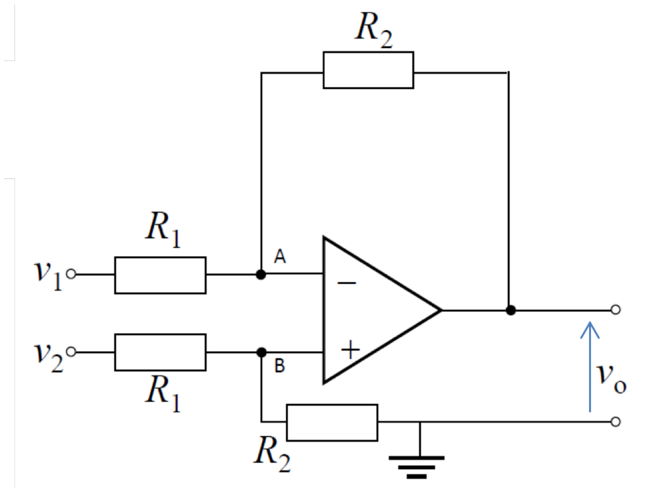
Indice

1 Esempi di circuiti con OpAmp

1.1 Difference amplifier

The circuit below is a difference amplifier. Assuming an ideal op-amp, find the voltage v_o in terms of $v_2 - v_1$.

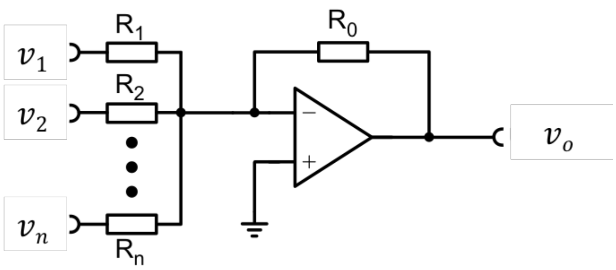


1.2 Summing amplifier

Show that the circuit below adds the input voltages as follows:

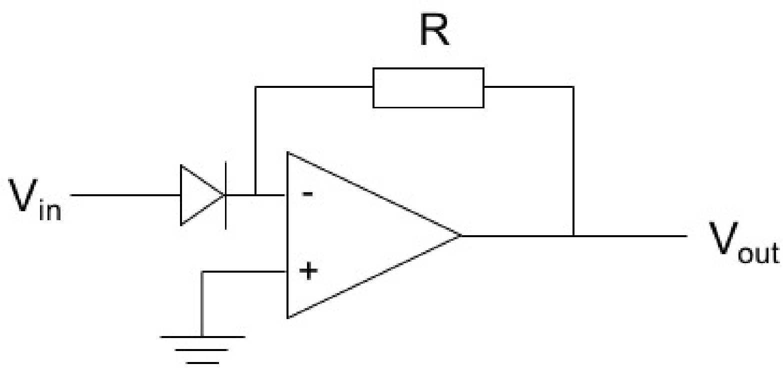
$$v_o = c_1 v_1 + c_2 v_2 + ... + c_n v_n, \quad (1)$$

with $c_n = -\frac{R_0}{R_n}$.



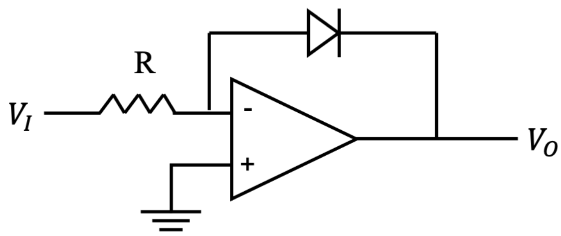
1.3 Exponential amplifier

Using the OpAmp Golden Rules rules, write down an expression for V_{out} as a function of V_{in} for the circuit below. Assume ideal diode behaviour.



