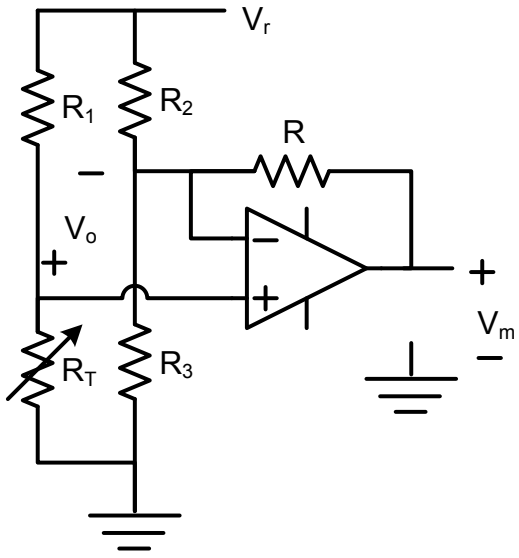
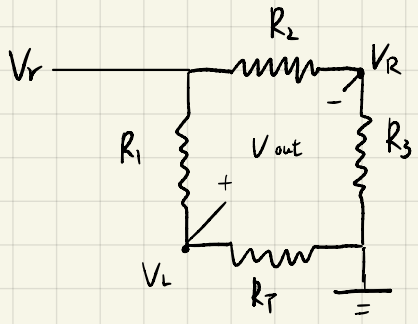
Whteatstone Bridge + OP
Due 6/12

Use the following circuit to measure temperature in the range from 0 °C to 100 °C, with a corresponding output (V_m) from 0V to 10V. The sensor (R_T) has the T.C.R. 0.075 Ω/K, a resistance of 2000 Ω at 25 °C, and a maximum acceptable current of 1 mA. The OP is assumed to be ideal.

1. Without the OP and R, derive the equation for the output voltage V_o as function of V_r, R_1, R_2, R_3, R_T.
2. With the OP and R, derive the equation for the output voltage V_m as function of the other components.
3. Determine the value of each component (V_r, R_1, R_2, R_3, R) to satisfy the measurement requirements stated above.
4. Use Matlab to plot the output voltage (V_m, y-axis) as function of temperature measurand (x-axis).



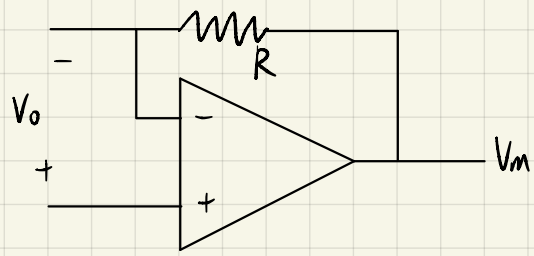
1.



$$V_L = V_r \cdot \frac{R_T}{R_1+R_T} \qquad V_R = V_r \cdot \frac{R_3}{R_2+R_3}$$

$$V_o = V_L - V_R = V_r\left(\frac{R_T}{R_1+R_T} - \frac{R_3}{R_2+R_3}\right) = V_r\left(\frac{R_T(R_2+R_3) - R_3(R_1+R_T)}{(R_1+R_T)(R_2+R_3)}\right)$$

2.



$$V_m = V_o = V_r\left(\frac{R_2R_T - R_1R_3}{(R_1+R_T)(R_2+R_3)}\right)$$

Voltage follower

3. $R_T = 2000 \qquad R_{Tf} = R_0(1+\alpha\Delta T) = 2000(1+0.075\cdot 75) = 13250\,\Omega \rightarrow \Delta R_T = 11250\,\Omega$

$I_{max} = 0.001\ A \rightarrow V_{max} = 13.25$, $V_{L\,max} = 13.25\ V \rightarrow V_R = 3.25\ V$

$gain = 0.5 \rightarrow V_r = 20V \qquad 3.25 = 20 \cdot \frac{R_3}{R_2+R_3}$, $R_3 = 13k\Omega \quad R_2 = 67k\Omega$

$13.25 = 20 \cdot \frac{13250}{R_1+13250} \qquad R_1 = 6750 \qquad R = 10k\Omega$