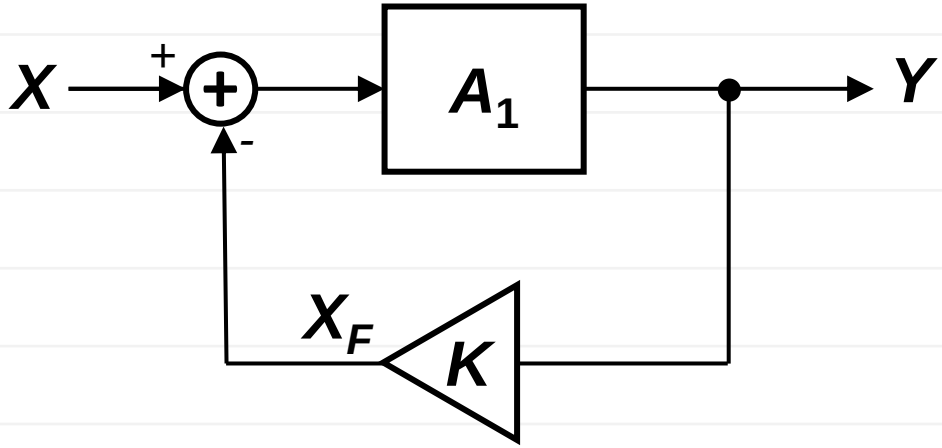
Feedback Basic

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General Feedback System

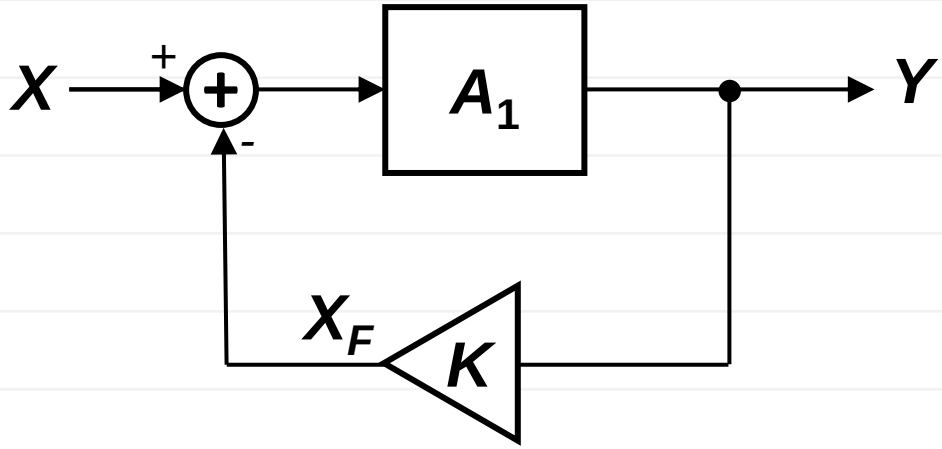
- Feedback plays a “regulatory” or “corrective” role





1) Feedforward system
2) Output sense mechanism
3) Feedback network; feedback factor $K = X_F/Y$
4) Comparison mechanism; Error = $X - X_F$

Open Loop and Closed Loop Gain

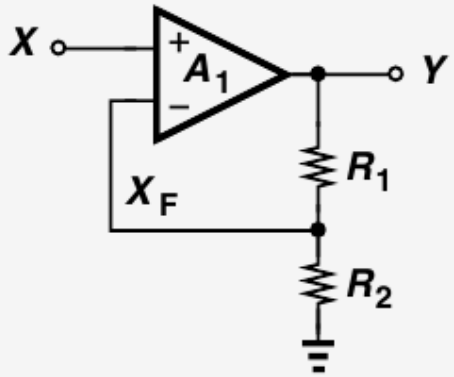


- When no signal is fed back, we call the system "open-loop." (K=0)
  - Open-loop gain Y/X = A_1
- When K ≠ 0, the system forms a "closed-loop." Then, how can we derive the closed-loop gain or transfer function, Y/X?

