Lecture 15: Negative Feedback

0. Review
1. Intro
2. Improved Amplifier Properties

Textbook Reading:

17-2 VCVS Voltage Gain
17-3 Other VCVS Equations

- Exam #2 re-do due next Tue (Nov 19)
- HW7 due next Thu (Nov 21) (box outside my office)
- Next Tue: Course Eval!
- Lab 5 report due Nov 26 (Tue) (1 per team)

0. Review

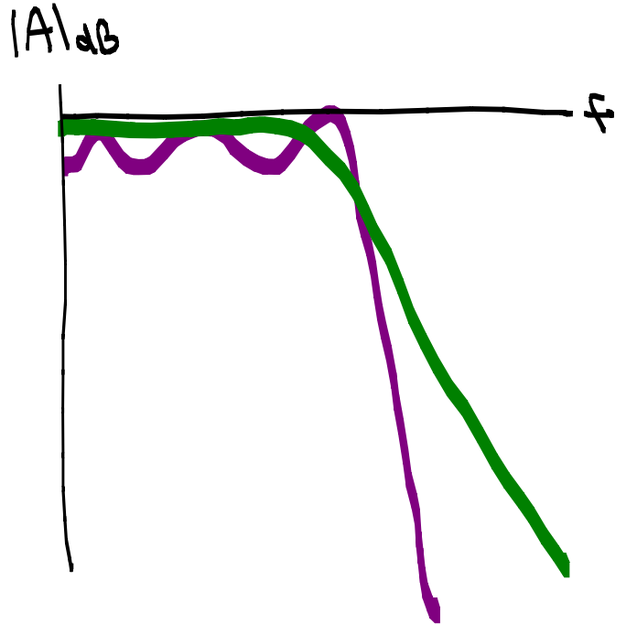
Active Filters ← Use op amps without inductors

① Butterworth:

$$Q = \frac{1}{2}\sqrt{\frac{C_2}{C_1}} = \frac{1}{\sqrt{2}}$$

$$f_c = \frac{1}{2\pi R\sqrt{C_1 C_2}}$$

(Low Pass)



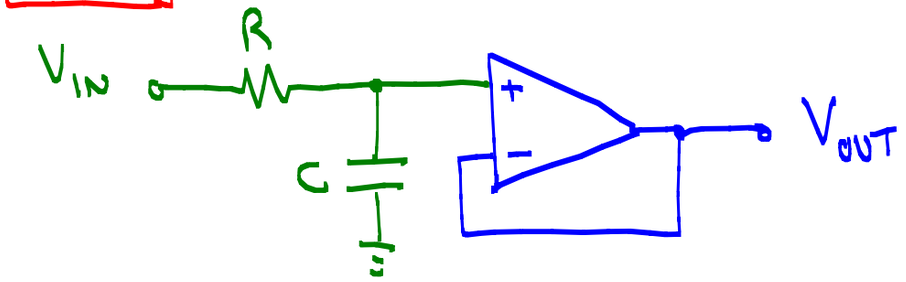
② Chebyshev:

$$Q = \frac{1}{2}\sqrt{\frac{C_2}{C_1}} > \frac{1}{\sqrt{2}}$$

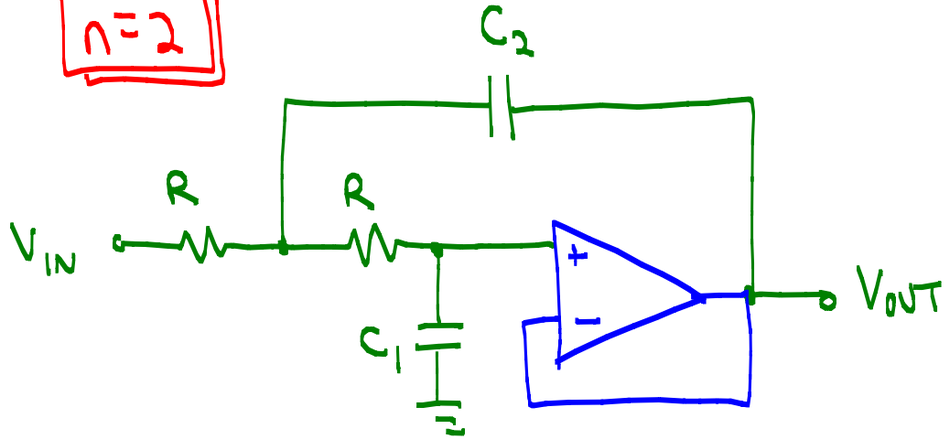
$$f_p = \frac{1}{2\pi R\sqrt{C_1 C_2}}$$

