Transconductance Amplifier

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For a feedback transconductance amplifier in Fig 0, derive an approximate expression for the closed loop transconductance T for the case of GH $\gg$1. Hence select a value of R_2 to obtain T=100 mA/V. If Q is biased to obtain g_m = 1mA/V, specify the value of the gian μ of the differential amplifier to obtain an amount of feedback of 60 dB. If Q has r_o = 50 kΩ find the R_{out}.

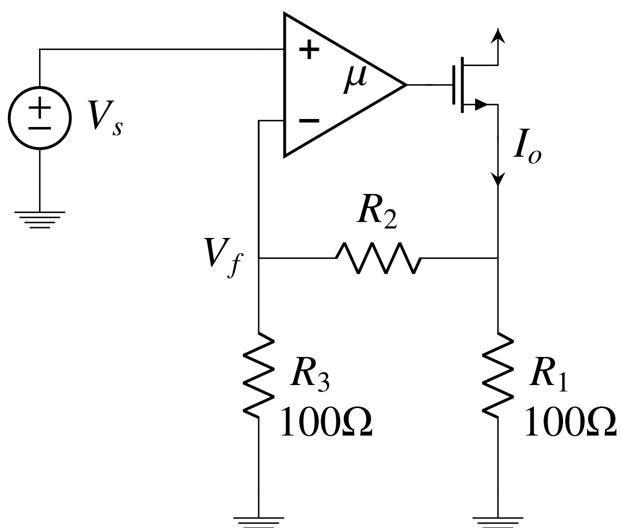

Fig. 0: Complete Circuit

1. Draw the small signal model for Fig. 0
Solution: See Fig. 1.1
2. Draw the block diagram and the transconductance freedback model.
Solution: See Figs. 2.1 and 2.1
3. Draw the feedback circuit for H and compute it.

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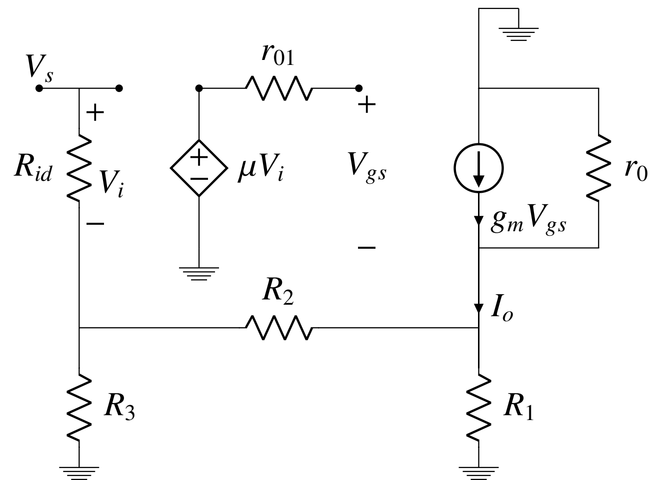