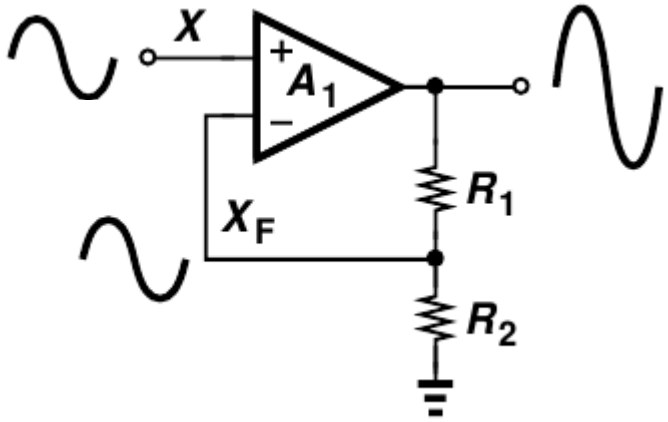
$$(X - KY)A_1 = Y \quad \Rightarrow \quad \frac{Y}{X} = \frac{A_1}{1 + KA_1}$$

Example 12.1

Analyze the noninverting amplifier of Fig. 12.2 from a feedback point of view.



Relation between Error and X

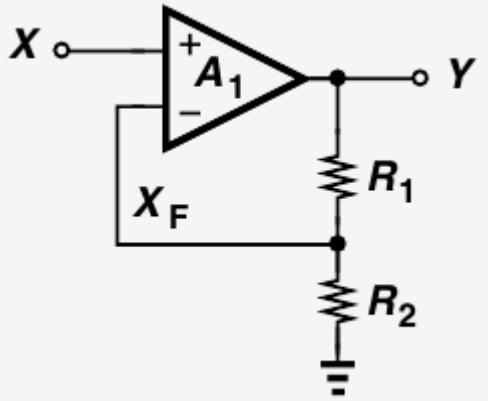


- $E = X - X_F = X - KA_1E$ ➔ $E = \frac{X}{1+KA_1}$
- When **the loop gain** KA_1 becomes large, then E becomes zero.

➔ Feedback signal, X_F, becomes a close replica of X

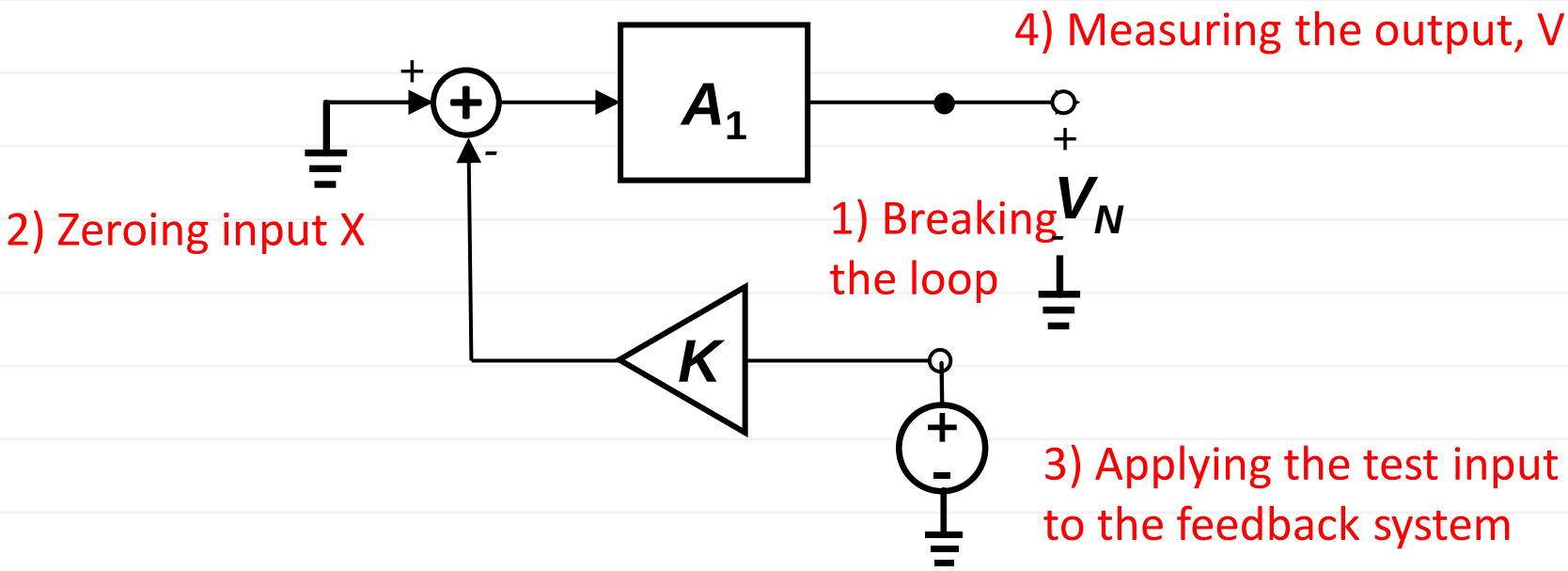
Example 12.2

Explain why in the circuit of Fig. 12.2, Y/X approaches $1 + R_1/R_2$ as $[R_2/(R_1 + R_2)]A_1$ becomes much greater than unity.



