Feedback Topologies

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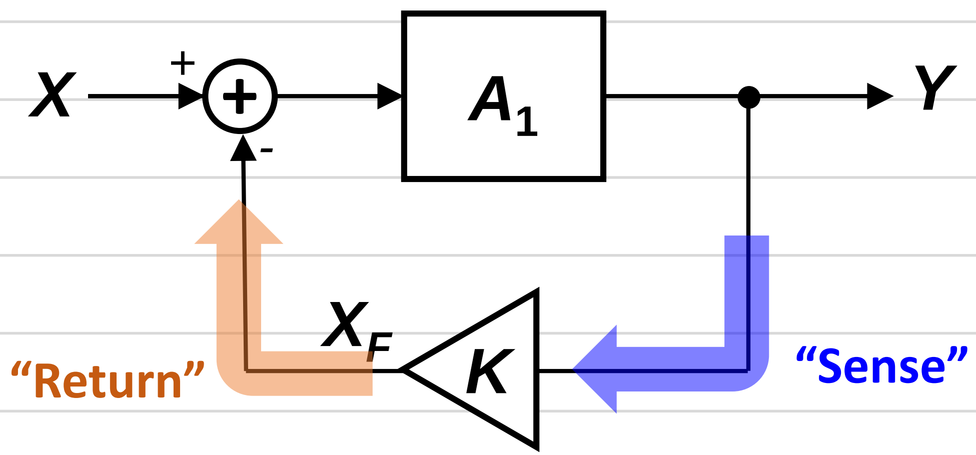
Possible Feedback Topologies

- Can you say one example of feedback type?

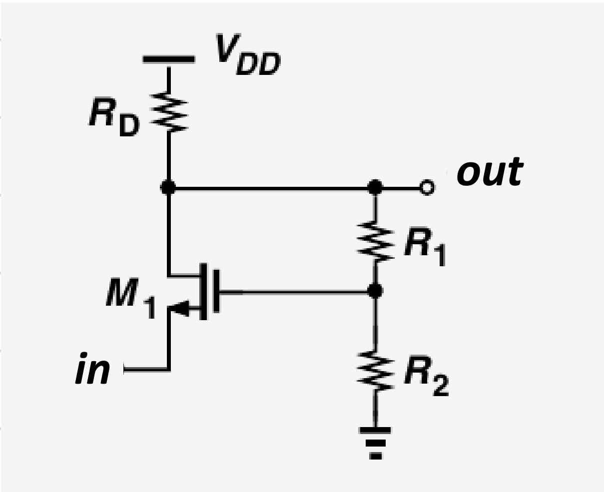
➔ For example, **current sense-voltage return** **: Current-Voltage Feedback**

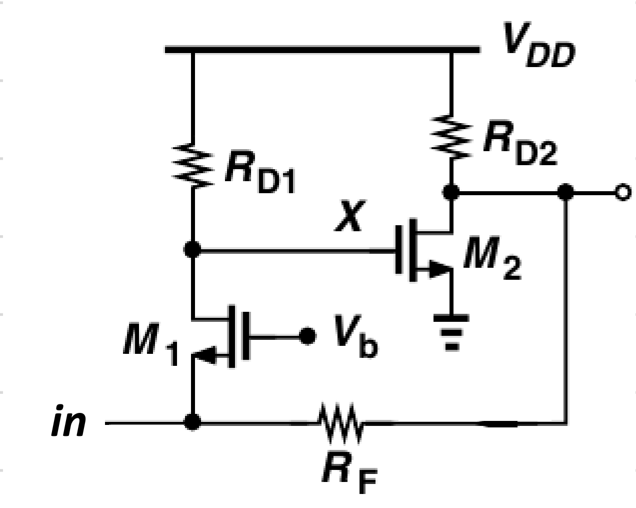
- There are four possible combinations
  ① Voltage-Voltage Feedback
  ② Voltage-Current Feedback
  ③ Current-Voltage Feedback
  ④ Current-Current Feedback



See the Examples!

