Problem sheet 3 (Week 5)

Q1: (Tutorial question for Week 6/7)

a) What is the difference between an ideal op-amp, an ideal voltage amplifier and a commercial op-amp?

b) Write an expression for the input impedance of the inverting amplifier below if R1=1k, R2=100k, the op-amp has a DC gain G=10^4 and its dominant pole is at f=1.59Hz. Evaluate the input impedance of this circuit at f=15.9 kHz. The op-amp has zero input conductance and output resistance.

The open loop gain of a “dominant pole amplifier” is given by $G(f) = \frac{G_{DC}}{1+s\tau} = \frac{G_{DC}}{1+s/\omega_0}$, with $G_{DC}$ the DC gain and $\omega_0 = 1/\tau$ the pole (also called the “break”) frequency.

c) Calculate the DC voltage gain of the emitter degenerated common emitter amplifier below if R1=50 Ohms, R2=200 ohms and IC=1mA. (leave this item for week 6)

Q2. Use superposition to show that the following circuit, built with an ideal op-amp, has an output equal to: $v_o = v_i \left( \frac{1+R_3/R_1}{1+R_3/R_4} \right) - v_i R_2 / R_1$

Chose relative resistor values so that $v_{out} = A(v_{i1} - v_{i2})$. what is the value of the constant A?
**Q3:** Apply the Miller Theorem to how that the input impedance of the following circuit is:

\[ Z_{in} = \frac{R}{1 - G} \]. Derive an expression for the input impedance of this circuit if \( G \) is a dominant pole inverting amplifier, the open loop gain of the amplifier is given by

\[ G(f) = \frac{G_{DC}}{1 + s \tau} = \frac{G_{DC}}{1 + s / \omega_b}. \]

What are the break frequencies of the impedance as a function of frequency? What is the input impedance at low frequencies and at very high frequencies?

The open loop gain of a “dominant pole amplifier” is given by

\[ G(f) = \frac{G_{DC}}{1 + s \tau} = \frac{G_{DC}}{1 + s / \omega_b}, \] with 

\( G_{DC} \) the DC gain and \( \omega_b = 1 / \tau \) the pole (also called the “break”) frequency.

![Circuit Diagram](image)

**Q4:** Show that the transfer function of the ideal differentiator below constructed with a dominant pole amplifier is:

\[ H(s) = \frac{v_{out}}{v_{in}} = \ldots = \frac{-sRCG_{DC}}{s^2 \tau RC + s (\tau + RC) + (G_{DC} + 1)} \]

Calculate the maximum gain of this filter which occurs, roughly, when denominator is purely imaginary.

![Differentiator Circuit Diagram](image)