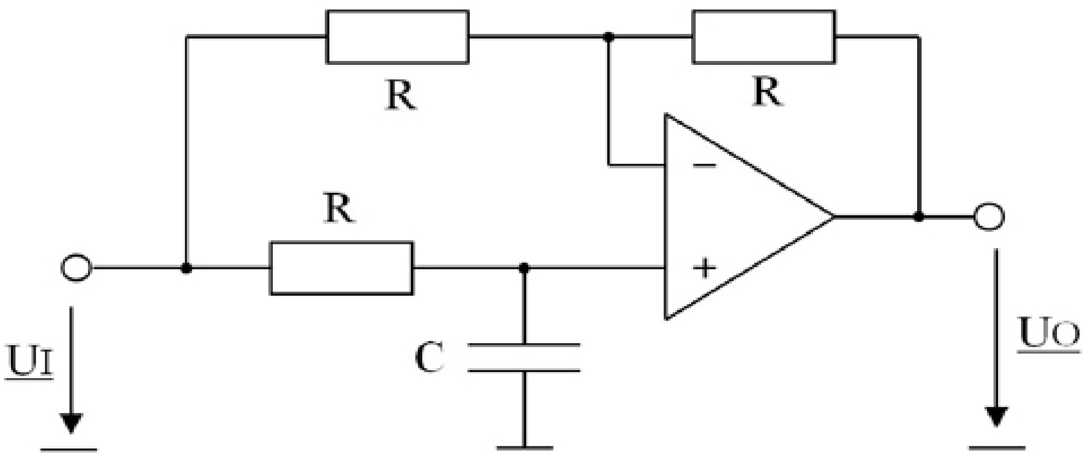
Roland Büchi

Exercises in Electronics

Operational Amplifier Circuits



examination papers and detailed

Contents

Exercises

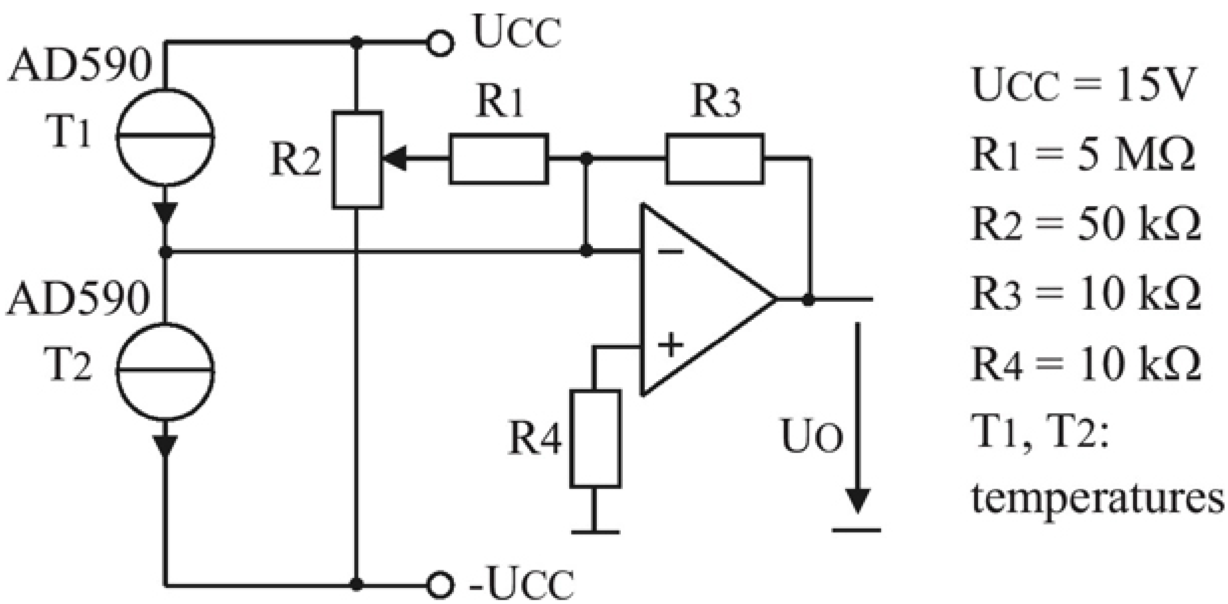
1. Circuits with ideal OpAmps
2. Circuits with non- ideal OpAmps
3. Filter Circuits
4. Schmitt- Trigger Circuits