- Can you classify the feedback type? Assume R_1, R_2, and R_F are large
- Strictly saying, No. Not always





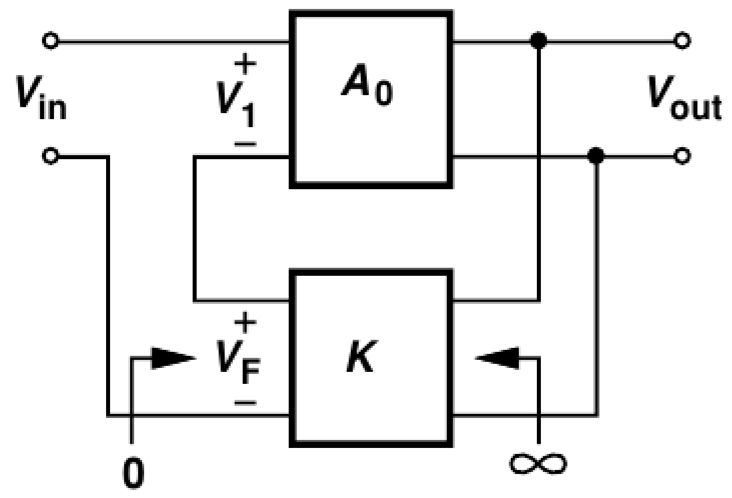
- Important things are
  1) Input and output types are given.
  2) Then how is the feedback structure supposed to look like?

Contents

- Closed loop gain, I/O impedances for
  ① Voltage-Voltage Feedback
  ② Voltage-Current Feedback
  ③ Current-Voltage Feedback
  ④ Current-Current Feedback

Voltage-Voltage Feedback

- Closed loop gain?



$$V_1 = V_{in} - V_F$$

$$V_{out} = A_0 V_1$$

$$V_F = K V_{out},$$

$$V_{out} = A_0(V_{in} - K V_{out})$$

$$\frac{V_{out}}{V_{in}} = \frac{A_0}{1 + K A_0}$$

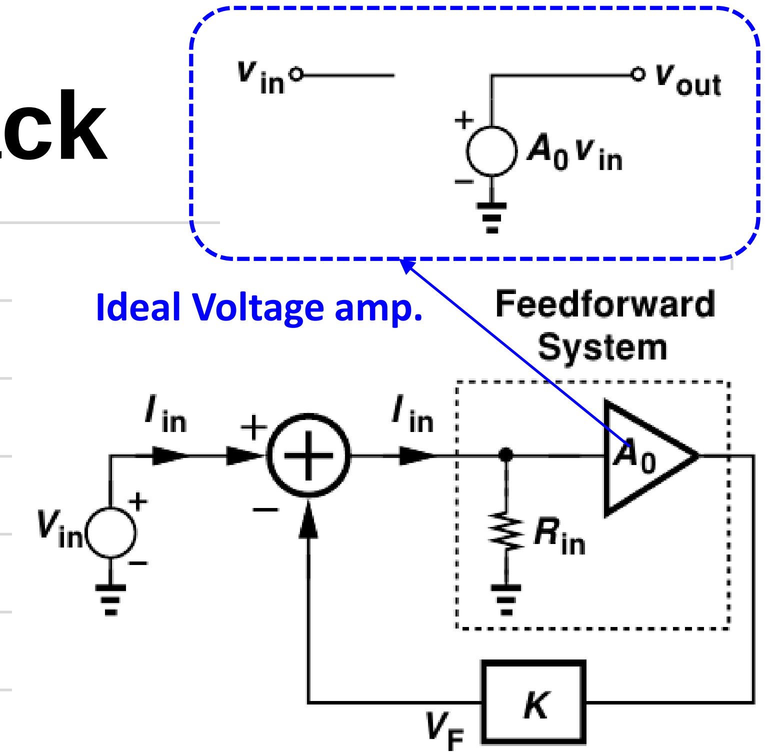
I/O Impedance in Voltage-Voltage Feedback

- Input impedance
  - For input impedance of feedforward system R_{in},

$$I_{in}R_{in} = V_{in} - V_F$$

$$= V_{in} - (I_{in}R_{in})A_0K.$$

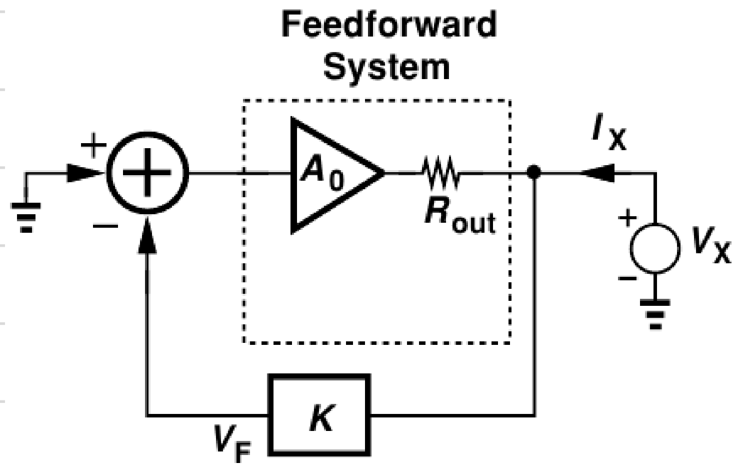
$$\frac{V_{in}}{I_{in}} = R_{in}(1 + KA_0)$$



