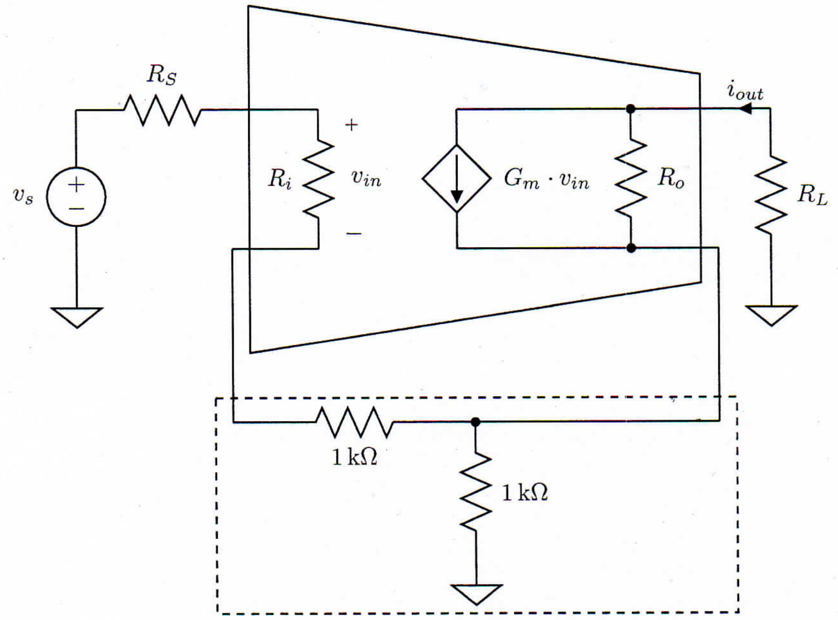
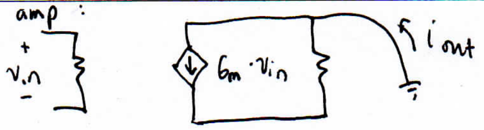
Part I:

(*20 points*) A feedback amplifier employing **series-series** feedback is shown in the figure below, where the feedback network is contained within the dashed box. For the open loop amplifier, $R_i = 7\,\text{k}\Omega$, $G_m = 100\,\text{mS}$, and $R_o = 3\,\text{k}\Omega$. The other component values are $R_S = 7\,\text{k}\Omega$ and $R_L = 6\,\text{k}\Omega$.



1. What is the unloaded open loop amplifier small signal gain, i_{out}/v_{in}? (*1 point*)

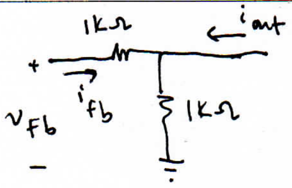
open-loop amp :



$i_{out}/v_{in} =$ 100 mS

$$\frac{i_{out}}{V_{in}} = G_m = 100\,\text{mS}$$

2. Draw the Thevenin two-port network representation of the feedback network. Label all components with their calculated values. (*7 points*)



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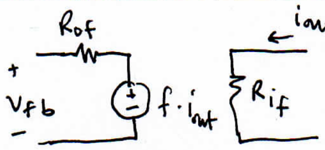
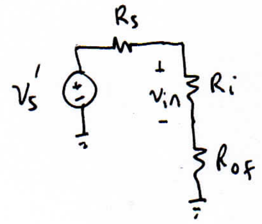


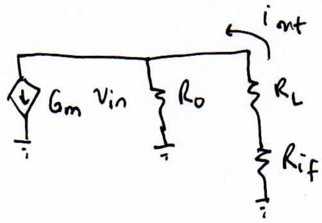
$R_{if} = 1\,\text{k}\Omega$

$R_{of} = 2\,\text{k}\Omega$

$$f = \left.\frac{V_{FL}}{i_{out}}\right|_{i_{FL}=0} = 1\,\text{k}\Omega$$

3. Calculate the open-loop gain of the amplifier, i_{out}/v_s', with the loading of the feedback network, source resistance, and load resistance. (*4 points*)





$$i_{out} = \frac{R_o}{R_o + R_L + R_{if}} \cdot G_m \cdot v_{in}$$

$$= \frac{3K}{3K + 6k + 1k} \cdot 100mS \cdot v_{in}$$

$$= 0.03 v_{in}$$

$$v_{in} = \frac{R_i}{R_s + R_i + R_{of}} \cdot v_s' = \frac{7K}{7k + 7k + 2k} \cdot v_s'$$

$$v_{in} = 0.4375 \cdot v_s'$$

$$i_{out} = 0.03(0.4375)\, v_s'$$

$$\frac{i_{out}}{v_s'} = 0.013125 \text{ A/V}$$

$i_{out}/v_s' =$ 13.125 mS

4. Calculate the closed-loop gain of the amplifier, $A_{CL} = i_{out}/v_s$, using feedback analysis. (*2 points*)

$$T = \frac{i_{out}}{v_s'} \cdot f = (0.013125)(1000) = 13.125$$

$$A_{CL} = \frac{\frac{i_{out}}{v_s'}}{1+T} = \frac{0.013125}{1 + 13.125} = 929 \mu S$$

$A_{CL} =$ 929 μS

5. Calculate the closed-loop input resistance of the amplifier, $R_{i,CL}$, using feedback analysis. (*2 points*)

$$R_{i,\text{open loop}} = R_s + R_i + R_{of} = 16\ k\Omega$$

$$R_{i,CL} = R_{i,\text{open loop}}(1+T) = 226\ k\Omega$$

$R_{i,CL} =$ 226 kΩ

6. Calculate the closed-loop output resistance of the amplifier, $R_{o,CL}$, using feedback analysis. (*2 points*)

$R_{o,\text{ open loop}} = R_o \parallel (R_L + R_{if}) = 3k \parallel (6k + 1k) = 2.1\ k\Omega$

$R_{o,CL} = R_{o,\text{ open loop}}(1+T) = 29.7\ k\Omega$

$R_{o,CL} =$ $29.7\ k\Omega$

7. If G_m increases by 5%, by approximately how much (as a percentage) does the closed-loop gain change? (*2 points*)

if G_m increases by 5%, $\frac{dA}{A} = 0.05$ where A is open-loop amplifier gain.

hence, $\frac{dA_{CL}}{A_{CL}} \approx \frac{\frac{dA}{A}}{1+T} = \frac{0.05}{1+T} = 0.00354$

$\frac{dA_{CL}}{A_{CL}} =$ $0.354\ \%$