Feedback Transconductance Amplifier

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Figure 0 shows a feedback transconductance amplifier implemented using an op amp with open-loop gain μ, a very large input resistance, and an output resistance r_o. The output current I_o that is delivered to the load resistance R_L is sensed by the feedback network composed of the three resistances R_M, R_1, and R_2, and a proportional voltageV_f is fed back to the negative-input terminal of the op amp. Find G,H and T. If the loop gain is large, find an approximate expression for T and state precisely the condition for which this applies. The parameters given are shown

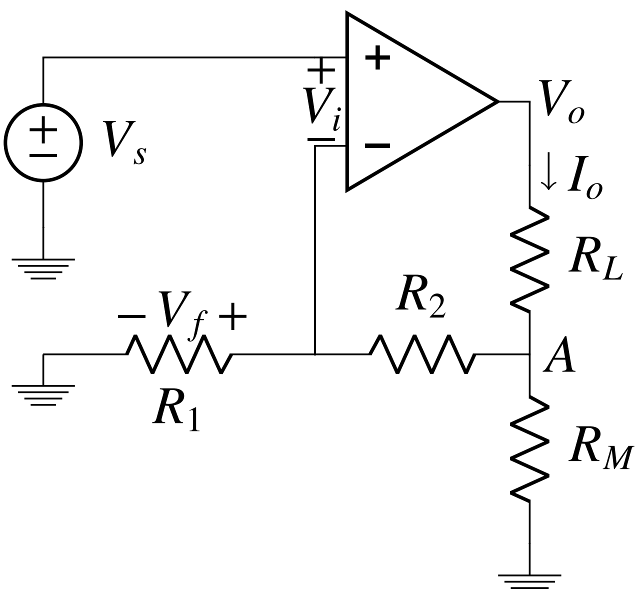

Fig. 0

in the TABLE.0

1. Draw the block diagram and the equivalent circuit for Fig. 0
   Solution: The equivalent circuit of the amplifier is in Fig. 1
2. Draw the block diagram and equivalent ciruit for H.

   Solution: See Fig. 2.3 and 2.4.

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Parameter	Value
input resistance	∞
output resistance	r_o
Input voltage	V_s
Output Voltage	V_o

TABLE 0: 1

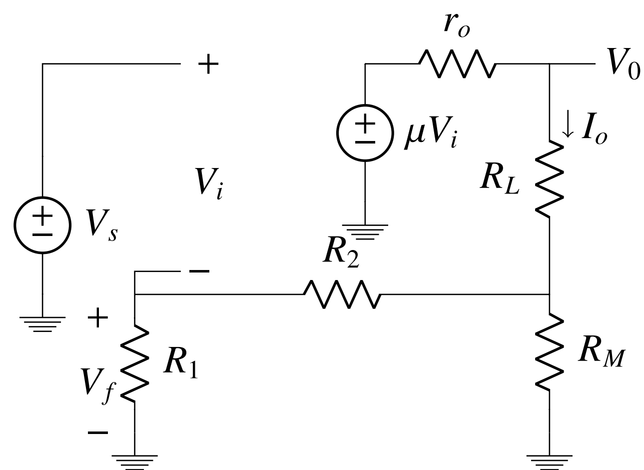

Fig. 1

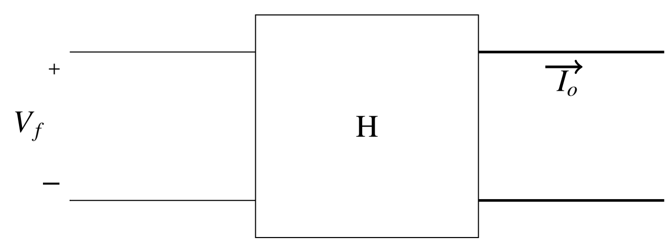

Fig. 2.3

3. Find H.
   Solution: From Fig. 2.3 and 2.4,

$$H = \frac{V_f}{I_o} \tag{3.1}$$

$$= \frac{R_1 R_M}{R_1 + R_2 + R_M} \tag{3.2}$$

4. Find G.

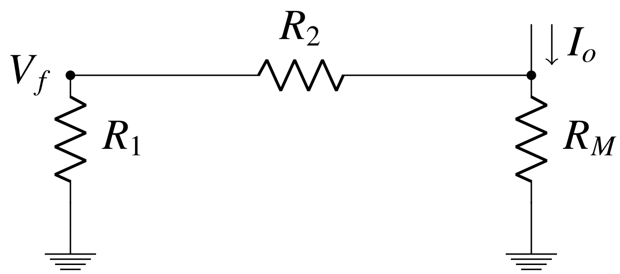

Fig. 2.4

Solution: From Fig. 1,

$$G = \frac{I_o}{V_i} \tag{4.1}$$
$$= \mu \tag{4.2}$$

5. Find T.

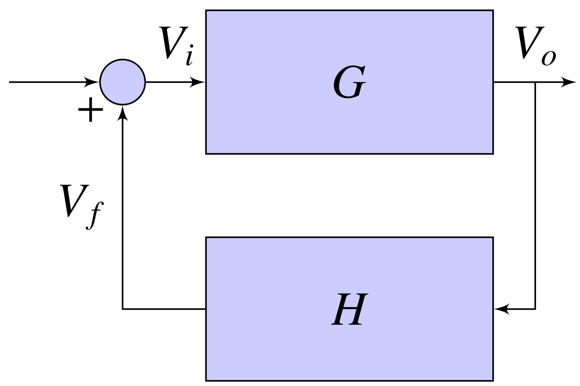

Fig. 5.5

Solution:

$$T = \frac{G}{1+GH} \tag{5.1}$$
$$= \frac{\mu\left(R_1 + R_2 + R_M\right)}{R_1 + R_2 + R_M + \mu R_1 R_M} \tag{5.2}$$
$$\approx \frac{1}{H} = \frac{R_1 + R_2 + R_M}{R_1 R_M} \tag{5.3}$$

6. Summarize your results in a table.
Solution: See Table 6
7. Find I_o for the parameters given in Table 7.
Solution: The following code computes the value of I_o using the fact that

$$I_o = \frac{V_s}{H} \tag{7.1}$$
$$\tag{7.2}$$

Parame-ters	Definition	For given circuit
Open loop gain	G	μ
Feedback factor	H	$\frac{R_1 R_M}{R_1+R_2+R_M}$
Loop gain	GH	$\mu\frac{R_1 R_M}{R_1+R_2+R_M}$
Amount of feedback	1+GH	$1+\frac{\mu R_1 R_M}{R_1+R_2+R_M}$
Closed loop gain	T	$\frac{\mu(R_1+R_2+R_M)}{R_1+R_2+R_M+\mu R_1 R_M}$

TABLE 6

Parameter	Value
R_1	1000Ω
R_2	1000Ω
R_L	1000Ω
R_M	1000Ω
V_s	$1V$

TABLE 7

```
codes/ee18btech11048/ee18btech11048_fbc.
    py
```

On running this code value of I_o is printed on terminal. The value obtained is 0.003 A.

8. Verify your result through spice.
Solution: The following readme file provides necessary instructions to simulate the circuit in spice.

```
codes/ee18btech11048/spice/README
```

The following netlist simulates the given circuit.

```
codes/ee18btech11048/spice/feedback.net
```

On running the spice simulations the I_o value is printed on terminal. The value printed is 0.003003266 A.
We observe that the value obtained using SPICE simulation is very close to the value obtained from the python code.
So the approximation for T gives accurate results.