- Output impedance
  - For output impedance of feedforward system R_{out},

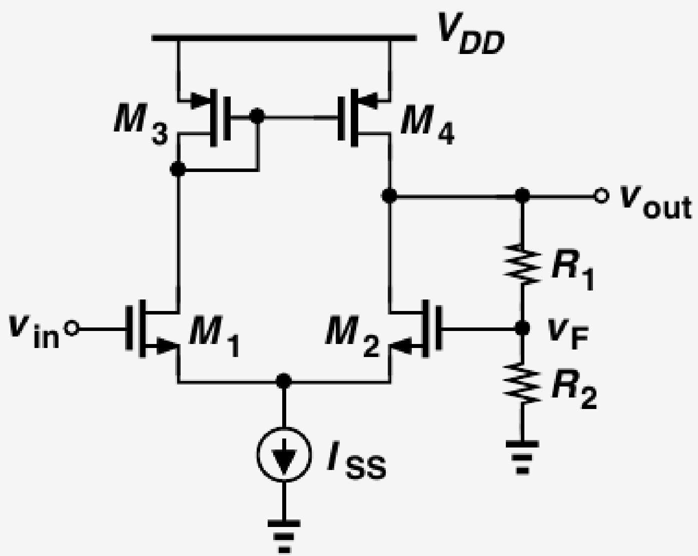
$$I_X = \frac{V_X - (-KA_0V_X)}{R_{out}}$$

$$\frac{V_X}{I_X} = \frac{R_{out}}{1 + KA_0}$$



Example 12.15

Determine the closed-loop gain of the circuit shown in Fig. 12.30, assuming $R_1 + R_2$ is very large.



Example 12.16

Determine the input impedance of the stage shown in Fig. 12.32(a) if $R_1 + R_2$ is very large.

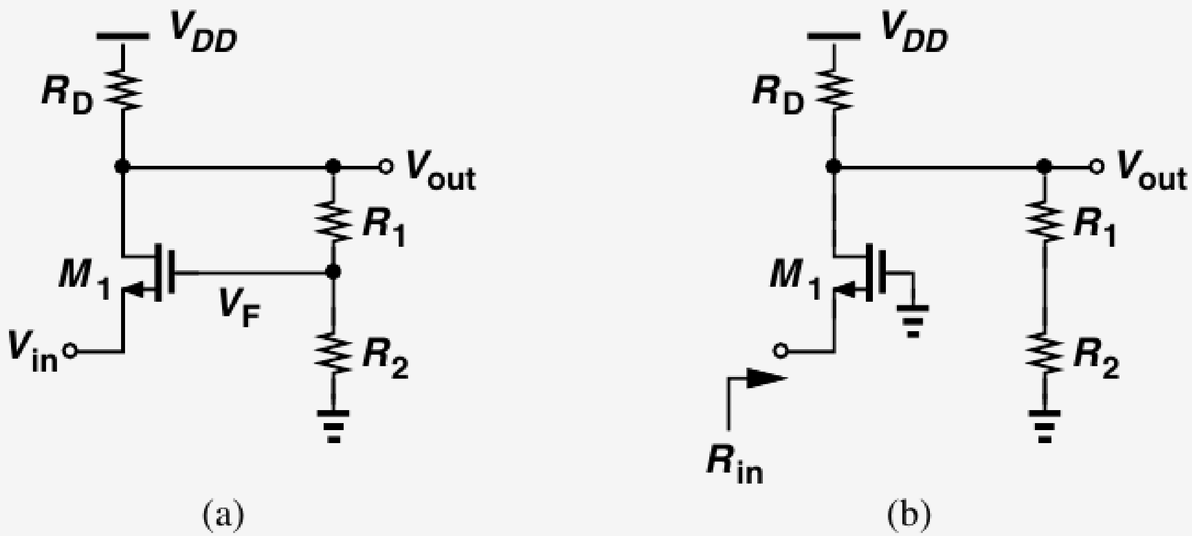


Figure 12.32

Example 12.17

Calculate the output impedance of the circuit shown in Fig. 12.34 if $R_1 + R_2$ is very large.

