Control Systems

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CONTENTS

***Abstract*—This manual is an introduction to control systems in feedback circuits. Links to sample Python codes are available in the text.**

Download python codes using

```
svn co https://github.com/gadepall/school/trunk/
    control/feedback/codes
```

1 Feedback Voltage Amplifier: Series-Shunt

2 Feedback Current Amplifier: Shunt-Series

2.1 Ideal Case

2.2 Practical Case

3 Feedback Current Amplifier: Example

3.1. Fig. 3.1.1 shows a feedback current amplifier. Draw the equivalent control system.
Solution: See fig 3.1.2

3.2. Refer table 3.2 for the parameters and draw the small signal equivalent model of the fig 3.1.1
Solution: See fig 3.2

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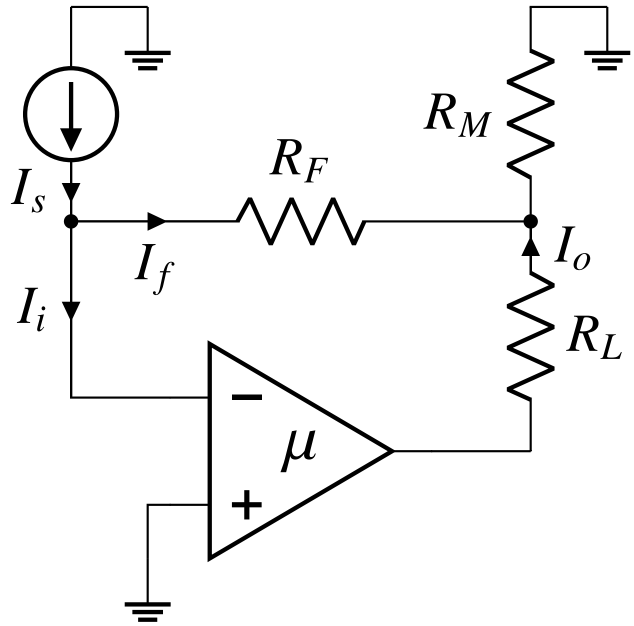

Fig. 3.1.1

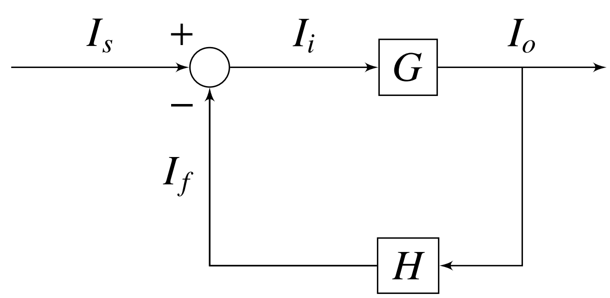

Fig. 3.1.2

Component	Description
R_{id}	Input Resistance of Op Amp
R_{out}	Output Resistance of Op Amp
I_s	Input Current
I_o	Output Current
R_M, R_F	Feedback Resistances
R_L	Load Resistance

TABLE 3.2

3.3. Given G (open-loop gain), H (feedback gain)

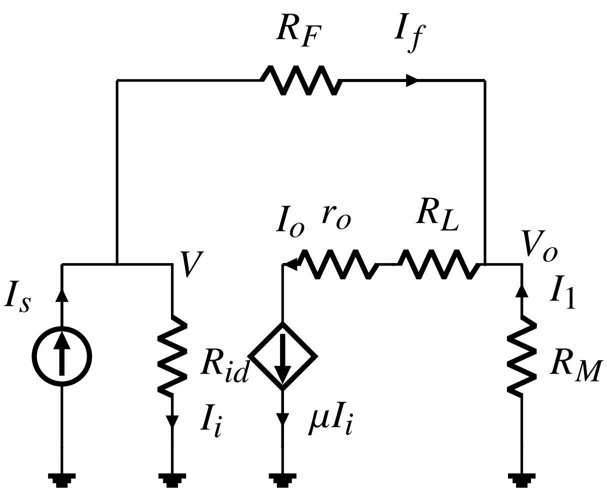

Fig. 3.2

and T (closed-loop gain) as

$$G = \frac{I_o}{I_i} \tag{3.3.1}$$

$$H = \frac{I_f}{I_o} \tag{3.3.2}$$

$$T = \frac{I_o}{I_f} \tag{3.3.3}$$

Find G and H as a function of the resistances.
Solution: Refer fig. 3.2,
We get,

$$I_o = \mu I_i \tag{3.3.4}$$

$$\implies G = \frac{I_o}{I_i} = \mu \tag{3.3.5}$$

And,

$$I_i = I_s - I_f \tag{3.3.6}$$

Using eq. 3.3.5, we get,

$$I_o = \mu\left(I_s - I_f\right) \tag{3.3.7}$$

Assuming virtual ground at V_1, we get,

$$V_o = -I_f R_F \tag{3.3.8}$$

Therefore,

$$I_1 = -\frac{V_o}{R_M} \tag{3.3.9}$$

$$\implies I_1 = I_f \frac{R_F}{R_M} \tag{3.3.10}$$

The output current is also expressed as,

$$I_o = I_f + I_1 \tag{3.3.11}$$

$$\implies \frac{I_o}{1 + \frac{R_F}{R_M}} = I_f \tag{3.3.12}$$

Now substituting I_f in eq. 3.3.7 we get,

$$I_o = \mu\left(I_s - \frac{I_o}{1 + \frac{R_F}{R_M}}\right) \tag{3.3.13}$$

(3.3.14)

$$\implies T = \frac{I_o}{I_s} = \frac{\mu}{1 + \frac{\mu}{1 + \frac{R_F}{R_M}}} \tag{3.3.15}$$

Therefore,

$$\implies H = \frac{I_f}{I_o} = \frac{1}{1 + \frac{R_F}{R_M}} \tag{3.3.16}$$

3.4. What will be closed-loop gain(T) if $\mu \to \infty$
Solution: From eq. 3.3.15 we get,

$$T = \frac{\mu}{1 + \frac{\mu}{1 + \frac{R_F}{R_M}}} \tag{3.4.1}$$

$$T = \frac{1}{\frac{1}{\mu} + \frac{1}{1 + \frac{R_F}{R_M}}} \tag{3.4.2}$$

Applying the limit, we get,

$$\implies T = 1 + \frac{R_F}{R_M} \tag{3.4.3}$$

3.5. Refer table 3.5 and find G, H and T

Component	**Value**
μ	10^4
R_{id}	$1\ M\Omega$
r_o	$100\ \Omega$
R_L	$10\ \text{k}\Omega$
R_M	$100\ \Omega$
R_F	$10\ \text{k}\Omega$

TABLE 3.5

Solution: Using eqs. 3.3.5, 3.3.16 and 3.3.15
We get,

$$G = \mu = 10^4 \tag{3.5.1}$$

$$H = \frac{1}{1 + \frac{R_F}{R_M}} = 9.9 \times 10^{-3} \tag{3.5.2}$$

$$T = \frac{\mu}{1 + \frac{\mu}{1 + \frac{R_F}{R_M}}} = 100 \tag{3.5.3}$$

3.6. Tabulate your results.
Solution: Refer table 3.6,

Gain	**Value**
G	10^4
H	9.9×10^{-3}
T	100

TABLE 3.6

4 Feedback Transconductance Amplifier: Series-Series