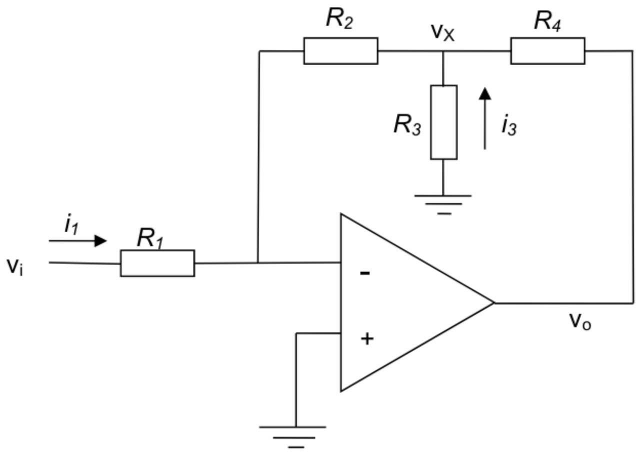
1.4 Logarithmic amplifier

Using the operational amplifier golden rules, write down the expression for V_O as a function of V_I for the circuit below, assuming $V_I > 0$ and ideal diode behaviour. Discuss what happens to the feedback if $V_I < 0$.



1.5 Inverting amplifier with modified feedback network

This problem refers to the following circuit with the indicated currents and voltages.



- Using your knowledge of ideal OpAmp behaviour, write down simple expressions for the following currents and voltages:

  1. The current i_1 in terms of v_i and R_1 ;
  2. The voltage v_x in terms of i_1 and R_2 ;
  3. The current i_3 in terms of v_x and R_3 ;
  4. The voltage v_o in terms of v_x, i_1, i_3 and R_4.

  In each case explain the property of the OpAmp or circuit that you have used.

- Show that the closed loop gain is given by

$$\frac{v_o}{v_i} = -\frac{R_2}{R_1}(1 + \frac{R_4}{R_2} + \frac{R_4}{R_3}).$$

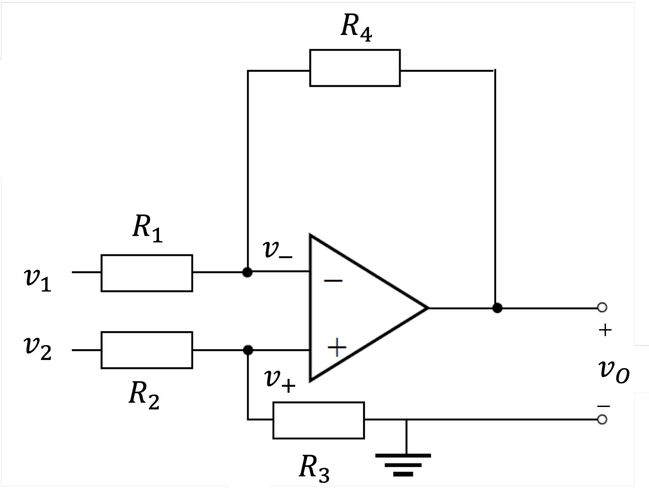
- Using three $1\,\mathrm{M\Omega}$ resistors and one $10.2\,\mathrm{k\Omega}$ resistor, show how the circuit can be used to achieve an input resistance of $1\,\mathrm{M\Omega}$ and a closed loop gain of -100.

- Explain the advantage of adding the resistor R_3 to the feedback network.

1.6 Analogue mixer

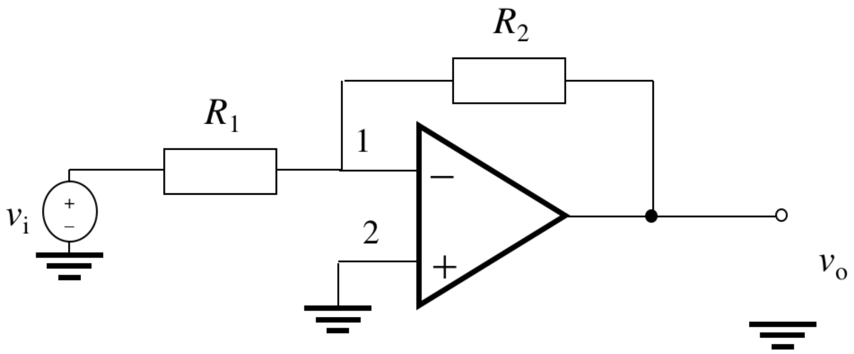
The circuit below acts as an analogue mixer producing an output voltage $v_O = \alpha v_+ - \beta v_-$.

- Write down expressions for v_+ and v_-.
- Hence find the coefficients α and β.
- What is needed for the mixer to operate instead as a differential amplifier, i.e. v_o proportional to $(v_+ - v_-)$?