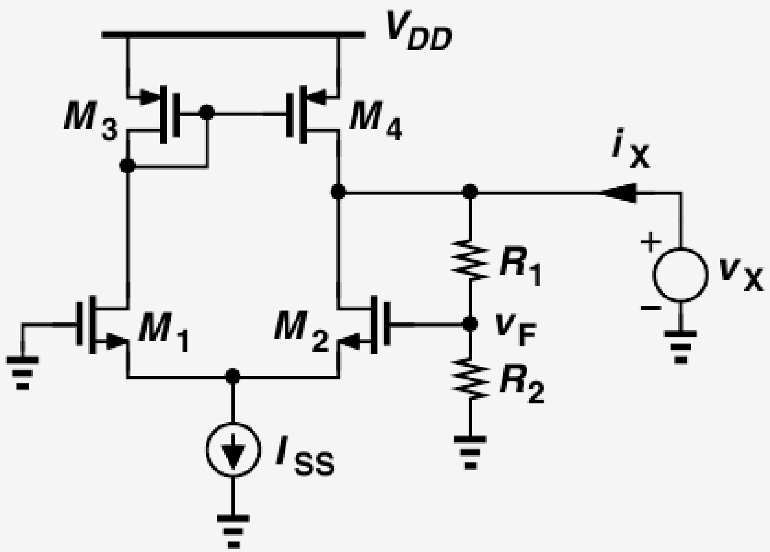


Figure 12.34

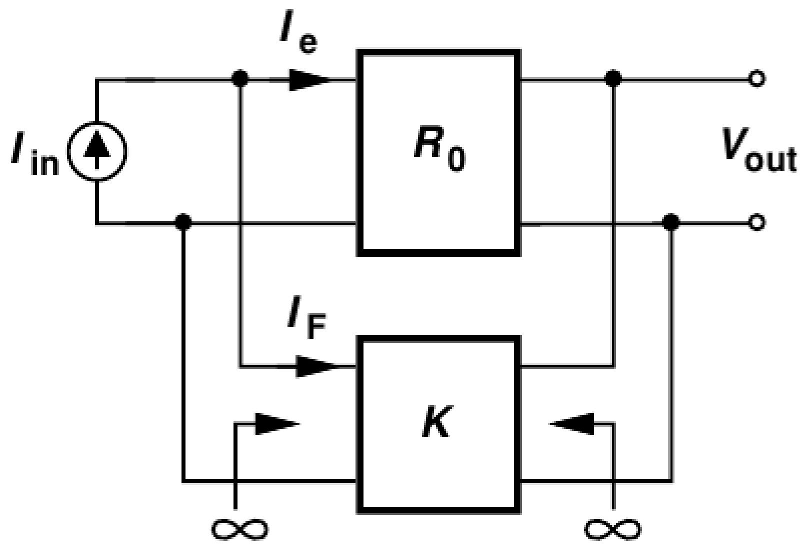
Voltage-Current Feedback

- Closed loop gain

$$V_{out} = (I_{in} - I_F)R_0$$

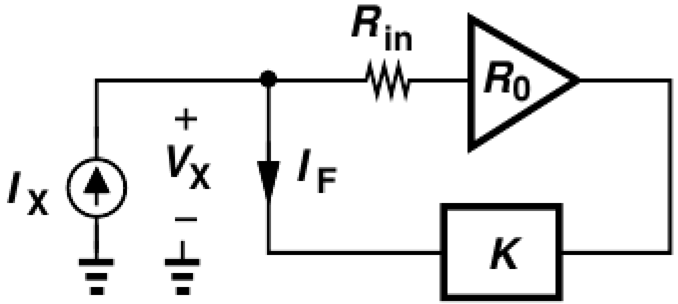
$$= (I_{in} - KV_{out})R_0$$

$$\frac{V_{out}}{I_{in}} = \frac{R_0}{1 + KR_0}$$



I/O Impedances in Voltage-Current Feedback

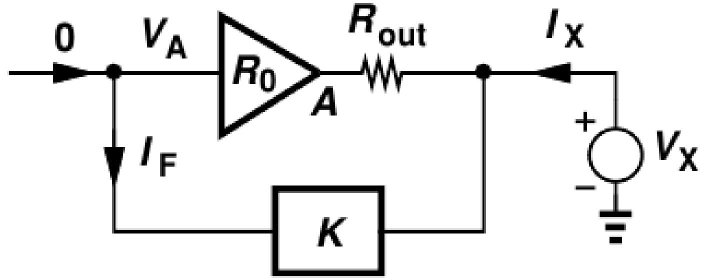
- Input impedance
  - For input impedance of feedforward system R_{in},



$$I_F = K\frac{V_X}{R_{in}}R_0 \Rightarrow I_X - K\frac{V_X}{R_{in}}R_0 = \frac{V_X}{R_{in}}$$

