

Transconductance Amplifier

Shreshta Thumati*

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 $T=100 \text{ mA/V}$. If Q is biased to obtain $g_m = 1 \text{ mA/V}$, specify the value of the gain μ of the differential amplifier to obtain an amount of feedback of 60 dB. If Q has $r_o = 50 \text{ k}\Omega$ find the R_{out} .

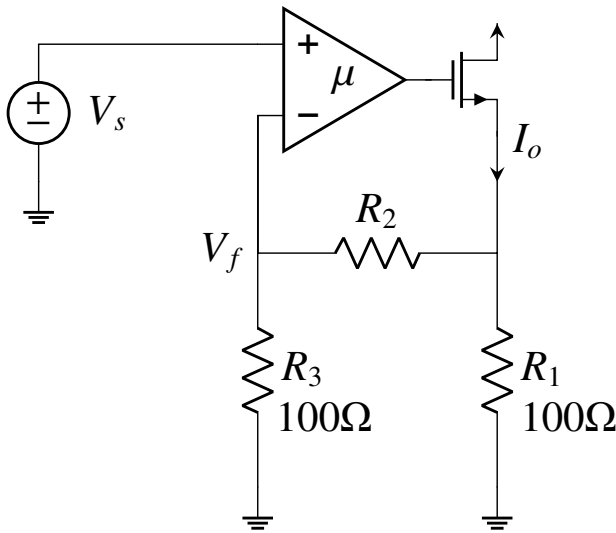


Fig. 0: Complete Circuit

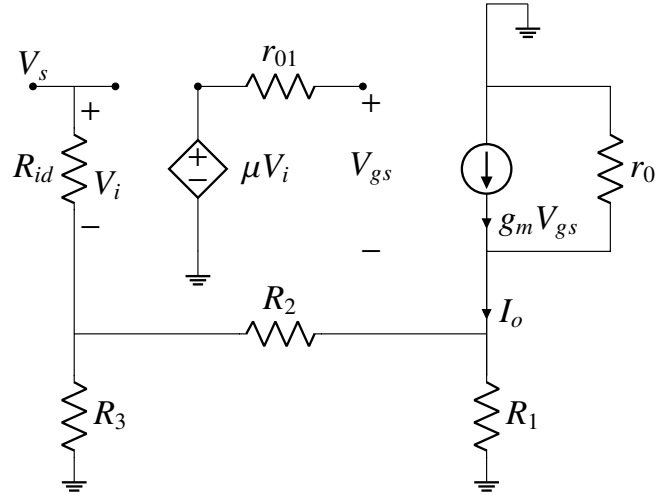


Fig. 1.1: Small signal model

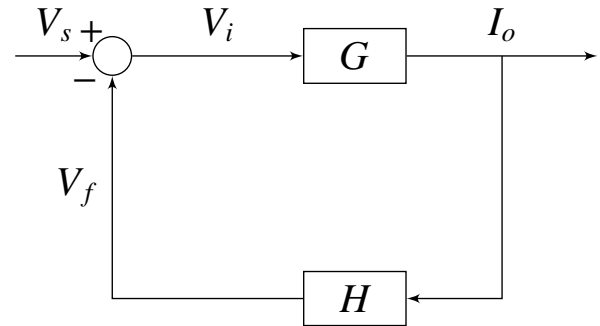


Fig. 2.1: Block Diagram

1. Draw the small signal model for Fig. 0

Solution: See Fig. 1.1

2. Draw the block diagram and the transconductance feedback model.

Solution: See Figs. 2.1 and 2.2

3. Draw the feedback circuit for H and compute it.

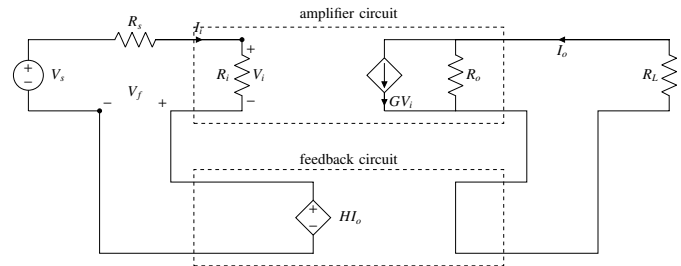


Fig. 2.2: Transconductance amplifier

Solution: From Fig. 3.1, using current division,

$$V_f = I_o \times \frac{R_1}{R_1 + R_2 + R_3} \times R_3 \quad (3.1)$$

$$\Rightarrow H = \frac{V_f}{I_o} \quad (3.2)$$

$$= \frac{R_1 R_3}{R_1 + R_2 + R_3} \quad (3.3)$$