Solutions

1. Circuits with ideal OpAmps
2. Circuits with non- ideal OpAmps
3. Filter Circuits
4. Schmitt- Trigger Circuits

1. Circuits with ideal OpAmps

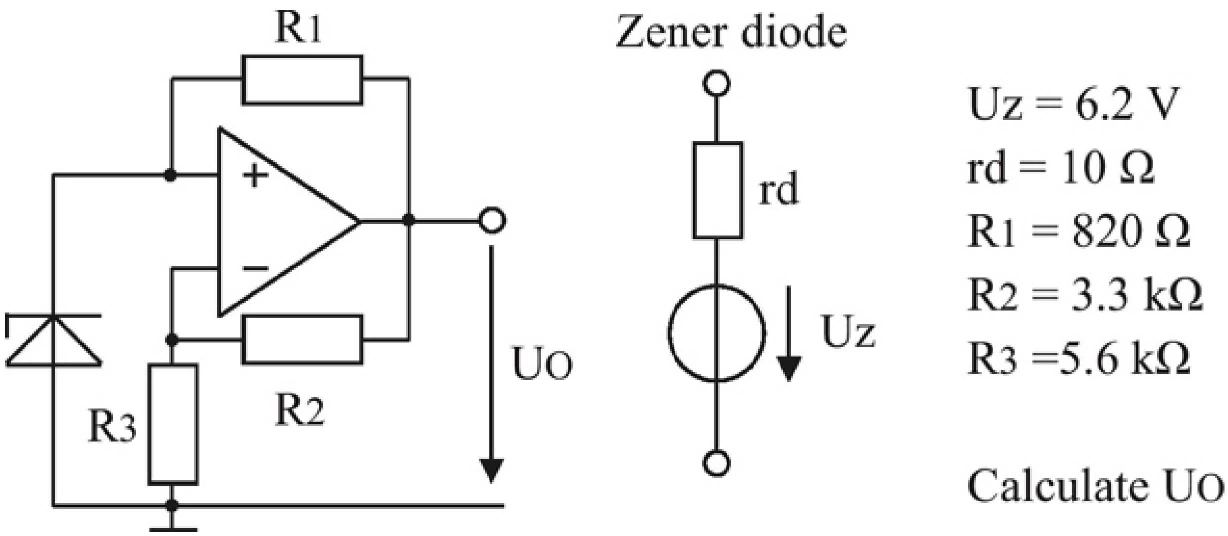
1.1 OpAmp for temperature measurement



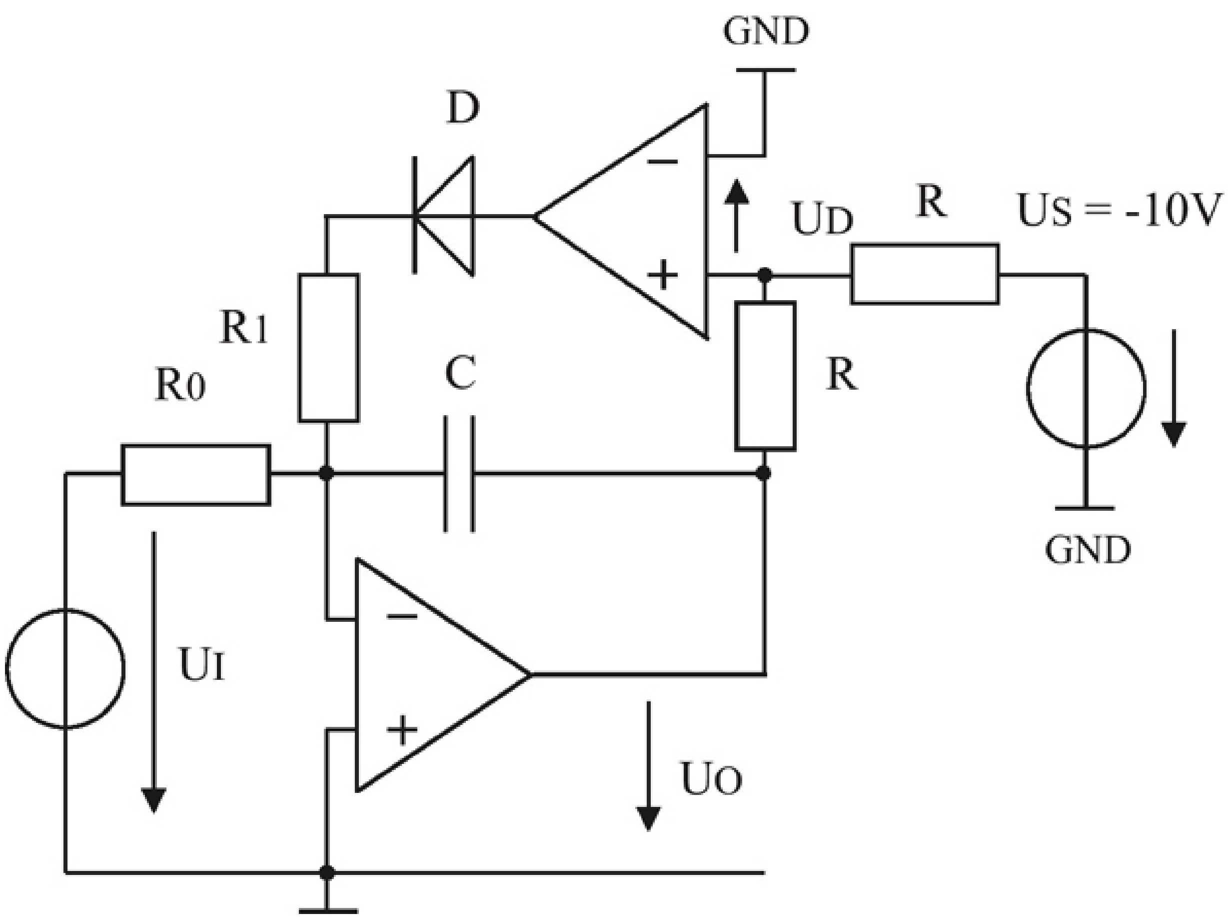
The AD590 is a temperature sensor, which provides an impressed current of 1µA/K.

a.) Calculate $U_A = f(T_1,T_2)$. Neglect the influences of R_1 and R_2.
b.) What are R_1, R_2 and R_4 for? Calculate their influence to U_A.

1.2 OpAmp as voltage reference



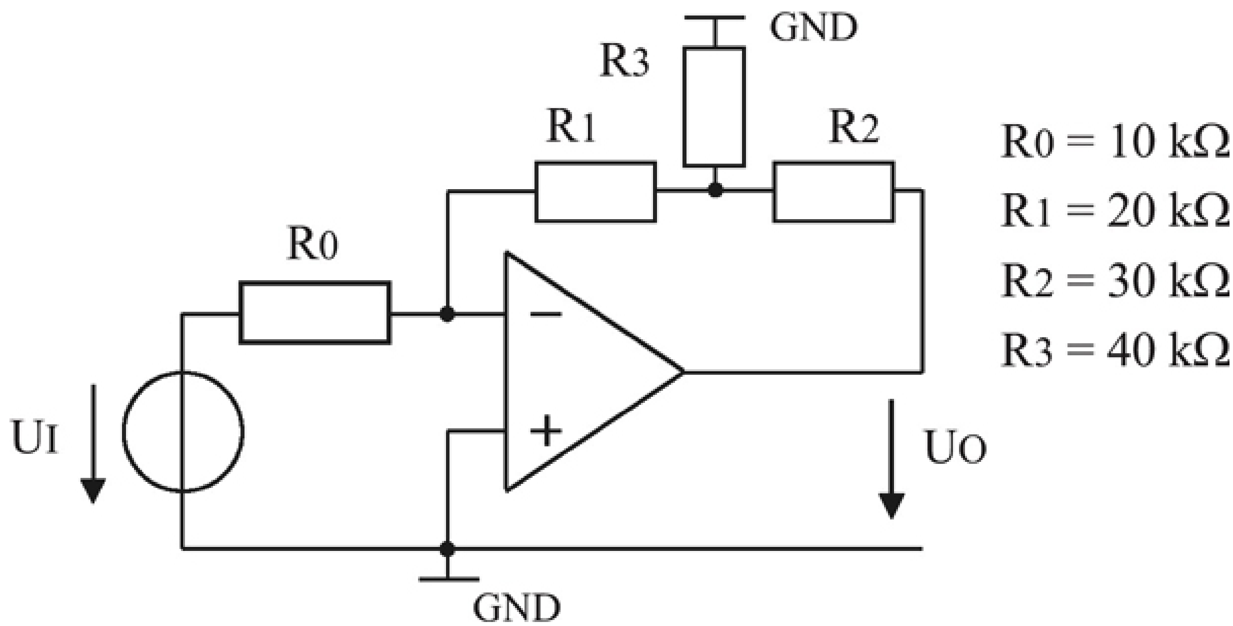
1.3 Limited integrator



This circuit provides limited integrator. There is $U_I < 0$.