$$\frac{V_X}{I_X} = \frac{R_{in}}{1+KR_0}$$

- Output impedance

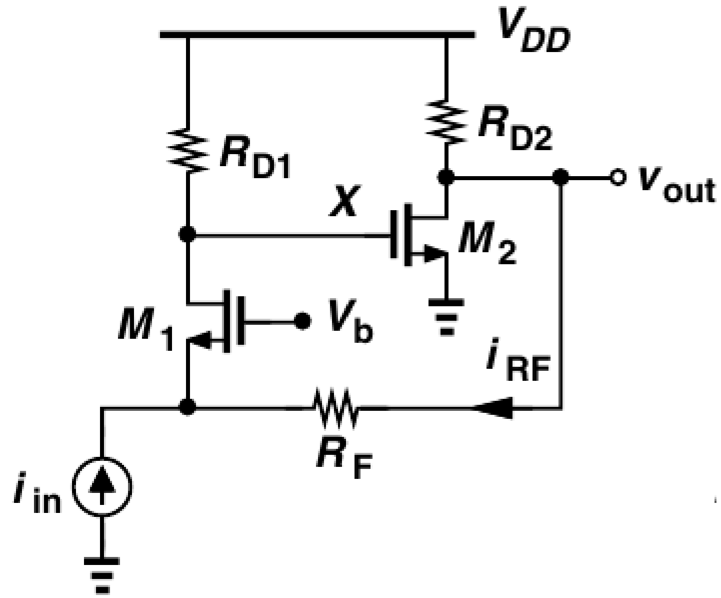


$$I_X = \frac{V_X - V_A}{R_{out}} = \frac{V_X + KV_XR_0}{R_{out}}$$

$$\frac{V_X}{I_X} = \frac{R_{out}}{1+KR_0}$$

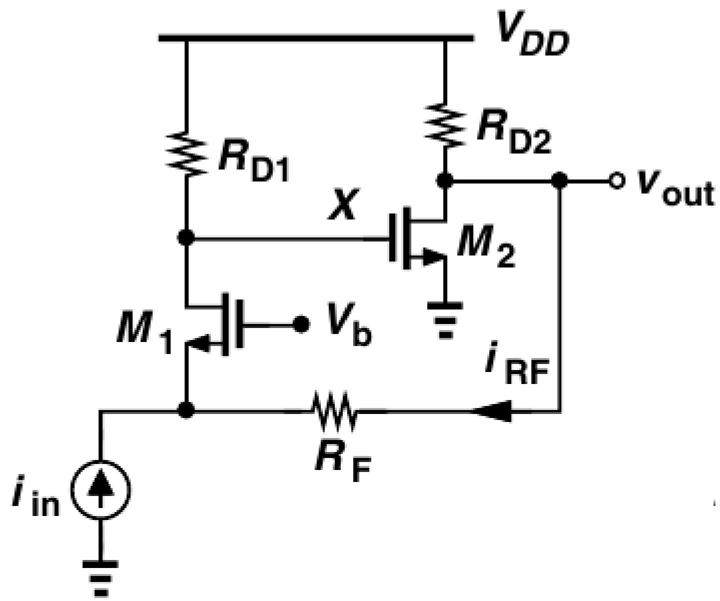
Example 12.18

For the circuit shown in Fig. 12.36(a), assume $\lambda = 0$ and R_F is very large and (a) prove that the feedback is negative; (b) calculate the open-loop gain; (c) calculate the closed-loop gain.



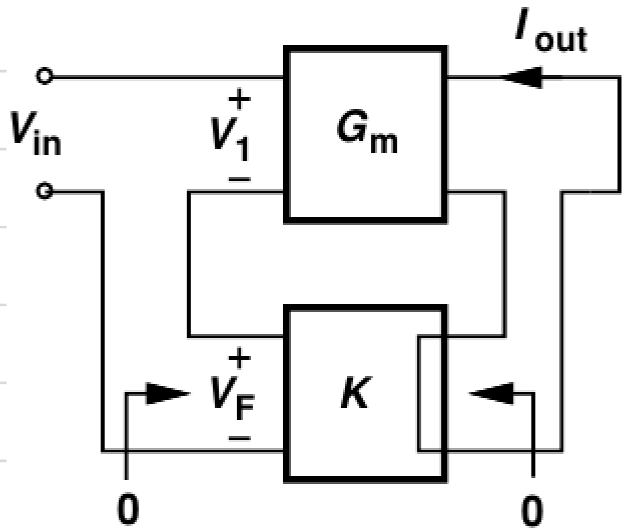
Example 12.19 Determine the closed-loop input impedance of the circuit studied in Example 12.18.

