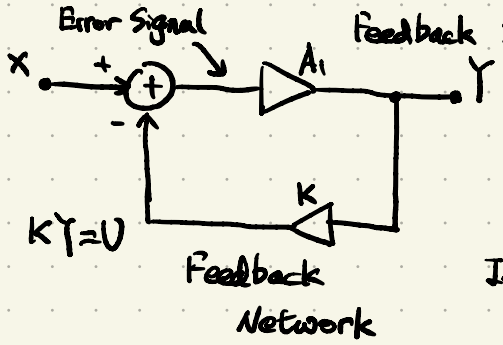
Lec 28

- Feedback Examples
- The Concept of Loop Gain
- Properties of Negative-Feedback Systems

Review of Lec. 27



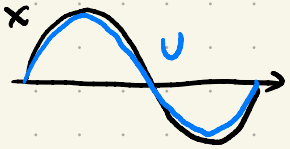
$$\frac{Y}{X} = \frac{A_1}{1+kA_1}$$

A_1: Open-Loop Gain

$\frac{A_1}{1+kA_1}$: Closed-Loop Gain

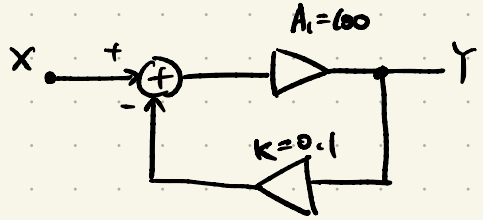
$$\text{Error} = \frac{X}{1+kA_1}$$

If error is small: $U \approx X$



- In a well-designed negative-feedback system, the feedback signal is a good copy (replica) of the input signal.

- Example



$$\frac{Y}{X} = \frac{100}{1+10} \approx 9.09$$

Example What happens if A_1 drops to 50 in the previous example?

$A_1 = 50$ $\quad \frac{Y}{X} = \frac{50}{1+5} = \underline{\underline{8.33}}$

$\not\Phi$ Even though the open loop gain changed by a factor of 2, the closed loop gain changed by only 10%

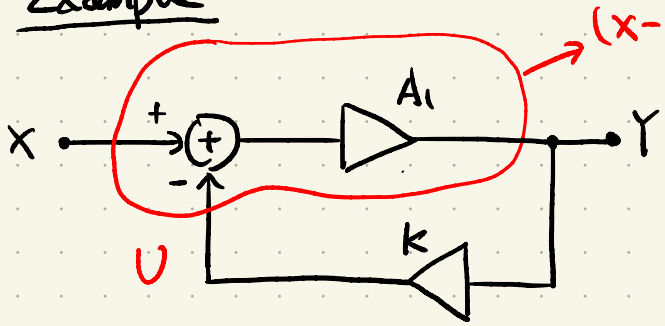
Observation: If $kA_1 >> 1 \Rightarrow$

$$\frac{Y}{X} \approx \frac{1}{k} \Rightarrow$$ closed-loop gain is relatively independent of the open-loop gain

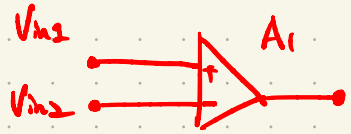
$\Rightarrow$ we should maximize kA_1.

Observation: k is usually chosen ≤ 1

Example

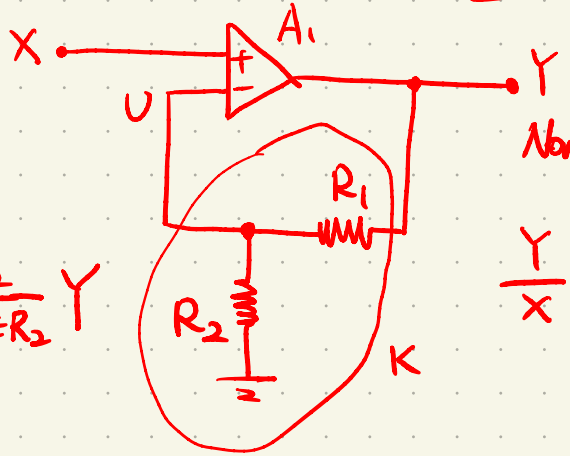


$(x-U)A_1$



$(V_{in1}-V_{in2})A_1$

$k<1$



Noninverting Amp.

