ k}\Omega$ . What is the power amplification of the amplifier, in decibels, with this connection?
- c) The amplitude of a sinusoidal output voltage must be 10 V from peak to peak. An available amplifier has a slew rate of  $0,5 \text{ V}/\mu\text{s}$ . What is the highest possible frequency that is not distorted?

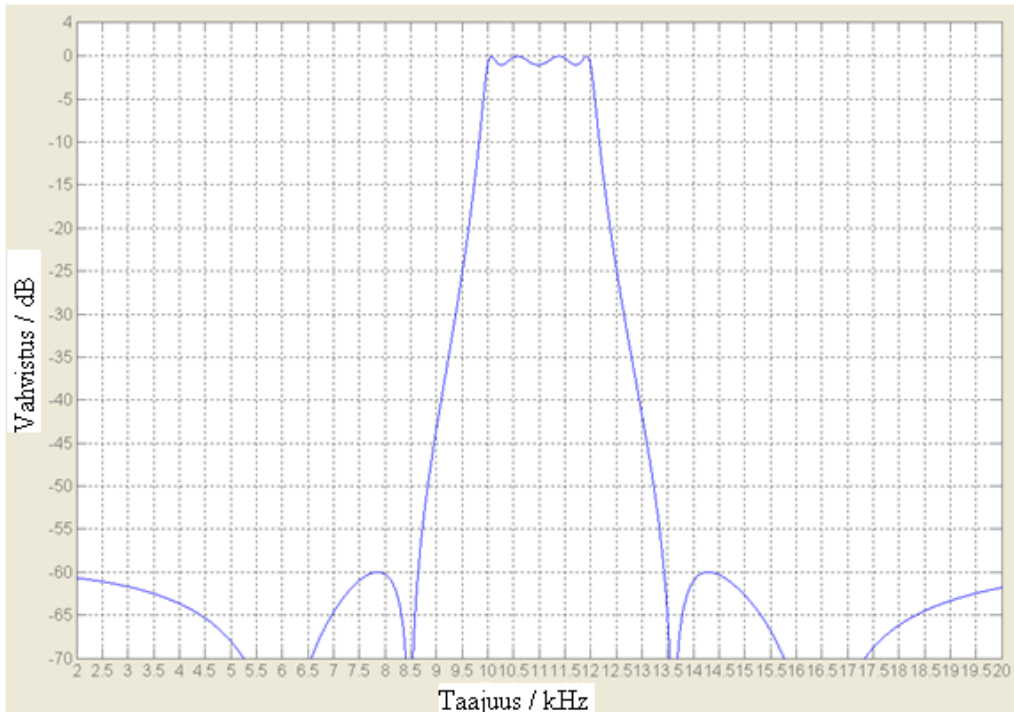
3. You use the following circuit to measure light intensity in a room:



- a) When the light intensity is at maximum, the photodiode produces a  $34\mu\text{A}$  current. In that case you want  $u_o$  to be 5 V. Choose a resistance value that fulfils this requirement.
- b) Is the output impedance of this circuit high or low? Why is this particular circuit not very suitable for light intensity measurements?
- c) The root-mean-square value of the current in the circuit is  $23 \text{ }\mu\text{A}$ , the room temperature is  $21 \text{ }^\circ\text{C}$ , and  $u_o$  is measured in the frequency range 10 Hz - 10 kHz. Calculate the SNR for  $u_o$ , take into account both thermal (Johnson) and shot noise.

**"Check box"-assignments. Bring these to the exercise session.**

**4.** Below is the frequency response of an 8th order elliptic band pass filter. From the plot, define the filter's  
a) -3dB points b) the slope of the damping c) bandwidth d) the flatness of the pass band.  
(Vahvistus=amplification, Taajuus=frequency)



**5.** You measure an unknown signal with a 200 Hz sampling frequency and the measured result seems to be an 80 Hz sine wave. You change the sampling frequency to 180 Hz and the same signal now looks like a 60 Hz sine wave.

- Which measurement technical phenomenon is this?
- What is the actual frequency of the measured signal?
- With what sampling frequency would the measured result be a constant voltage?