

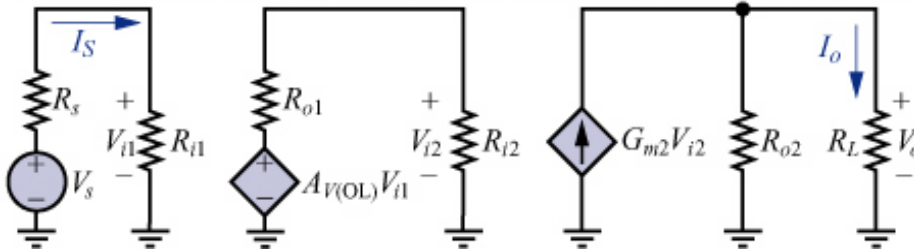
Op-amps with resistive components

Q1. [Problem 8.1]

The following circuit has a signal source, two stages of amplification, and a load R_L . Determine the power gain G of the $\text{P}_O/\text{P}_S = V_O I_O / V_S I_S$.

$R_S = R_L = 0.6 \text{ k}\Omega$, $R_{i1} = R_{i2} = 3 \text{ k}\Omega$, $R_{o1} = R_{o2} = 2 \text{ k}\Omega$, $A_{V(OL)} = 100$, $G_{m2} = 350 \text{ mS}$

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Q2. [Problem 8.2]

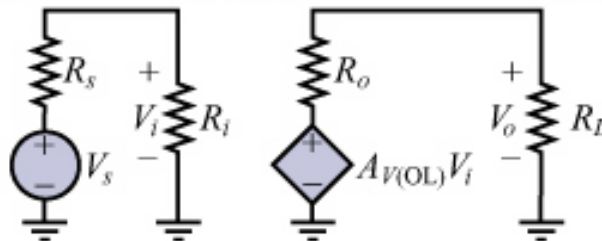
A temperature sensor in a production line under normal operating conditions produces a no-load voltage: $v_s = V_{SO} \cos(\omega t)$, $R_S = 400 \Omega$, $V_{SO} = 500 \text{ mV}$, $\omega = 6.28 \text{ krad/s}$

The temperature is monitored on a display, requiring a voltage supplied to the display input terminals where $R_L = 12 \text{ k}\Omega$, $v_o = V_O \cos(\omega t)$, $V_O = 6 \text{ V}$

The sensor must be amplified. The following voltage amplifier is connected between the sensor and the display with $R_i = 2 \text{ k}\Omega$ and $R_o = 3 \text{ k}\Omega$.

Determine the no-load gain of the amplifier.

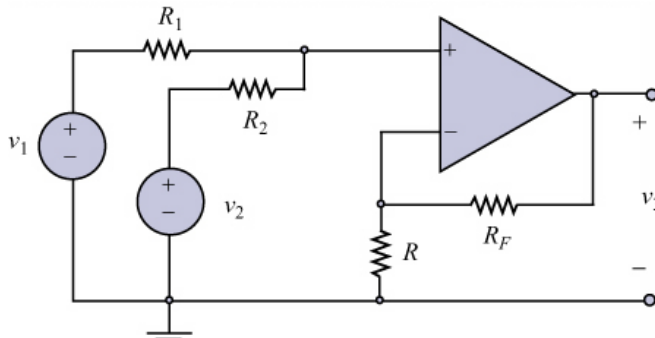
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Q3. [Problem 8.19]

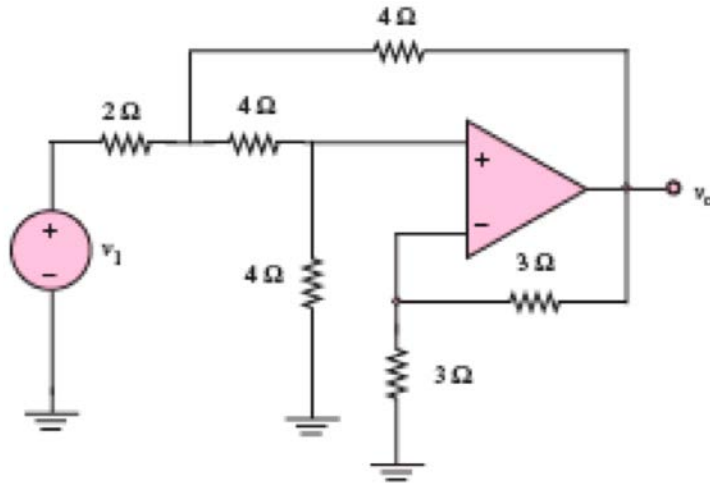
Show that the circuit of Figure P8.19 is a non-inverting summer where:

$$V_3 = \left(1 + \frac{R_f}{R}\right) \left(\frac{R_1}{R_1 + R_2} V_2 + \frac{R_2}{R_1 + R_2} V_1\right)$$



Q4. [Problem 8.9]

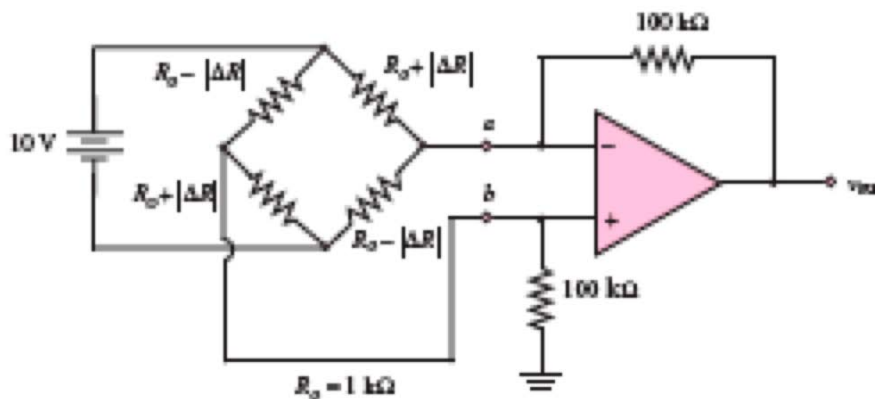
Determine the expression for the overall gain $A = v_o/v_i$ for the circuit. Find the input conductance $G_{in} = i_i/v_i$ seen by the voltage source v_i . Assume the op amp is ideal.