Example 12.20 Calculate the closed-loop output impedance of the circuit studied in Example 12.18.



Current Voltage Feedback

- Closed loop gain?

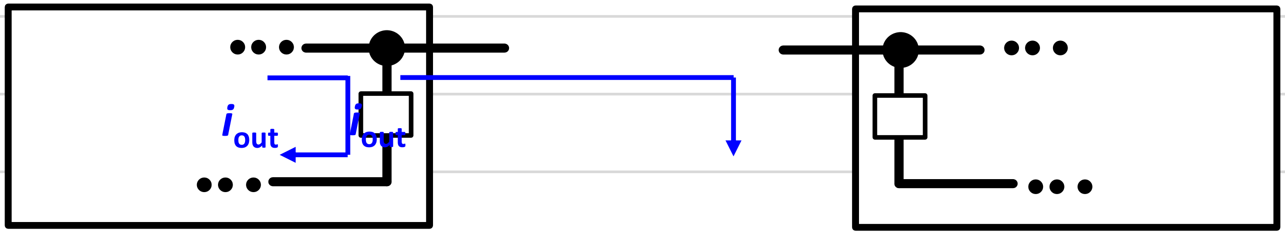


$$I_{out} = G_m(V_{in} - KI_{out})$$

$$\frac{I_{out}}{V_{in}} = \frac{G_m}{1 + KG_m}$$

R_{out} in Current Output Circuit

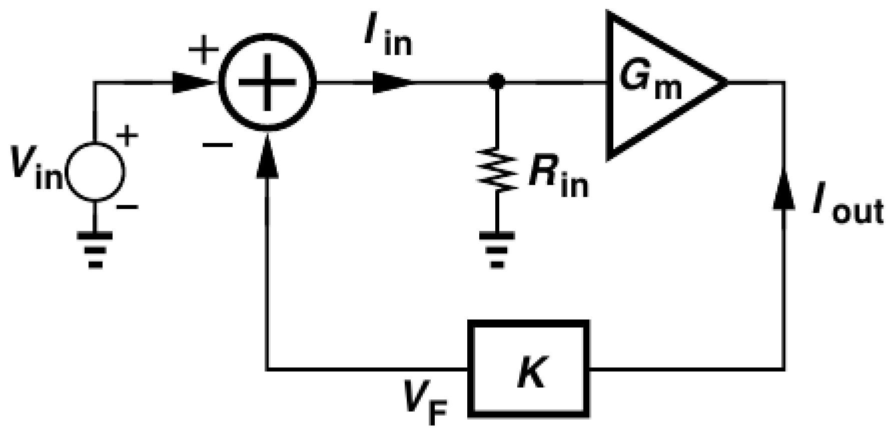
- How could R_{out} be measured?



I/O Impedances in Current-Voltage Feedback

- Input impedances

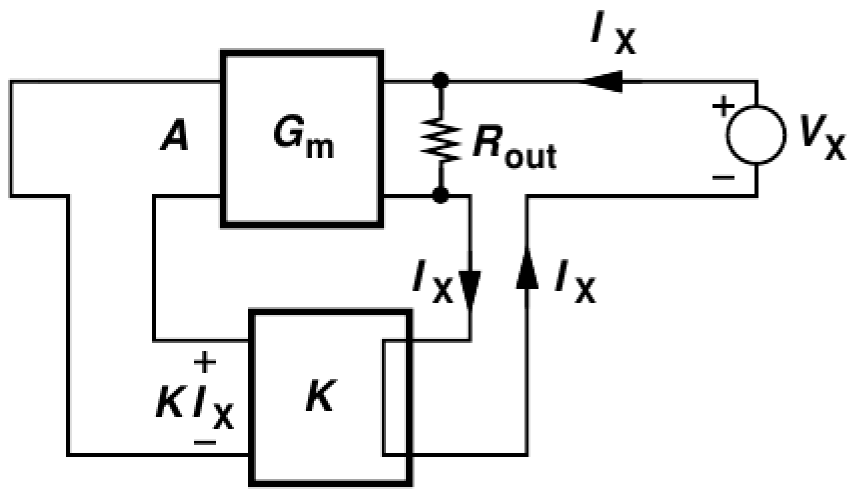
$$\frac{V_{in}}{I_{in}} = R_{in}(1 + KG_m)$$