Fig. 1.1: Small signal model

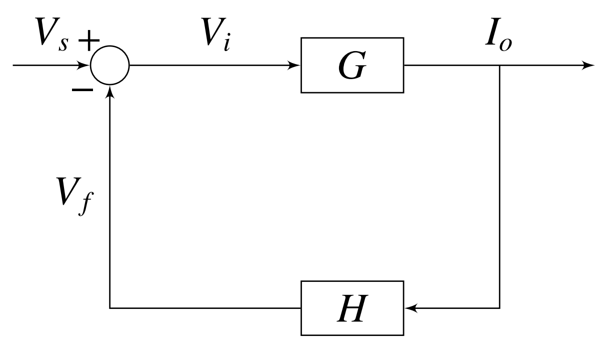

Fig. 2.1: Block Diagram

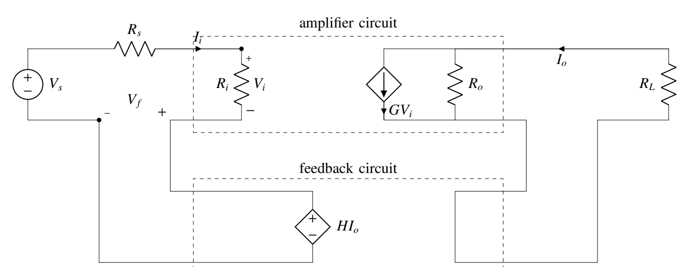

Fig. 2.2: Transconductance amplifier

Solution: From Fig. 3.1, using current division,

$$V_f = I_o \times \frac{R_1}{R_1 + R_2 + R_3} \times R_3 \tag{3.1}$$

$$\implies H = \frac{V_f}{I_o} \tag{3.2}$$

$$= \frac{R_1 R_3}{R_1 + R_2 + R_3} \tag{3.3}$$

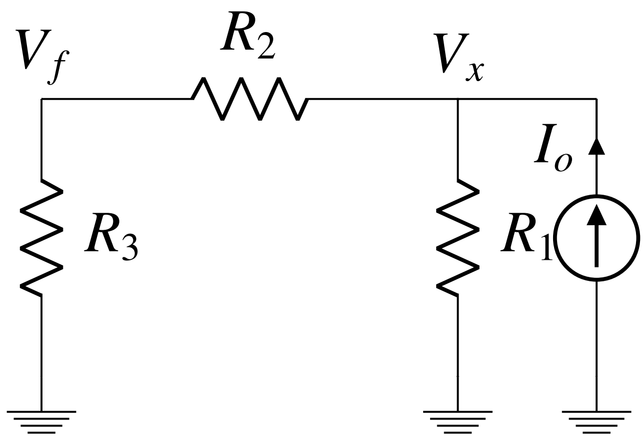

Fig. 3.1: Feedback Circuit

4. For $GH \gg 1, T = 100$ mA/V, find H and R_2.
   Solution:

$$T \approx \frac{1}{H} \tag{4.1}$$
$$= \frac{R_1 + R_2 + R_3}{R_1 R_3} \tag{4.2}$$
$$\implies R_2 = 800\Omega \quad \text{and} \tag{4.3}$$
$$H = 10 \tag{4.4}$$