**Figure P8.9****Q5. [Problem 8.21]**

Differential amplifiers are often used in conjunction with the Wheatstone bridge. Each resistor in the bridge shown is a temperature-sensing element whose resistance changes directly proportional to a change in the temperature.

- Find the Thevenin equivalent seen by the amplifier inputs at a and b. $R_o = 1\text{k}\Omega$. Hint: Short circuit the supply to find the equivalent resistance. Assume that $|\Delta R|^2 \ll R_o$, and $R_o = 1\text{k}\Omega$.
- If $|\Delta R| = K\Delta T$ (where K is a constant), find an expression for v_{out} as a function of temperature change (ie $v_{out}(\Delta T)$).

Hint: Your answer in part (a) should now enable you to re-draw the circuit as a differential amplifier.

**Figure P8.21****Q6. [Problem 8.34]**

In the circuit shown in Figure P8.34, if $v_{S1} = v_{S2} = 7\text{mV}$, $R_F = 2.2\text{k}\Omega$, $R_1 = 850\Omega$, $R_2 = 1.5\text{k}\Omega$ and the MC1741C op-amp has the following parameters: $r_1 = 2\text{M}\Omega$, $\mu = 200,000$, $r_o = 25\Omega$. Determine,

- An expression for the output voltage and value
- The voltage gain for each of the two input signals

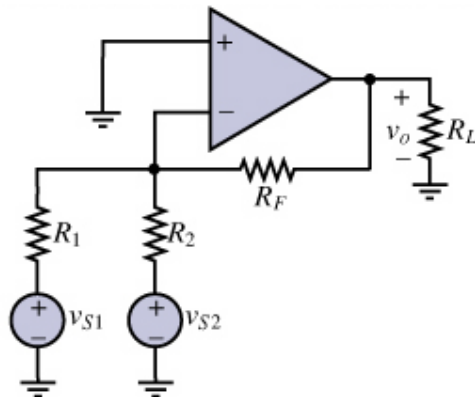


Figure P8.34

Q7. [Problem 8.36]

In a differential amplifier, if $A_{v1} = -20$ and $A_{v2} = +22$, derive expressions for the common-mode and differential-mode gains. Hence determine their respective values.

Q8. [Problem 8.44]

Show that the expression for the output voltage in the circuit of Figure P8.44 is given by:

$$v_o = -\frac{R_{F2}}{R_{S2}} \left(1 + \frac{R_{F1}}{R_{S1}} \right) v_s$$

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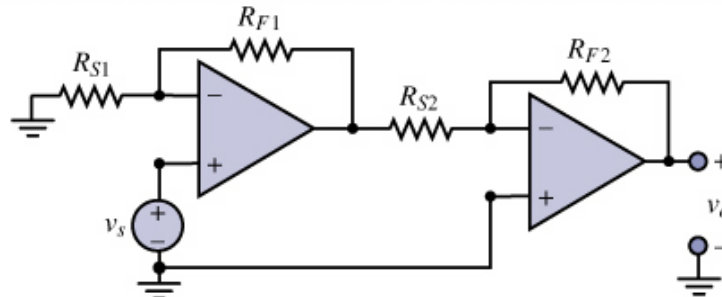


Figure P8.44

Q9. [Problem 8.41]

Figure P8.41 shows a voltage-to-current converter. Show that the current through the LED (thus also its brightness), is proportional to the source voltage V_s as long as $V_s > 0$.

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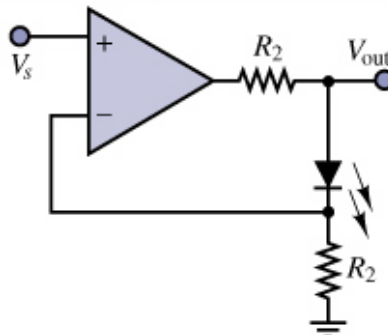


Figure P8.41

Numerical solutions**Q1 [Problem 8.1]**

Power gain = 3.915×10^8

In dB: $10 \cdot \log_{10}(\text{Power Gain}) = 85.9 \text{ dB}$

Q2 [Problem 8.2]

No-load gain = 18

Q4 [Problem 8.9]

Current to voltage gain = 0.125 S

Q5 [Problem 8.27]

Voltage gain = 101

Q6 [Problem 8.34]

a. Output voltage = -28.38mV

b. Voltage gain for V_{S1} , $A_{V1} = -2.488$; Voltage gain for V_{S2} , $A_{V2} = -1.467$

Q7 [Problem 8.36]

Common mode gain, $A_{cm} = 1$

Differential mode gain, $A_{dm} = 42$

Q9 [Problem 8.41]

$I_{out} = V_S/R_2$