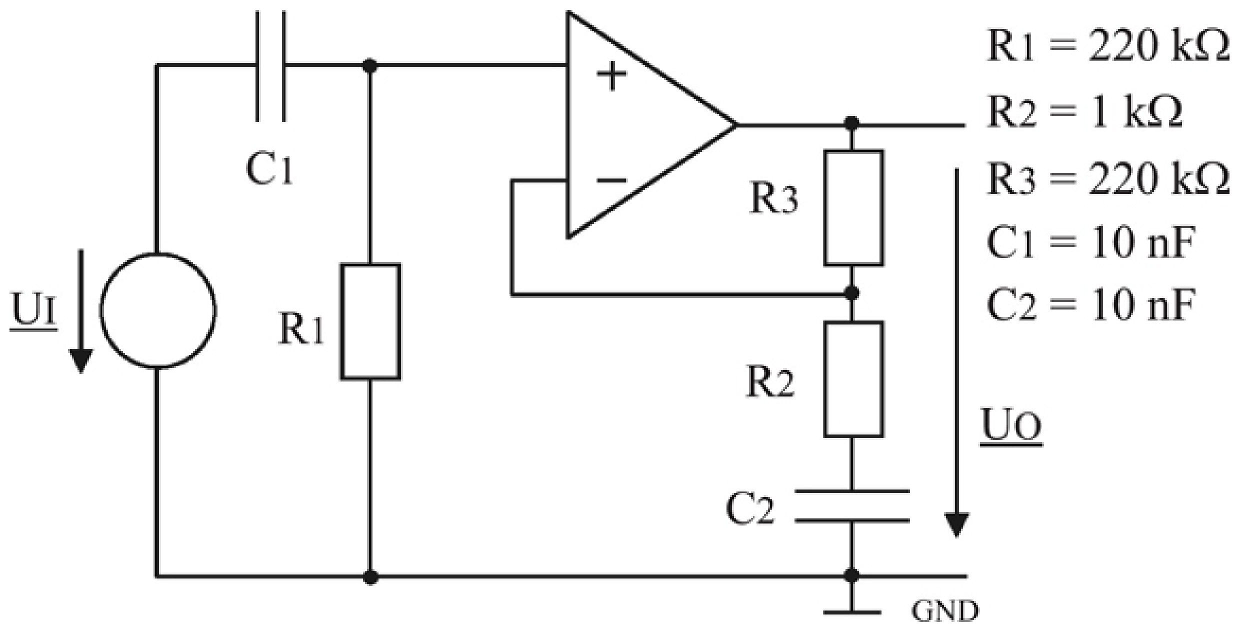
a.) Identify the blocks ‘integrator ‘ and ‘limitation’ in the circuit.
b.) Draw the characteristic $U_D = f(U_O)$.
c.) Mark the areas in the drawing of b.), where the Diode D is conducting, respectively blocking
d.) To which value, the voltage U_O is limited?
e.) Complete the circuit, so that positive and negative voltages U_O are limited.

1.4 OpAmp circuit



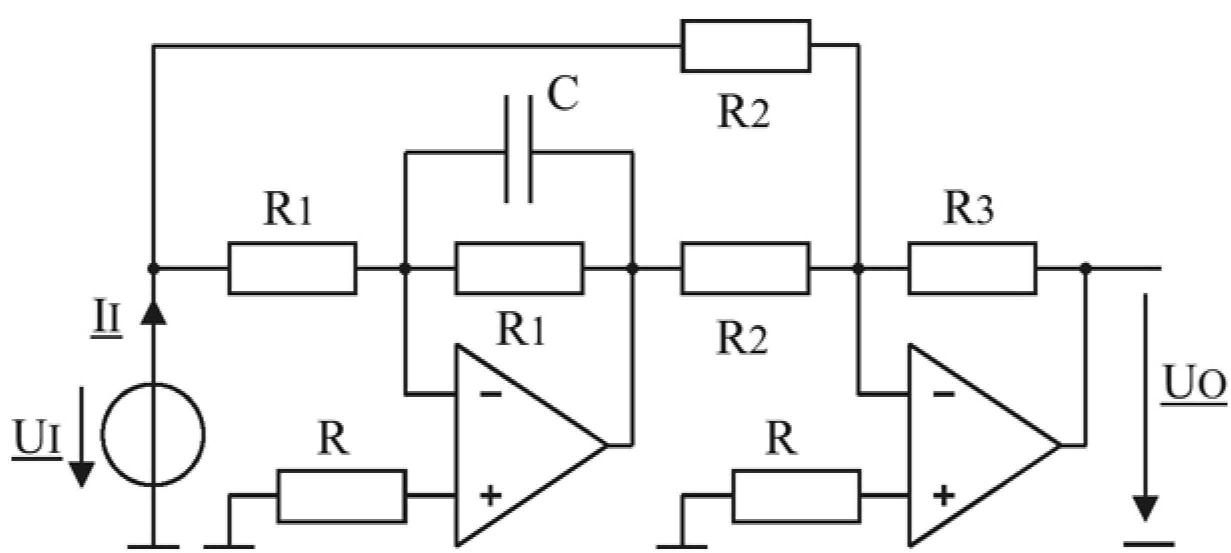
Calculate U_O/U_I.

1.5 Amplifier circuit, high pass filter



a.) Calculate the transfer function $\underline{U}_O/\underline{U}_I$.
b.) The sinusoidal frequency ω is infinite. Calculate $|\underline{U}_O/\underline{U}_I|$ and the input impedance Z_I.
c.) ω = 0: Calculate $|\underline{U}_O/\underline{U}_I|$. Explain the function of C_1 and C_2.

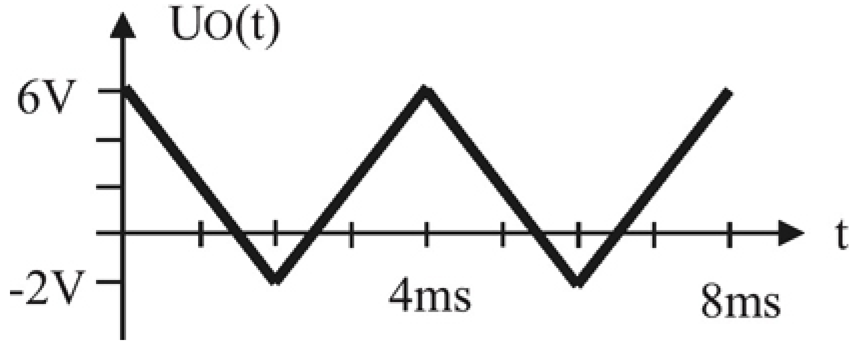
1.6 Circuit with two OpAmps



a.) Calculate the transfer function $\underline{U}_O/\underline{U}_I$.
b.) Calculate the input impedance $\underline{Z}_I = \underline{U}_I/\underline{I}_I$.