Loop Gain

- How can you calculate the loop gain KA_1 from general circuit?

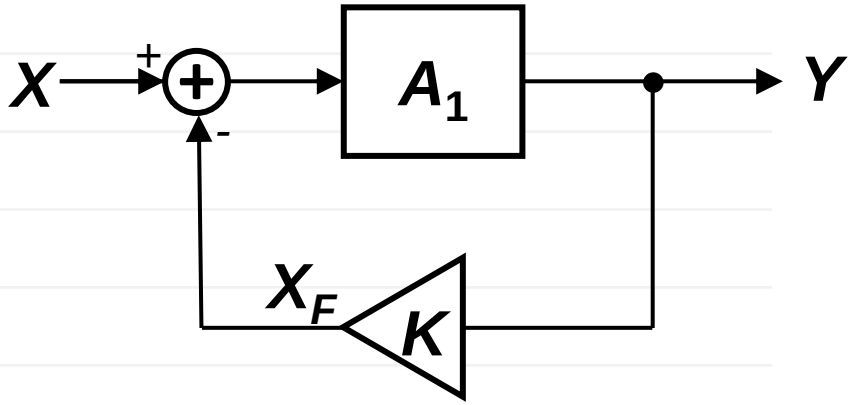


$$V_N = -KV_{test}A_1$$

$$KA_1 = -\frac{V_N}{V_{test}}$$

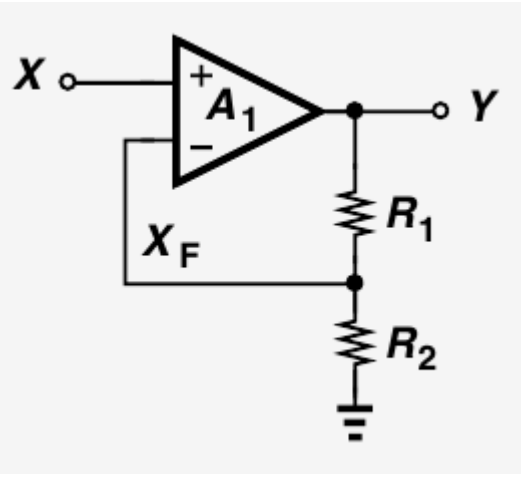
Example 12.3

Compute the loop gain of the feedback system of Fig. 12.1 by breaking the loop at the input of A_1.



Example 12.4

The circuit of Fig. 12.2 is designed for a nominal gain of 4. (a) Determine the actual gain if $A_1 = 1000$. (b) Determine the percentage change in the gain if A_1 drops to 500.



System becomes less Sensitive to Variation

- What if A_1 changes because of circuit component variations?
- What if signal frequency rises?
- What if X fluctuates severely, although A_1 is not constant for X?