- Output impedances

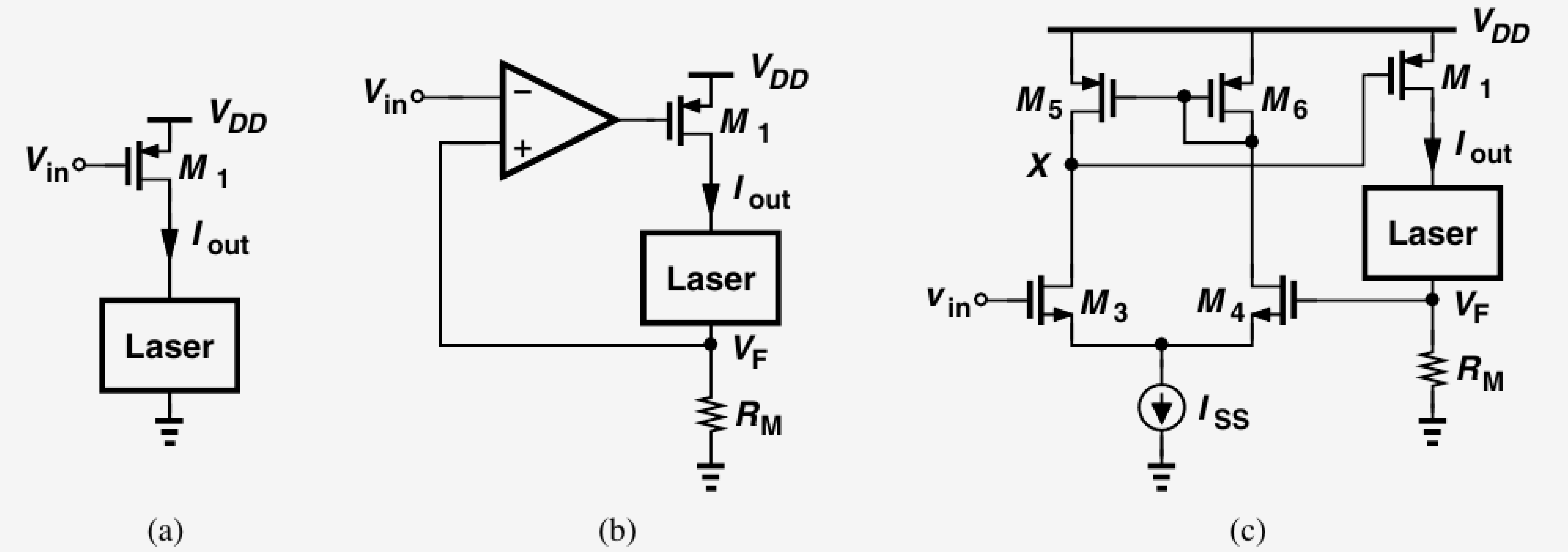
$$I_X = \frac{V_X}{R_{out}} - KG_mI_X$$

$$\frac{V_X}{I_X} = R_{out}(1 + KG_m)$$



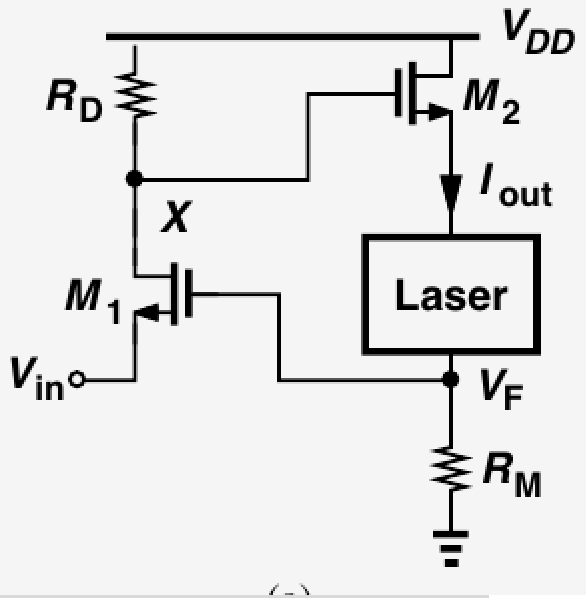
Example 12.21

We wish to deliver a well-defined current to a laser diode as shown in Fig. 12.40(a),[11] but the transconductance of M_1 is poorly controlled. For this reason, we "monitor" the current by inserting a small resistor R_M in series, sensing the voltage across R_M, and returning the result to the input of an op amp [Fig. 12.40(b)]. Estimate I_{out} if the op amp provides a very high gain. Calculate the closed-loop gain for the implementation shown in Fig. 12.40(c).



Example 12.22

An alternative approach to regulating the current delivered to a laser diode is shown in Fig. 12.42(a). As in the circuit of Fig. 12.40(b), the very small resistor R_M monitors the current, generating a proportional voltage and feeding it back to the subtracting device, M_1. Determine the closed-loop gain and I/O impedances of the circuit.