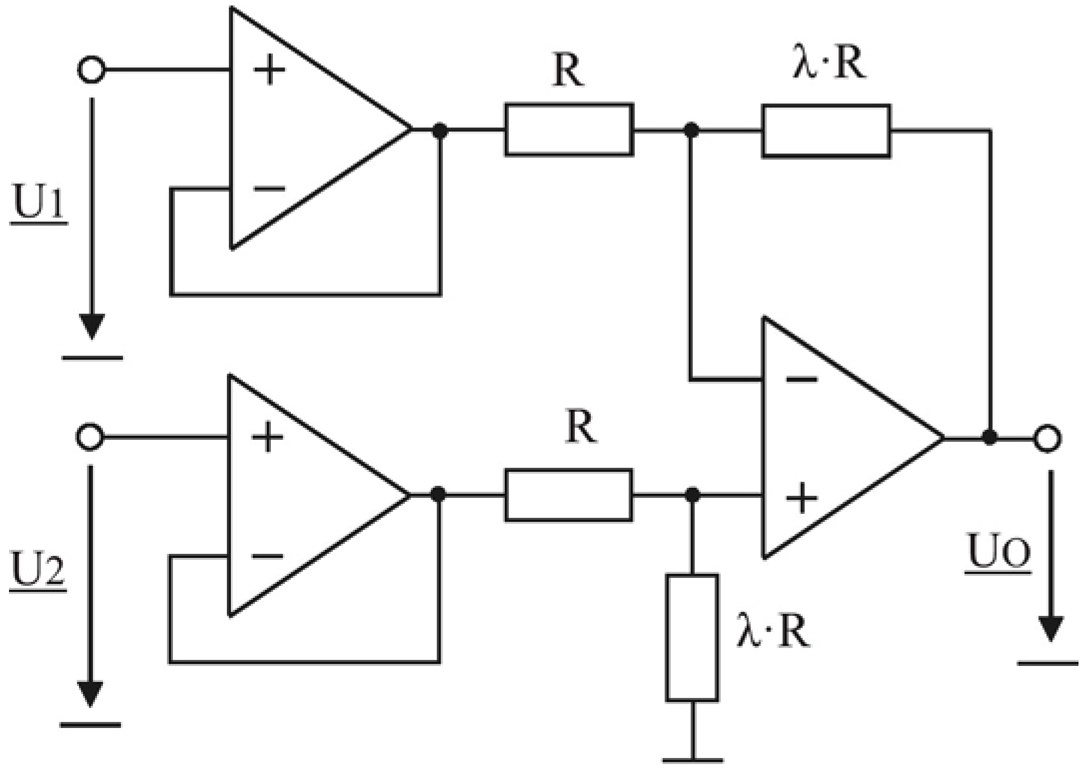
c.) Draw the amplitude response of the system.

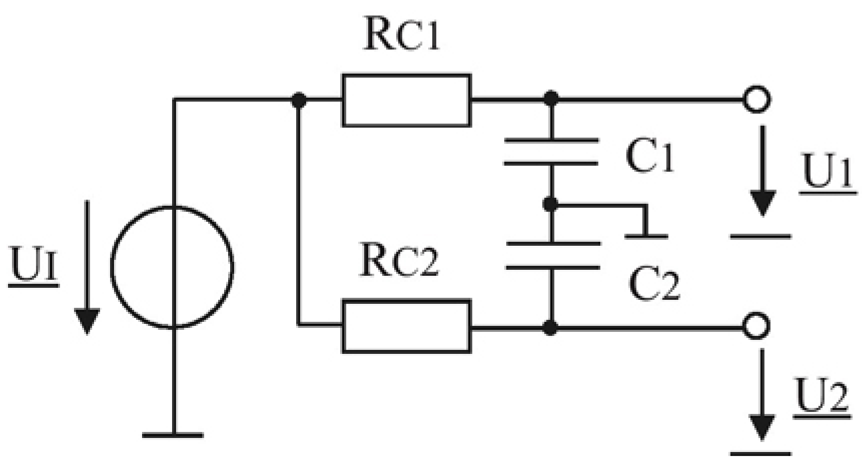
1.7 Triangle rectangle generator



Develop a circuit which generates the above waveform. There are rail to rail Operational Amplifiers available with a supply voltage of +/-15V. Resistors may be used any desired, capacitors from the standard series E6. It is important to ensure that no OpAmp output is loaded with less than 2kΩ.

1.8 Subtracting amplifier

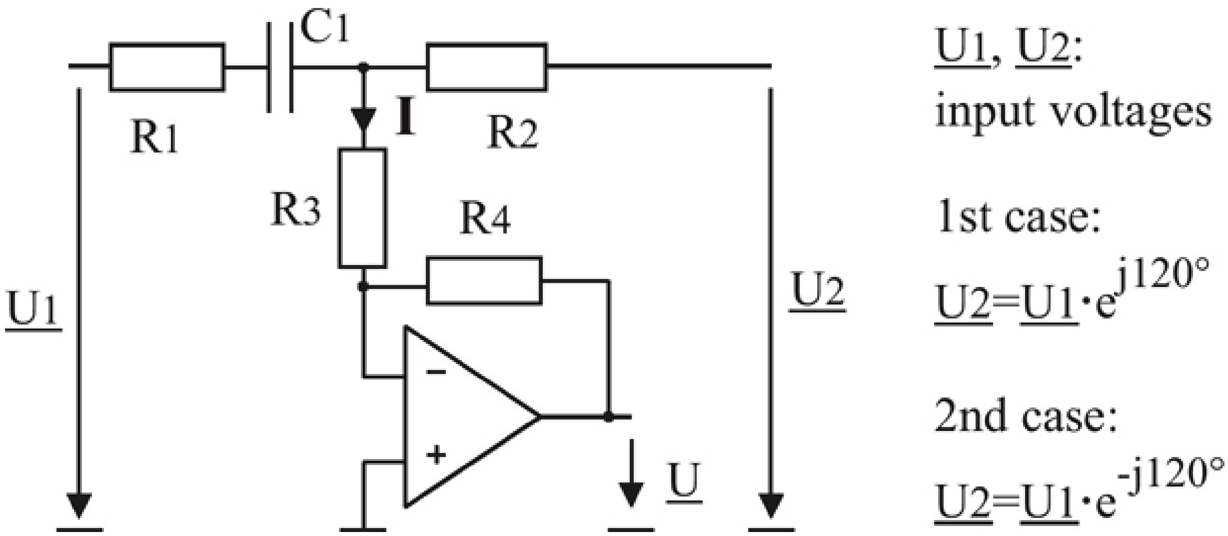




The inputs of the circuit are supplied with wires of different length. These are modelled by RC elements. Both lines are connected together on the other side. There, the voltage U_I is applied.