$U=\frac{R_2}{R_1+R_2}Y$

$$\frac{Y}{X}=\frac{A_1}{1+kA_1}$$

$$=\frac{A_1}{1+\frac{R_2}{R_1+R_2}A_1}$$

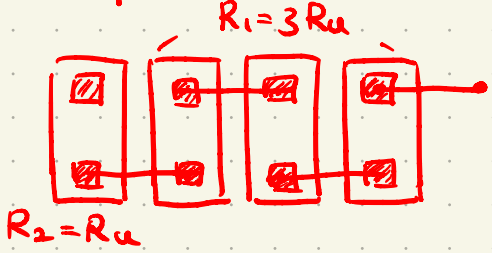
In a well designed negative-feedback circuit,

$$kA_1 \gg 1 \Rightarrow \frac{R_2}{R_1+R_2}A_1 \gg 1 \Rightarrow \frac{Y}{X}\approx\frac{1}{k}=1+\frac{R_1}{R_2}$$

Even if R_1, R_2 vary with temperature, etc.

$1+\frac{R_1}{R_2}$ is accurate.

$\frac{Y}{X}=4.0$, so $\frac{R_1}{R_2}=3$



- Loop Gain kA_1: in a well designed negative-feedback system, loop-gain $\gg 1$

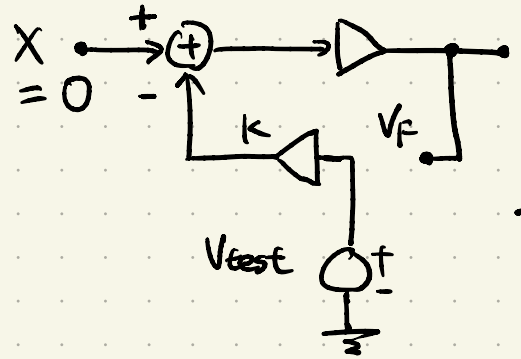
  $\Rightarrow$ closed-loop gain $\approx \frac{1}{k}$

Example

Find the loop gain in the noninverting amp:

$$kA_1=\frac{R_2}{R_1+R_2}A_1$$

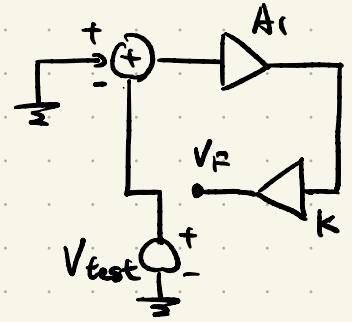
- Loop Gain Calculation



Loop Gain $=-\frac{V_F}{V_{test}}$

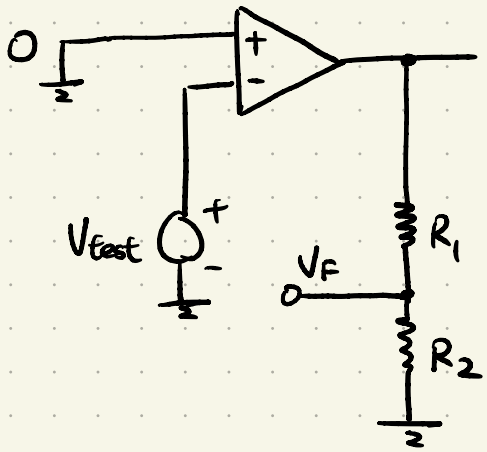
$-V_{test}kA_1=V_F \Rightarrow -\frac{V_F}{V_{test}}=kA_1$

Example



$-V_{test}A_1k=V_F$

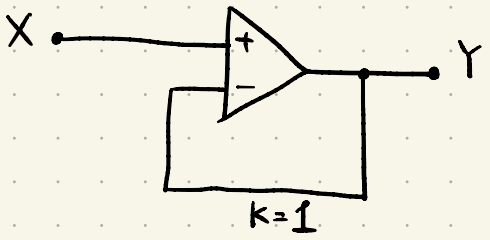
Example



$$V_{test} \times (-A_1) \frac{R_2}{R_1+R_2} = V_F$$

$$-\frac{V_F}{V_{test}} = \frac{R_2}{R_1+R_2} A_1$$

Example



$$\frac{Y}{X} = \frac{A_1}{1+kA_1}$$

$$= \frac{A_1}{1+A_1} \approx 1$$

Unity-Gain Buffer

Loop Gain = A_1

One Important Property: If $kA_1 >> 1 \Rightarrow$

$\frac{Y}{X} \approx \frac{1}{k}$ and relatively indep. of A_1