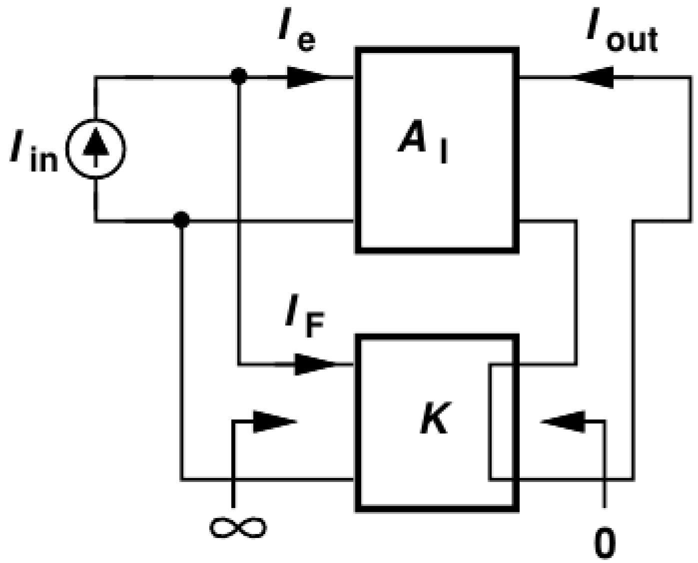
Current-Current Feedback

- Closed loop gain

$$I_{out} = A_I(I_{in} - I_F)$$

$$= A_I(I_{in} - KI_{out})$$

$$\frac{I_{out}}{I_{in}} = \frac{A_I}{1 + KA_I}$$

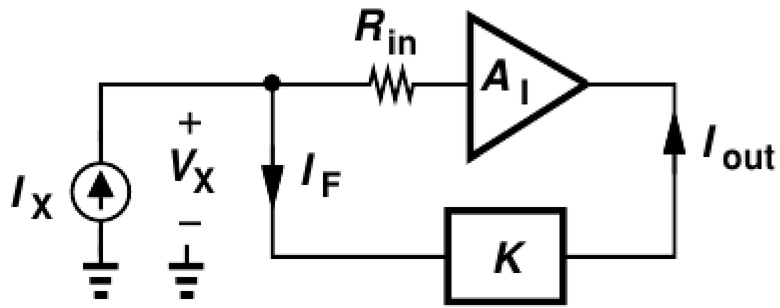


I/O Impedances

- Input impedance

$$I_X = \frac{V_X}{R_{in}} + I_F = \frac{V_X}{R_{in}} + KA_I \frac{V_X}{R_{in}}.$$

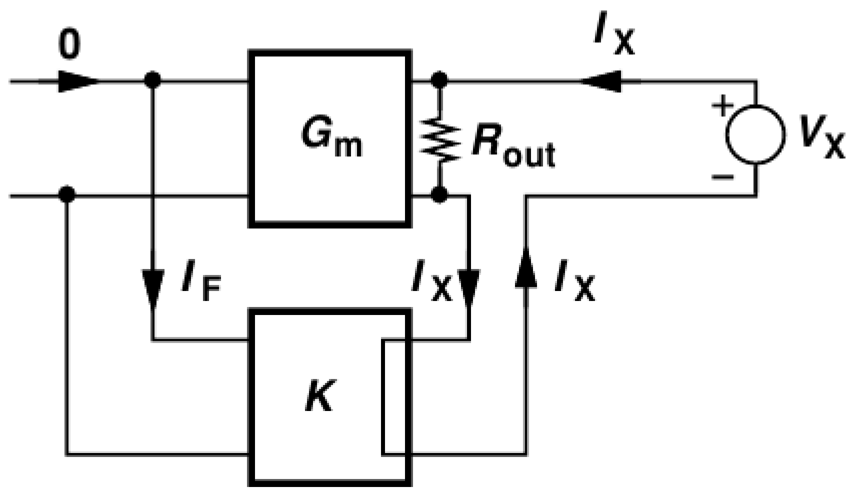
$$\frac{V_X}{I_X} = \frac{R_{in}}{1 + KA_I}$$



- Output impedance

$$I_X = \frac{V_X}{R_{out}} - KA_I I_X$$

$$\frac{V_X}{I_X} = R_{out}(1 + KA_I)$$



Example 12.24

Consider the circuit shown in Fig. 12.47(a), where the output current delivered to a laser diode is regulated by negative feedback. Prove that the feedback is negative and compute the closed-loop gain and I/O impedances if R_M is very small and R_F very large.