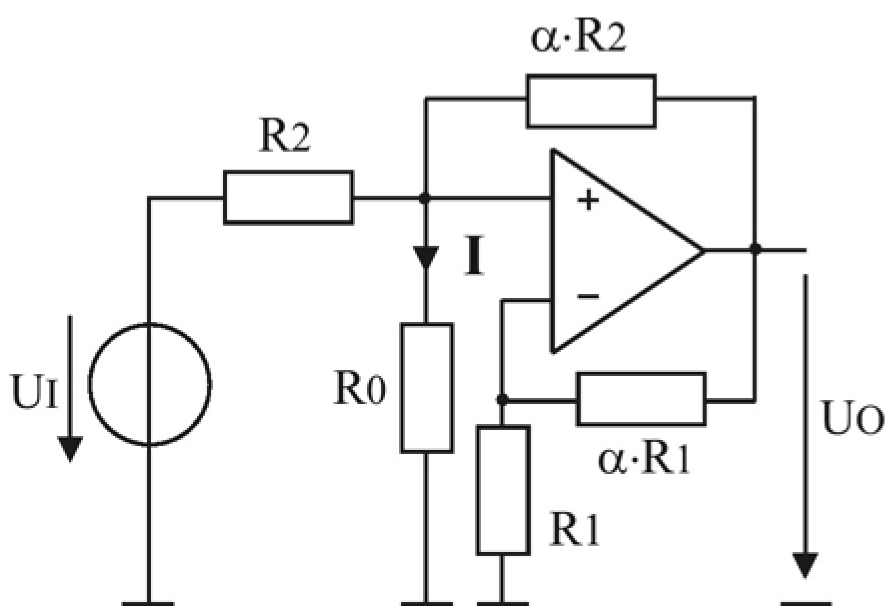
a.) $C_1 = 0$, $C_2 = 0$. Calculate $\underline{U}_O = f(\underline{U}_I)$.
b.) $C_1 \neq 0$, $C_2 \neq 0$, $R_{C1} \neq 0$, $R_{C2} \neq 0$. Calculate $\underline{U}_O = f(\underline{U}_I)$.
c.) Calculate $|\underline{U}_O|$, when $\omega \cdot R_{C1} \cdot C_1 << 1$, $\omega \cdot R_{C2} \cdot C_2 << 1$.

1.9 Rotating field detection circuit



a.) For which case, I = 0 is in principle possible?
b.) Give C1 and R1 as a function of R2, for I = 0 in a.)
c.) For which purpose, the circuit may be used?

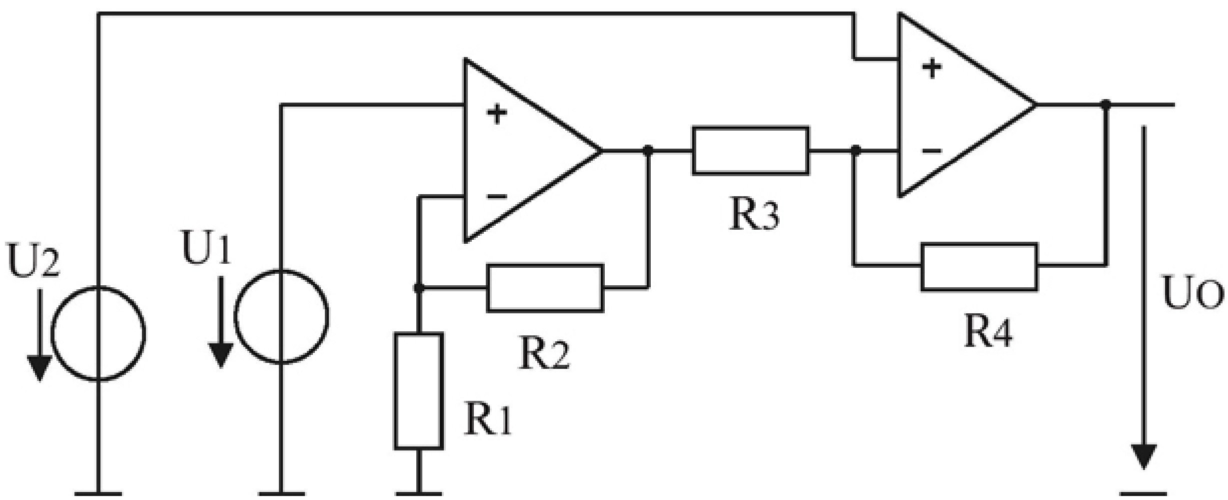
1.10 Current source



It is assumed that the operational amplifier will operate in negative feedback.

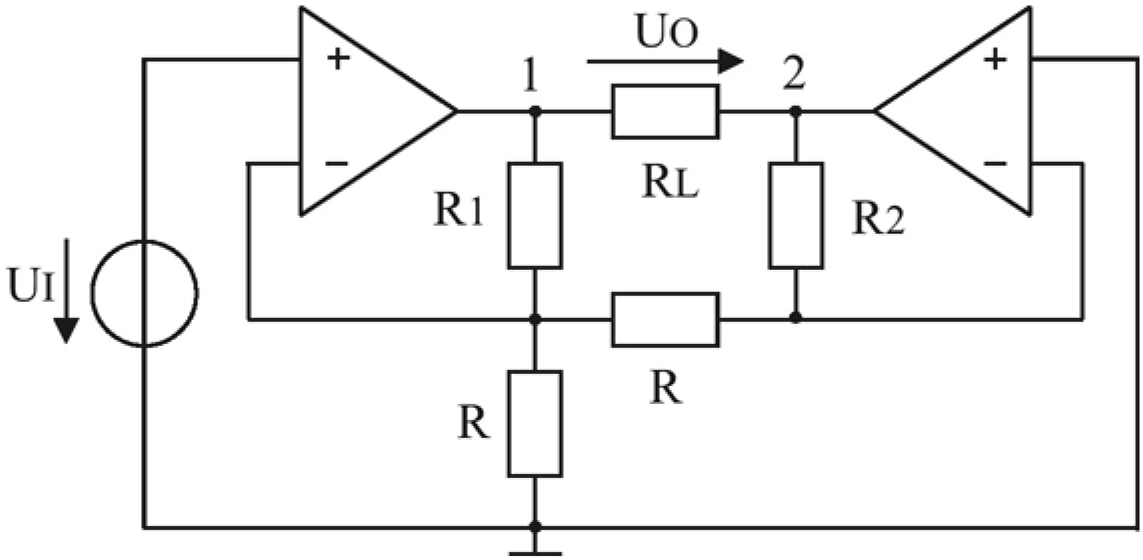
a.) Calculate I = f(U_I).
b.) Calculate U_O = f(U_I).
c.) What is the purpose of the circuit for R_0?

1.11 Subtracting amplifier



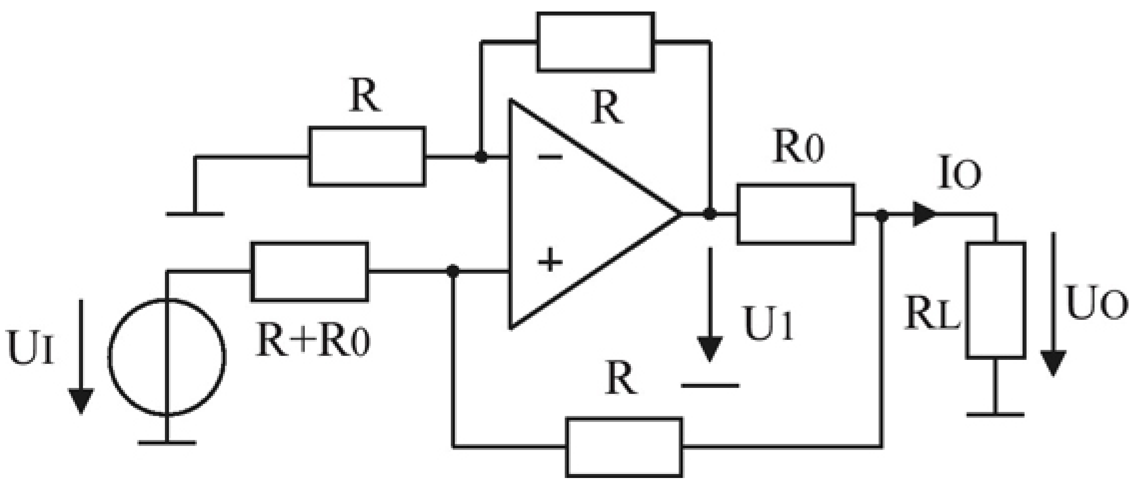
a.) Calculate U_O as a function of U_1 and U_2.
b.) Which condition must the resistors R_1, R_2, R_3 and R_4 fulfill, so that it applies $U_O = k\cdot(U_2-U_1)$.
c.) Subtracting amplifiers can be realized with only one OpAmp. In comparison, what is the advantage of this circuit?