1.7 Inverting amplifier with rejection circuit

Consider the inverting amplifier shown below. Assume an ideal op-amp.



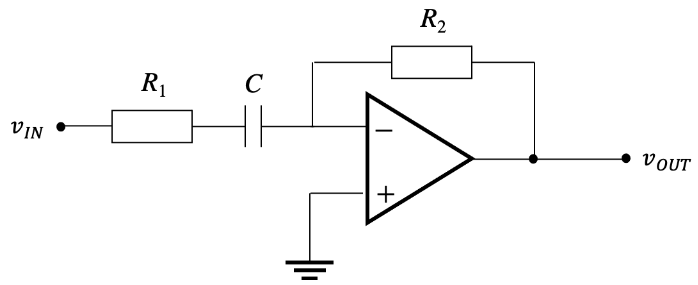
- Derive the expression for the closed loop gain, G, and calculate its value for $R_1 = 10\,\mathrm{k}\Omega$ and $R_2 = 100\,\mathrm{k}\Omega$.
- How should the circuit be modified to compensate for any input bias current? What value of the component should be used to keep the gain value calculated above?

Consider a filter constructed by inserting a rejection circuit in the feedback loop of the inverting amplifier above, in parallel to R_2. The rejection circuit is formed by the parallel combination of an inductor and a capacitor.

- Determine the complex impedance of the rejection circuit, Z_{LC}, and describe its variation with frequency in the following cases: $\omega \to 0$, $\omega \to \infty$, and $\omega = \frac{1}{\sqrt{LC}}$.
- Write the expression for the gain of the circuit including the rejection circuit in terms of Z_{LC}, R_1, and R_2. Discuss how the addition of the rejection circuit affects the feedback and thus the gain.
- Sketch the variation of the gain with angular frequency, labelling any key features on the x and y axes.
- What type of filter is this?

1.8 OpAmp filters

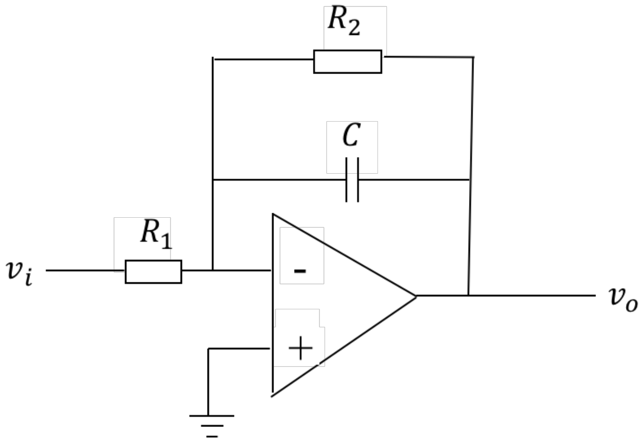
Consider the circuit below. Assume the operational amplifier is ideal.



- Derive an expression for the closed loop gain, G, and show that its magnitude is $|G| = \frac{\omega C R_2}{\sqrt{1+\omega^2 C^2 {R_1}^2}}$, where ω is the frequency.
- Find the expressions for the gain G at high frequency, and for the 3 dB frequency, ω_0.
- Find the values of the components such that the circuit has a high frequency input impedance of 1 kΩ, a high frequency gain of 40 dB and a 3 dB frequency of 1 kHz.
- What function does this circuit perform?
- Suggest what component should be added to the circuit in order to produce a band pass filter. Where should this component be placed? Calculate the value of this component assuming that the band pass filter has a lower 3 dB frequency of 1 kHz and high 3 dB frequency of 100 kHz.

1.9 OpAmp filters

This problem refers to the following circuit:



- Show that the closed-loop gain of this circuit is given by

$$G = \frac{v_o}{v_i} = \frac{-R_2/R_1}{1 + j\omega C R_2}$$

  where ω is the angular frequency of the input. You may assume that the op-amp is ideal.

- What function does this circuit perform? (Hint: test the circuit at high and low frequency.)

- Find values of the components such that the circuit would have an input impedance of $1\,\mathrm{k\Omega}$, a gain of 100 at low frequency, and a $3\,\mathrm{dB}$ frequency of $1 \times 10^2\,\mathrm{rad\,s^{-1}}$.

- At what angular frequency does the output lag the input by 60° and what is the value of the gain at this frequency?