$$f_c = K_c f_p$$

n = 1



n = 2

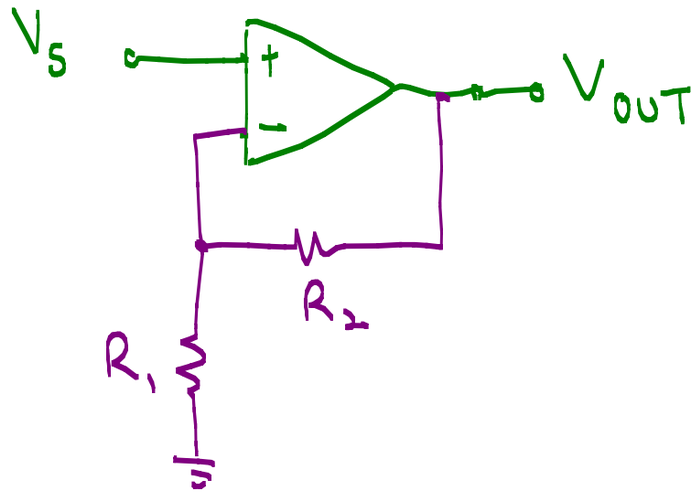


1. Intro

Recall an op amp's Golden Rules:

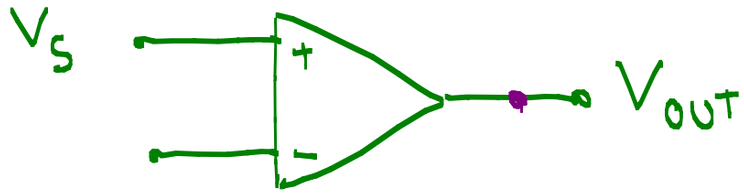
1.

2.

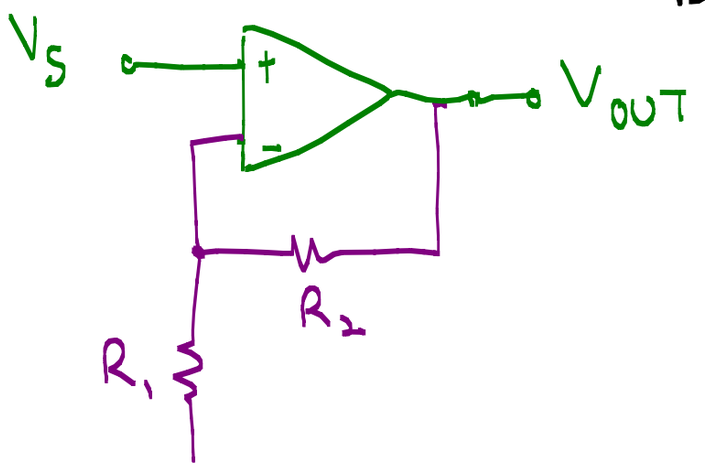


Q: How is Rule #1 ($V_+ = V_-$) possible?

A:



- Let's analyze the non-inverting amplifier WITHOUT Golden Rule #1!



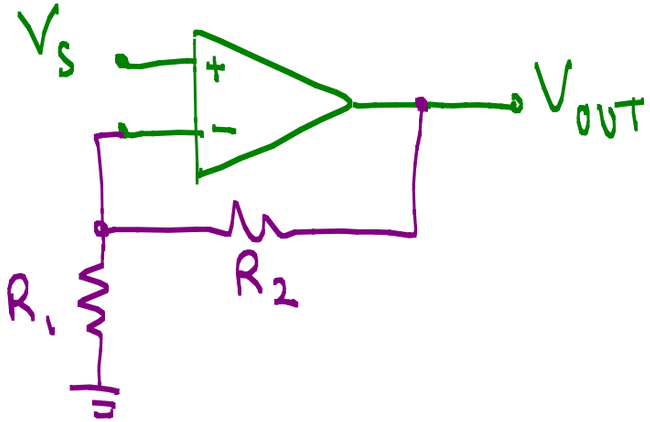
$V_{OUT} =$

- we can generalize this concept of negative feedback.