$$\frac{Y}{X} = \frac{A_1}{1 + KA_1}$$

Bandwidth Extension

- As examined previously, gain is likely to decrease with frequency, that is,

$$A_1(s) = \frac{A_0}{1 + \frac{s}{\omega_0}}$$

- Here, the closed loop gain is

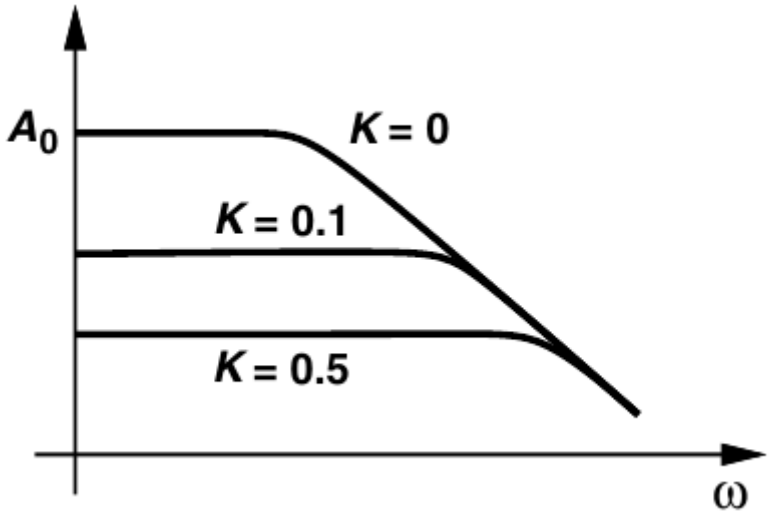
$$\frac{Y}{X} = \frac{\frac{A_0}{1 + \frac{s}{\omega_0}}}{1 + K\frac{A_0}{1 + \frac{s}{\omega_0}}} = \frac{A_0}{1 + KA_0 + \frac{s}{\omega_0}} = \frac{\frac{A_0}{1 + KA_0}}{1 + \frac{s}{(1 + KA_0)\omega_0}}$$

$$\text{Bandwidth} = (1 + KA_0)\omega_0.$$

Example 12.5

Plot the closed-loop frequency response given by Eq. (12.19) for $K = 0$, 0.1, and 0.5. Assume $A_0 = 200$.

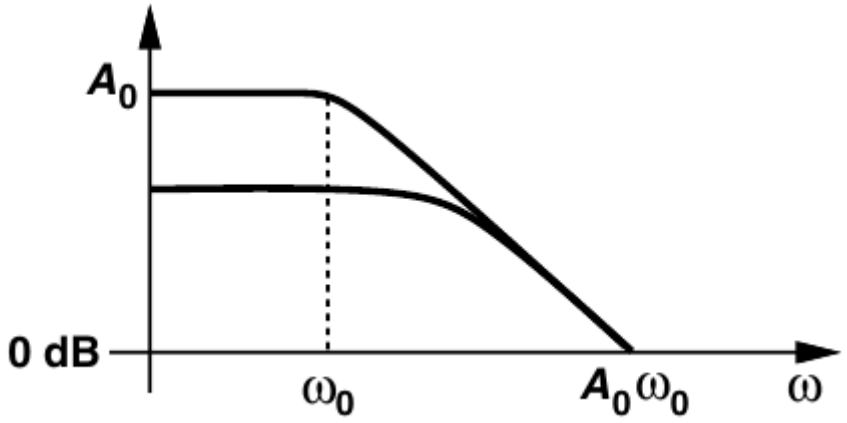
$$\frac{Y}{X}(s) = \frac{\dfrac{A_0}{1 + KA_0}}{1 + \dfrac{s}{(1 + KA_0)\omega_0}}.$$



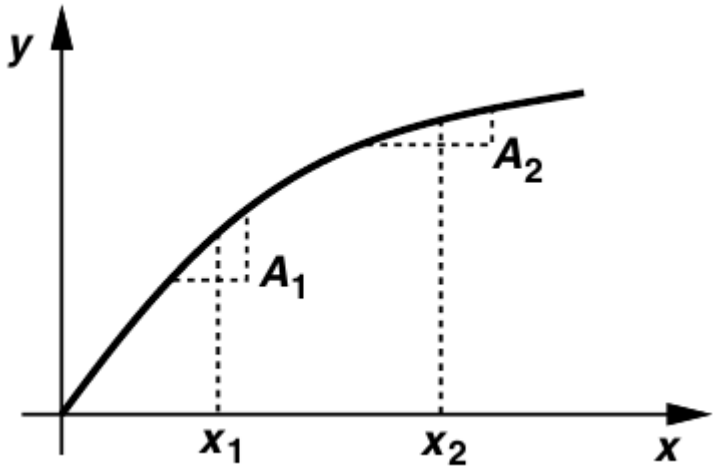
Example 12.6

Prove that the unity-gain bandwidth of the above system remains independent of K if $1 + KA_0 \gg 1$ and $K^2 \ll 1$.

- Unity-gain bandwidth?



Linearity Comparison



$$\text{Gain at } x_1 = \frac{A_1}{1 + KA_1} \approx \frac{1}{K}\left(1 - \frac{1}{KA_1}\right)$$

$$\text{Gain at } x_2 = \frac{A_2}{1 + KA_2} \approx \frac{1}{K}\left(1 - \frac{1}{KA_2}\right)$$

Summary

- What is the feedback system?
- What is the loop gain? How can we calculate it?
- Why do we use the feedback system?