1.12 Symmetric amplifier



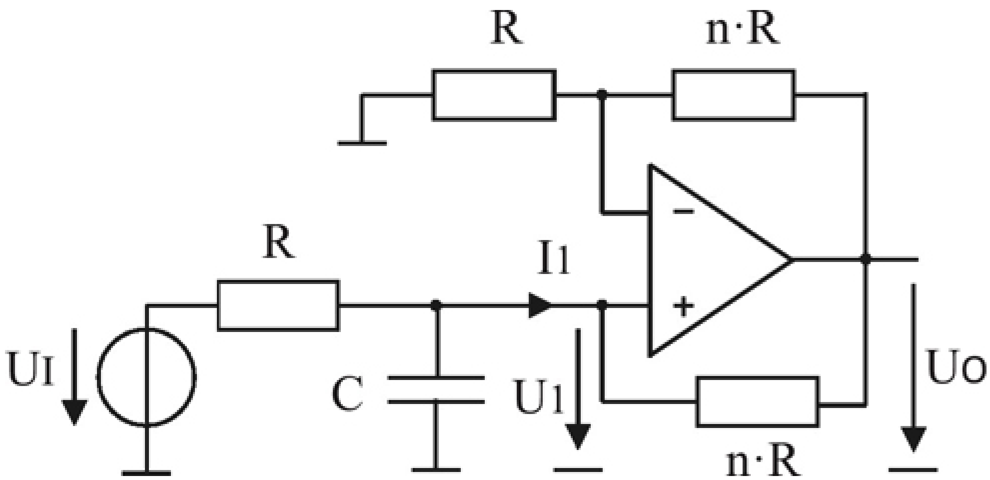
a.) Calculate $U_O=f(U_I)$.
b.) Calculate $R_2 = f(R,R_1)$ such that between ‘1’ and ‘2’ results a symmetric voltage to the reference potential.

1.13 Current source with OpAmp



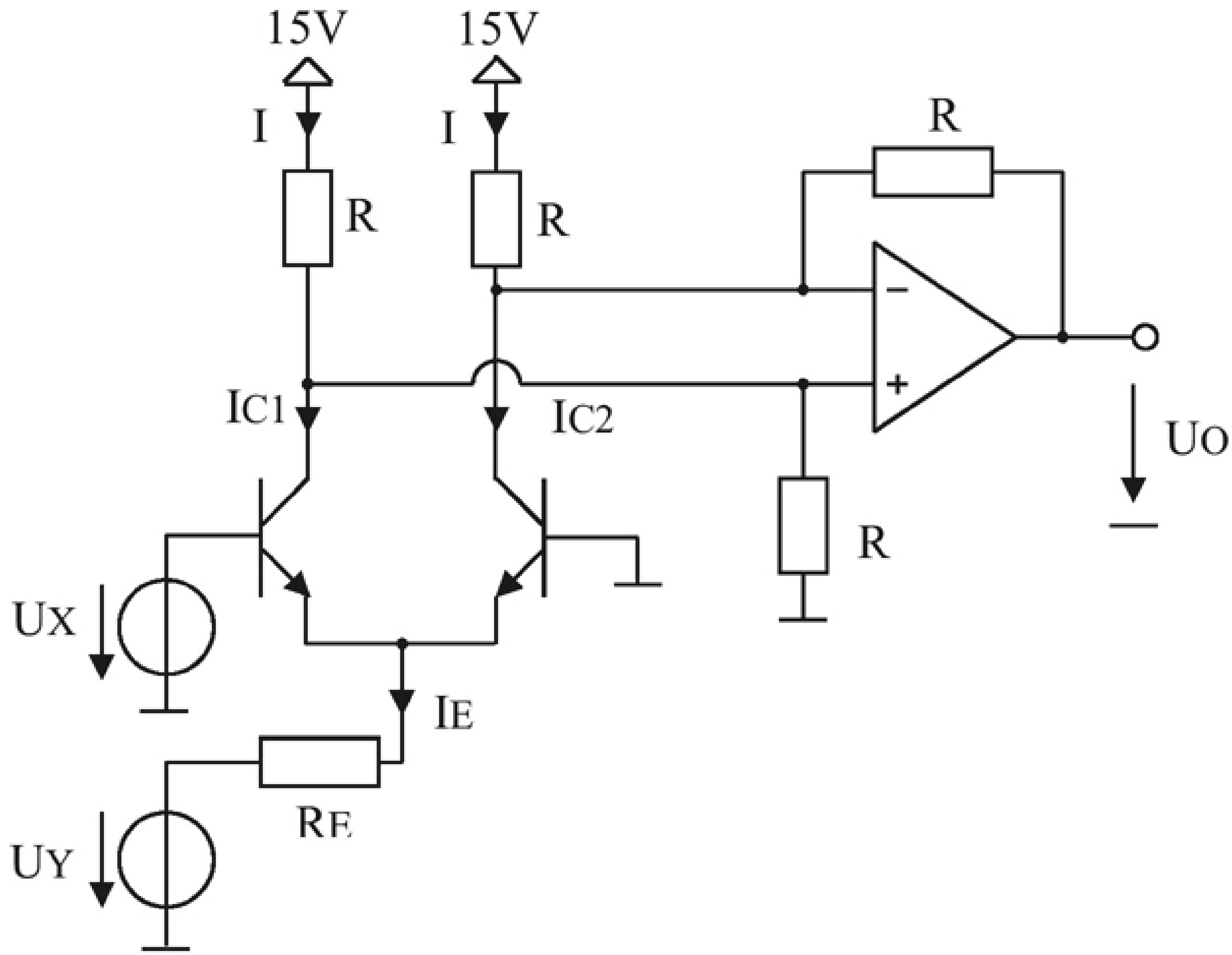
Calculate $I_O = f(U_O,U_1)$, $U_1 = f(U_I, U_O)$ and $I_O = f(U_I)$.

1.14 Input resistor



a.) Calculate the input resistor U_1/I_1. (RC element is not part of the equation)
b.) Calculate the transfer function $U_1(s)/U_I(s)$.
c.) Calculate the transfer function of the whole circuit, $U_O(s)/U_I(s)$.