① SOURCE → Amplifier A_o → OUTPUT

②

- Example: Non-inverting amplifier



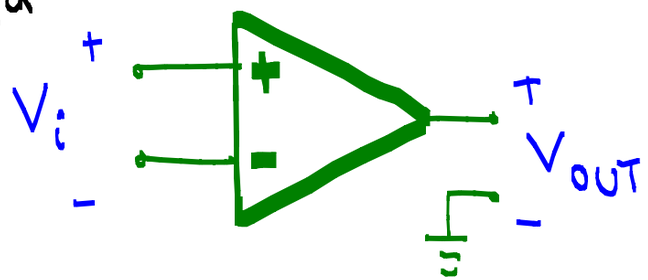
$X_S =$

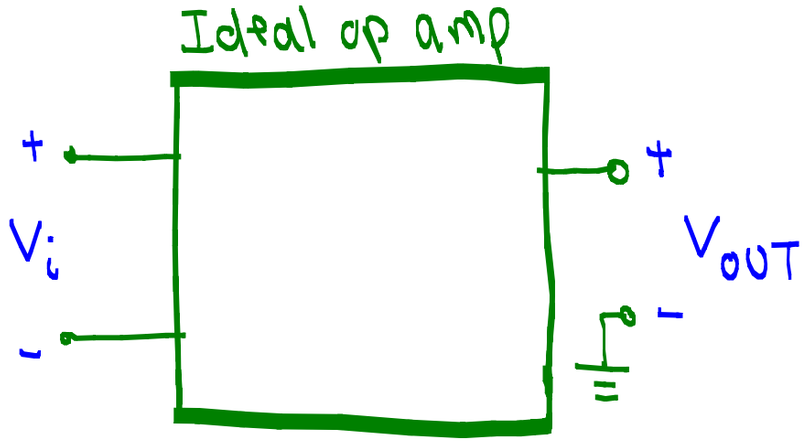
$X_F =$

$X_{OUT} =$

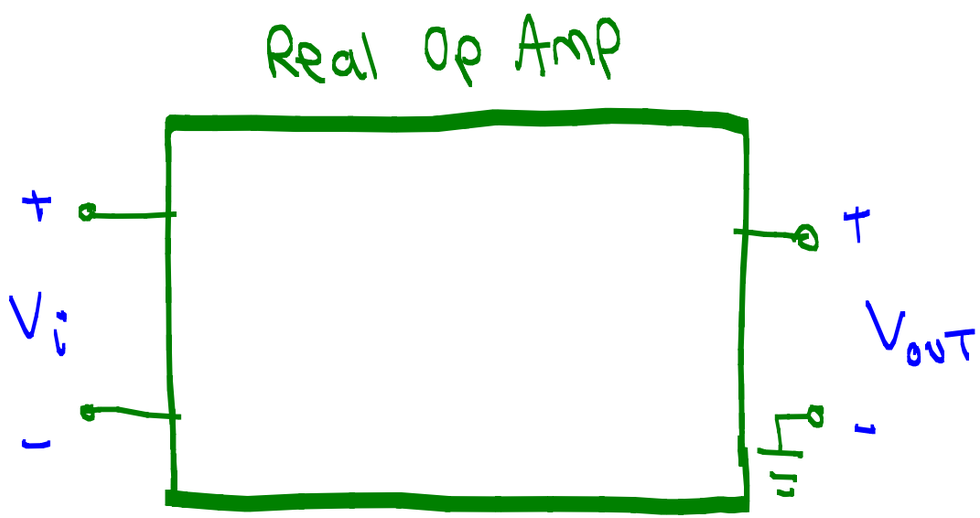
2. Improved amplifier properties

- So far, we have assumed an ideal op amp



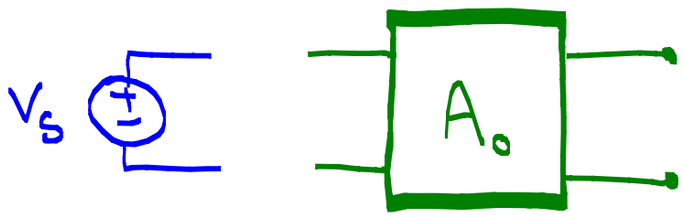


- A real op amp



- Negative feedback is a good thing!