*The author is with the Department of Electrical Engineering, Indian Institute of Technology, Hyderabad 502285 India. All content in this manual is released under GNU GPL. Free and open source.

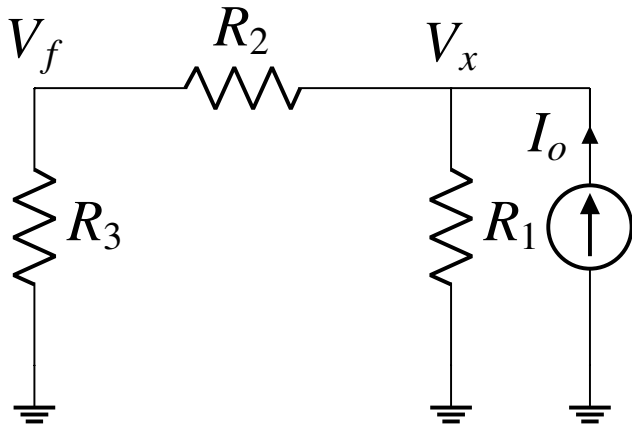


Fig. 3.1: Feedback Circuit

4. For $GH \gg 1$, $T = 100 \text{ mA/V}$, find H and R_2 .

Solution:

$$T \approx \frac{1}{H} \quad (4.1)$$

$$= \frac{R_1 + R_2 + R_3}{R_1 R_3} \quad (4.2)$$

$$\Rightarrow R_2 = 800\Omega \quad \text{and} \quad (4.3)$$

$$H = 10 \quad (4.4)$$

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

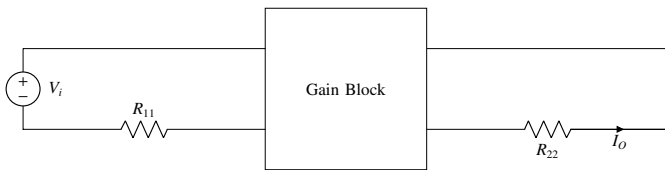


Fig. 5.1: Block Diagram of G

Solution: From Fig. 3.1,

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

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

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

Solution:

$$G = \frac{I_o}{V_i} \quad (6.1)$$

From Fig. 6.1 we can see that

$$V_{gs} = \mu V_i - V_x \quad (6.2)$$

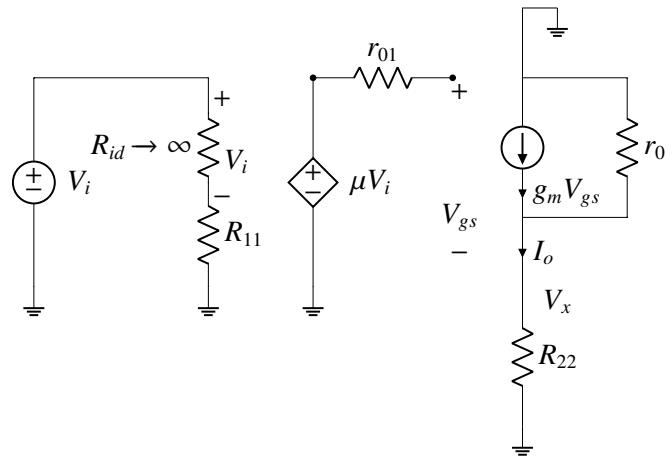


Fig. 6.1: Gain equivalent circuit

$$g_m V_{gs} - \frac{V_x}{r_o} = I_o \quad (6.3)$$

From equations 6.2 to 6.3

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

7. If $GH = 60\text{dB}$, find μ .

Solution:

$$20 \log_{10} GH = 60 \quad (7.1)$$

$$\Rightarrow G = 100 \quad (7.2)$$

Substituting the values in the Eq. 6.4

$$\mu = 109180 \quad (7.3)$$

The following code generates the values

```
codes/ee18btech11041.py
```

8. Verify your results using spice.

Solution: The following read.me file provides necessary instructions to simulate the circuit in spice

```
codes/spice/README.md
```

The following code generates results from spice solution

```
codes/spice/ee18btech11041_spice.py
```

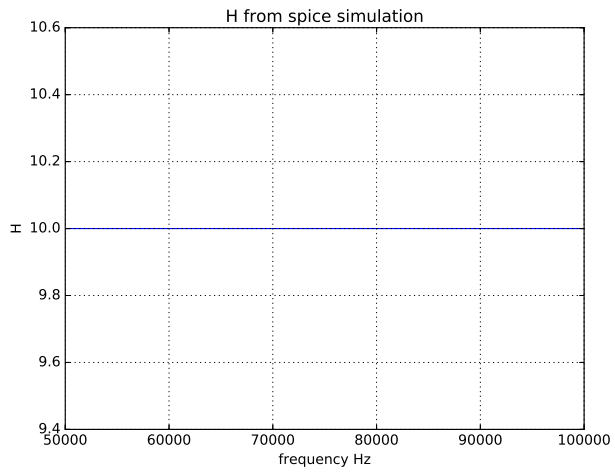


Fig. 8.1

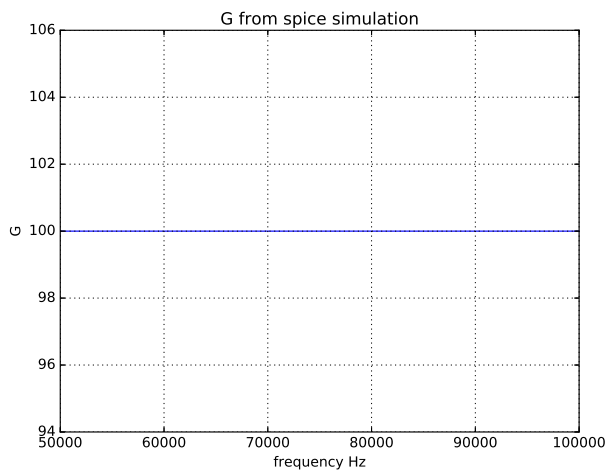


Fig. 8.2

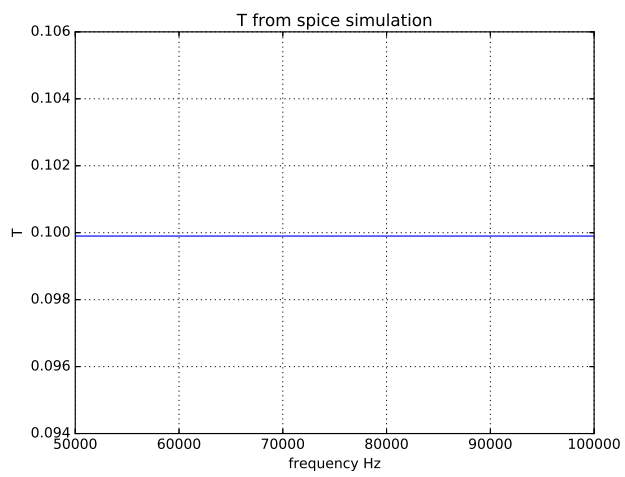


Fig. 8.3