1.15 Multiplier

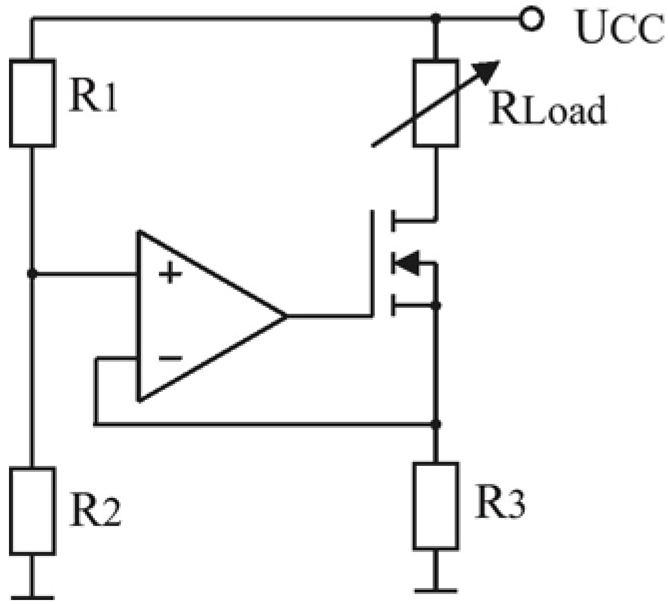


For $U_X \ll U_T$ (=25mV) is:

$$I_{C1,2} = I_E/2 \cdot (1 \pm U_X/(2 \cdot U_T)$$

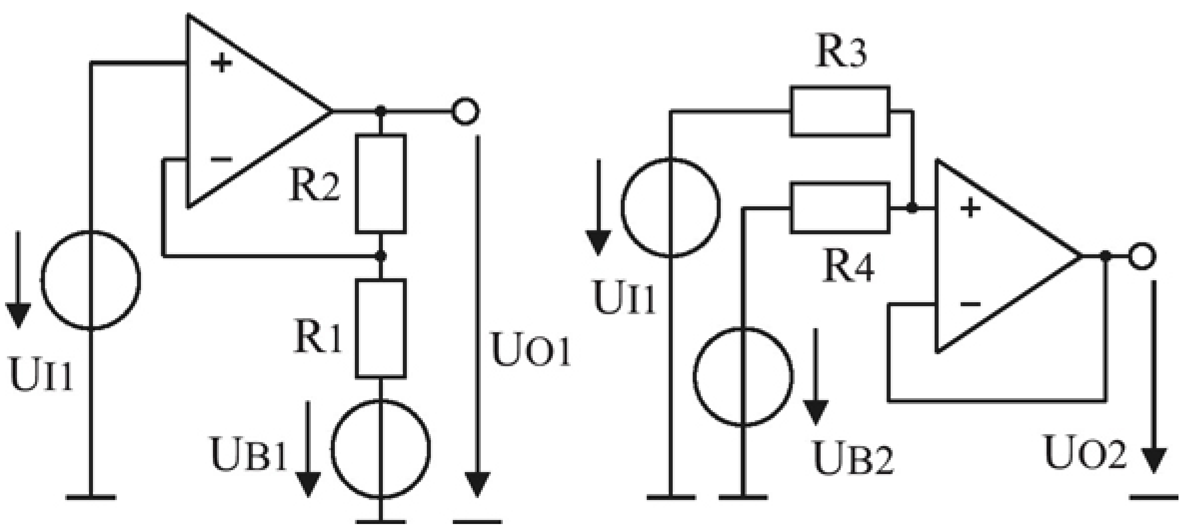
a.) Calculate $I_E = f(U_Y)$. There is $U_{BE1,2} = 0.6V$ and $U_X = 0V$, $U_Y < 0$, $|U_Y| >> U_{BE}1,2$.
b.) Calculate (I_C1-I_C2) and $U_O = f(I_C1-I_C2)$.
c.) Calculate $U_O = f(U_X,U_Y)$.

1.16 OpAmp with FET



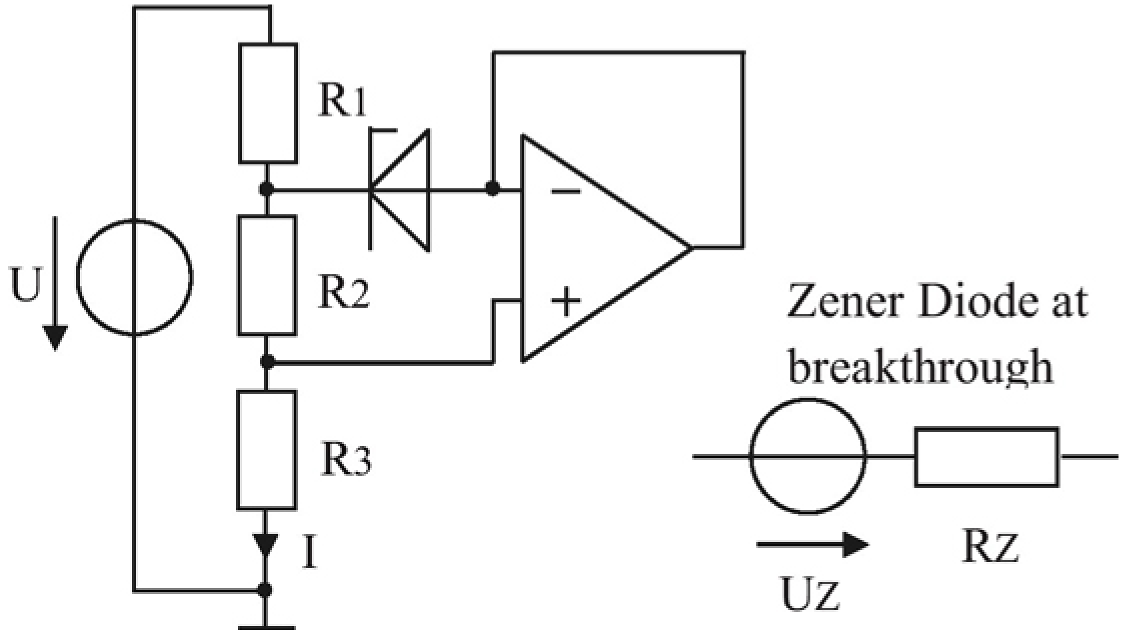
a.) Calculate I_D and U_{DS}.
b.) What function does the circuit for R_{Load}? Draw a circuit with the same function for R_{Load}, but with one connection of R_{Load} on Ground.