5. Find R_{11} and R_{22} in Fig. 5.1

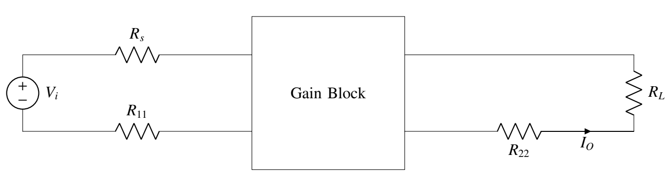

Fig. 5.1: Block Diagram of G

Solution: From Fig. 3.1,

$$R_{11} = (R_2 + R_1) \parallel R_3 \tag{5.1}$$

$$R_{22} = (R_2 + R_3) \parallel R_1 \tag{5.2}$$

6. Draw the equivalent circuit for G and find it.
   Solution:

$$G = \frac{I_o}{V_i} \tag{6.1}$$

From Fig. 5.1 we can see that

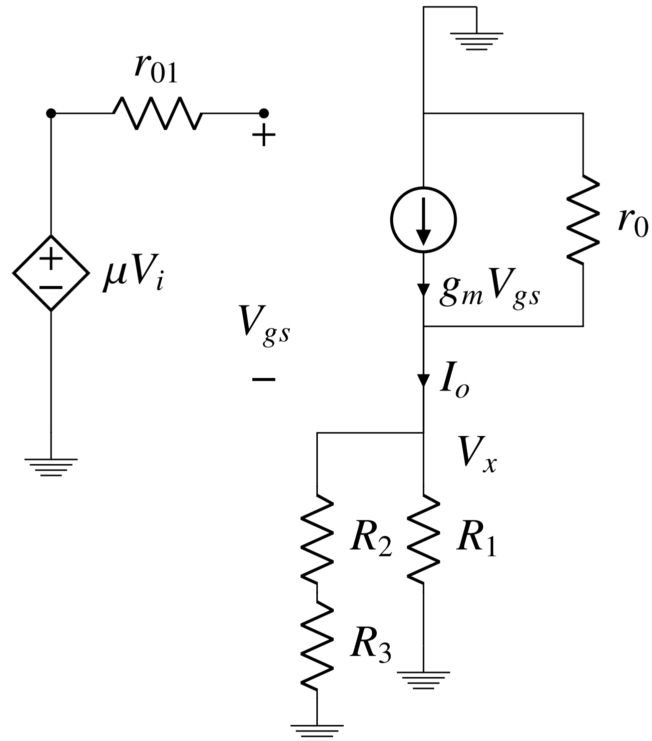

Fig. 6.1: Gain equivalent circuit

$$V_{gs} = \mu V_i - V_x \tag{6.2}$$

$$g_m V_{gs} - \frac{V_x}{r_o} = I_o \tag{6.3}$$

From equations 6.2 to 6.3

$$G = \frac{I_o}{V_i} = \frac{g_m \mu r_o}{r_o + (1 + g_m r_o)((R_2 + R_3) \parallel R_1)} \tag{6.4}$$

7. If GH = 60dB, find μ.
   Solution:

$$20 \log_{10} GH = 60 \tag{7.1}$$
$$\implies G = 100 \tag{7.2}$$

Substituting the values in the Eq. 6.4

$$\mu = 109180 \tag{7.3}$$

The following code generates the values

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codes/ee18btech11041.py
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8. Verify your results using spice.
   Solution: The following code generates results from spice solution

codes/spice/ee18btech11041_spice.py

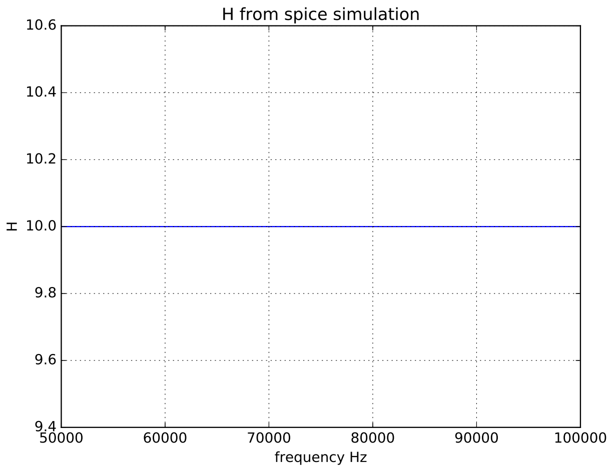

Fig. 8.1

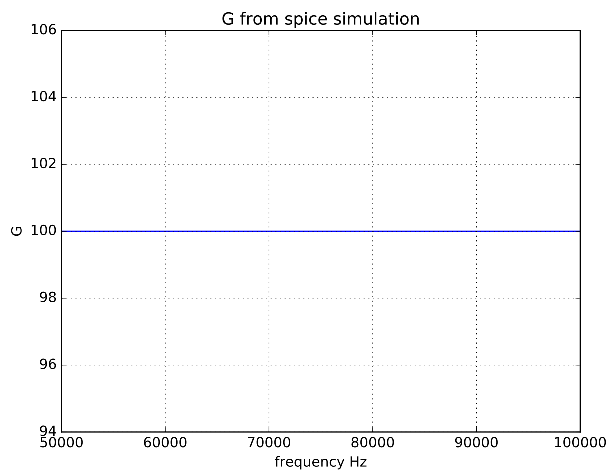

Fig. 8.2

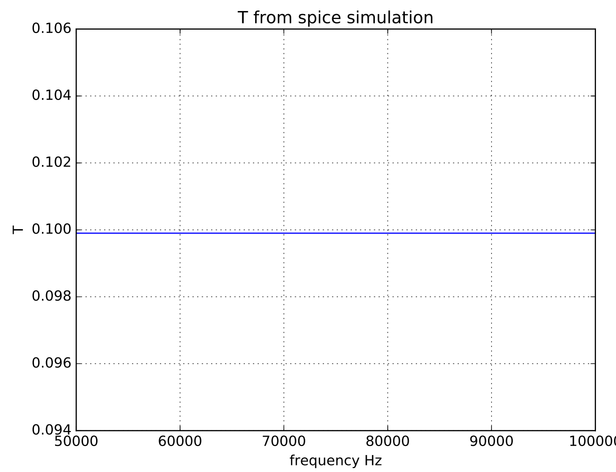

Fig. 8.3