

# Feedback Transconductance Amplifier

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Figure 0 shows a feedback transconductance amplifier implemented using an op amp with open-loop gain  $\mu$ , 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 voltage  $V_f$  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

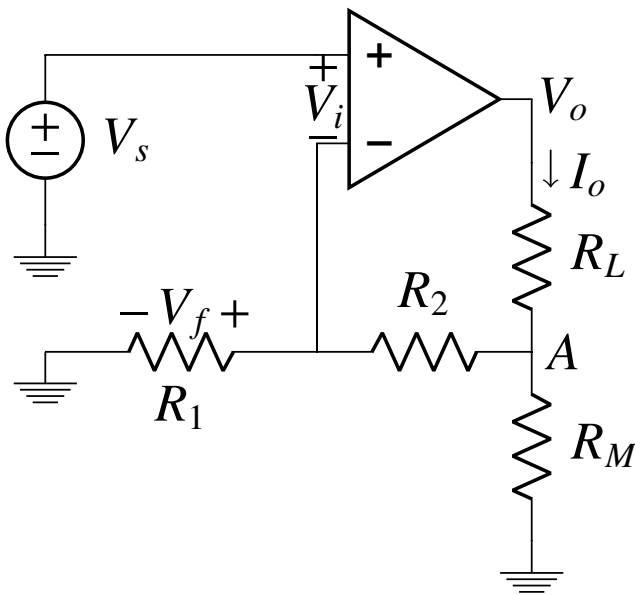


Fig. 0

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 circuit for H.

**Solution:** See Fig. 2.1 and 2.2.

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Parameter	Value
input resistance	$\infty$
output resistance	$r_o$
Input voltage	$V_s$
Output Voltage	$V_o$

TABLE 0: 1

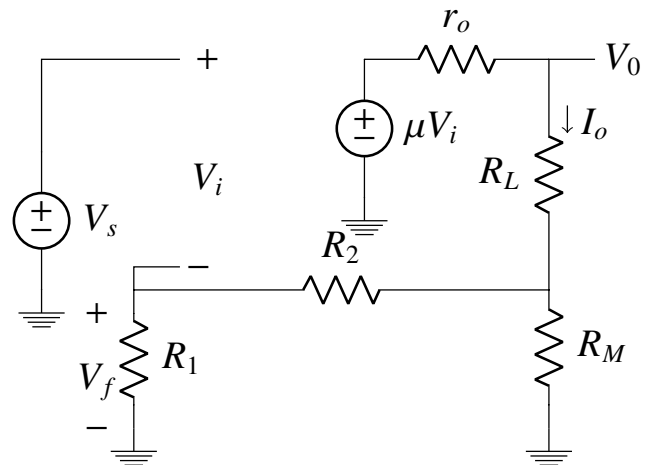


Fig. 1

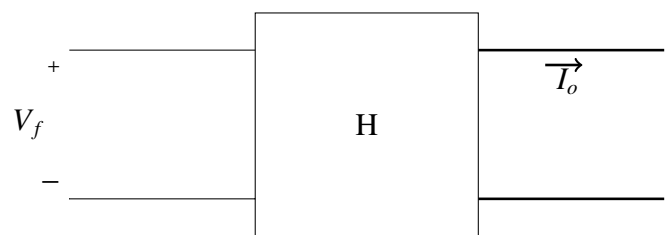


Fig. 2.1

3. Find H.

**Solution:** From Fig. 2.1 and 2.2,

$$H = \frac{V_f}{I_o} \quad (3.1)$$

$$= \frac{R_1 R_M}{R_1 + R_2 + R_M} \quad (3.2)$$

4. Find G.

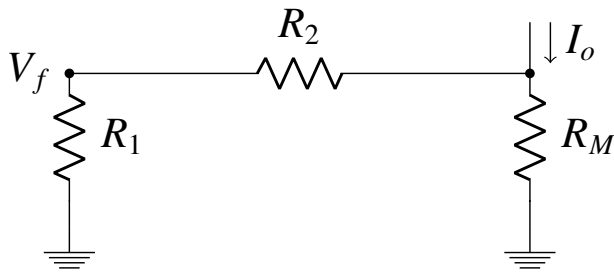


Fig. 2.2

**Solution:** From Fig. 1,

$$G = \frac{I_o}{V_i} \quad (4.1)$$

$$= \mu \quad (4.2)$$

5. Find  $T$ .

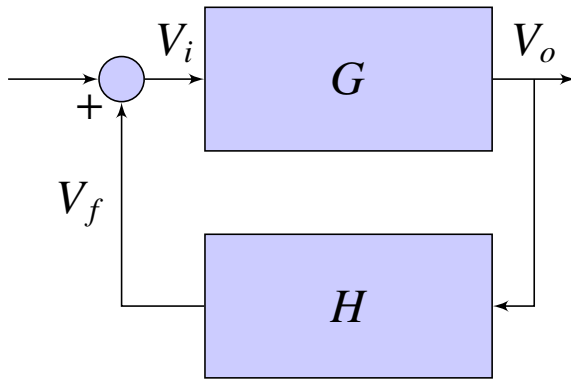


Fig. 5.1

**Solution:**

$$T = \frac{G}{1 + GH} \quad (5.1)$$

$$= \frac{\mu(R_1 + R_2 + R_M)}{R_1 + R_2 + R_M + \mu R_1 R_M} \quad (5.2)$$

$$\approx \frac{1}{H} = \frac{R_1 + R_2 + R_M}{R_1 R_M} \quad (5.3)$$

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

$$I_o = \frac{V_s}{H} \quad (7.1)$$

$$(7.2)$$

Parameters	Definition	For given circuit
Open loop gain	G	$\mu$
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
$R_1$	1000 $\Omega$
$R_2$	1000 $\Omega$
$R_L$	1000 $\Omega$
$R_M$	1000 $\Omega$
$V_s$	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.