1.17 Two possibilities for changing potential



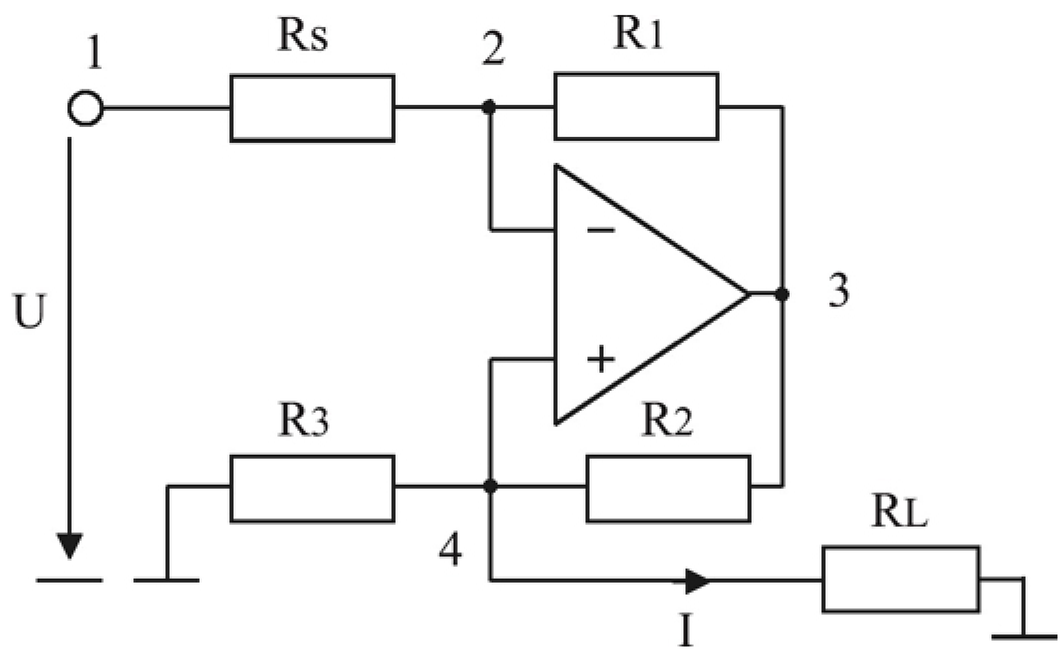
a.) Calculate $U_{O1} = f(U_I1, U_B1, R_1, R_2)$
b.) Calculate $U_{O2} = f(U_I2, U_B2, R_3, R_4)$

1.18 Current source using OpAmp and Zener Diode



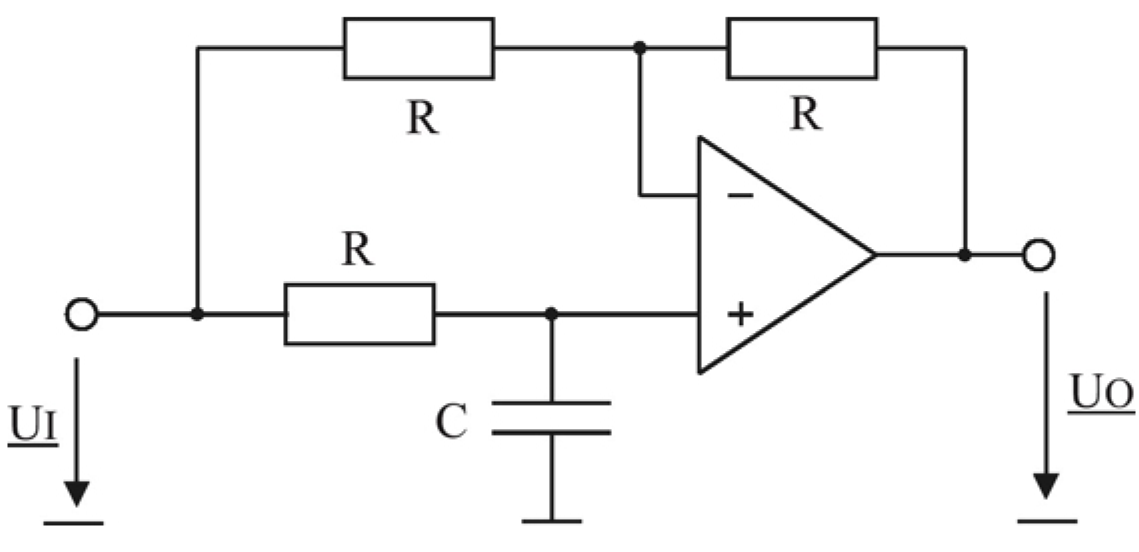
a.) Calculate $I = f(U, U_Z, R_1, R_2, R_3, R_Z)$
b.) Under what condition, I is independent of R_3?

1.19 Current source (negative feedback is assumed)



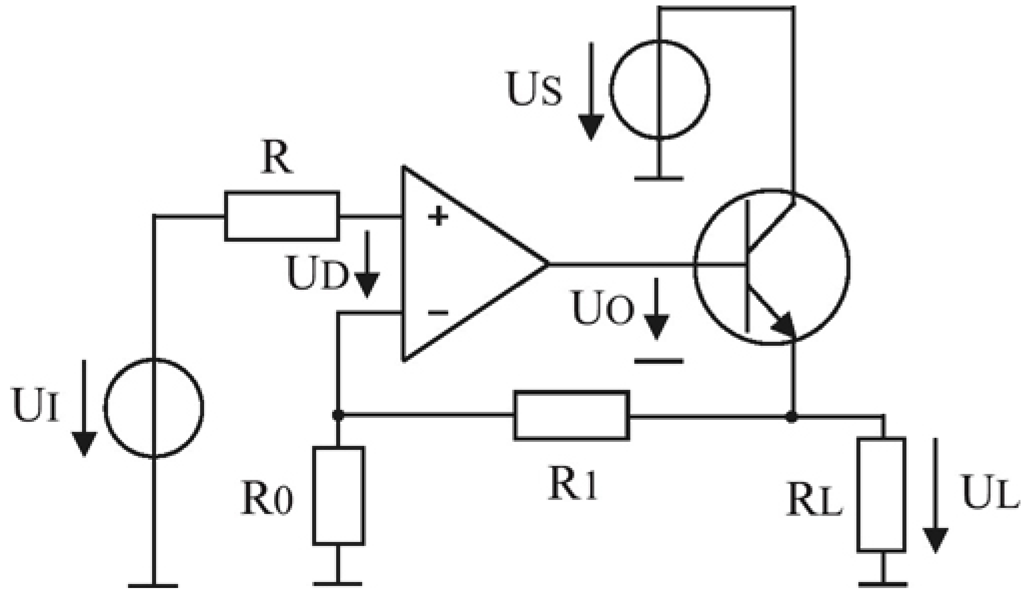
a.) Calculate I.
b.) It is $R_1 \cdot R_3 = R_S \cdot R_2$. Calculate I for this special case.

1.20 Phase shifting circuit



a.) Calculate the transfer function $\underline{U}_O/\underline{U}_I$.
b.) Bring the transfer function into the form $\lambda \cdot e^{i\varphi}$.
c.) Explain the function of the circuit.

1.21 Voltage regulator



a.) UO = A·UD, A → ∞. Determine the voltage UL as a function of the given circuit parameters.
b.) Determine the voltage UL with the assumption A ≠ ∞.

1.22 Circuit with three OpAmps