Open Loop



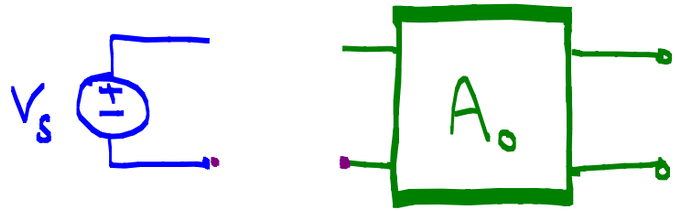
GAIN:

Z_{IN}:

Z_{OUT}:

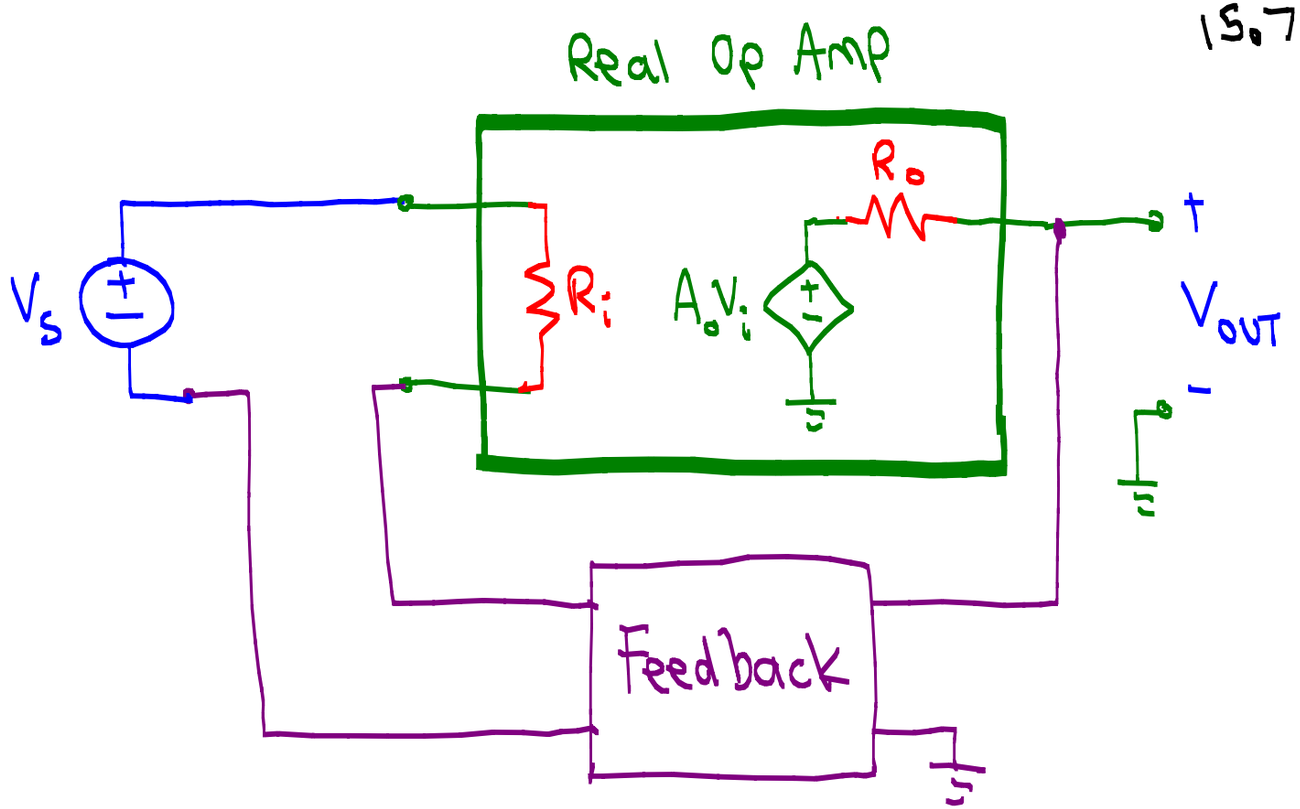
BANDWIDTH:

Closed Loop

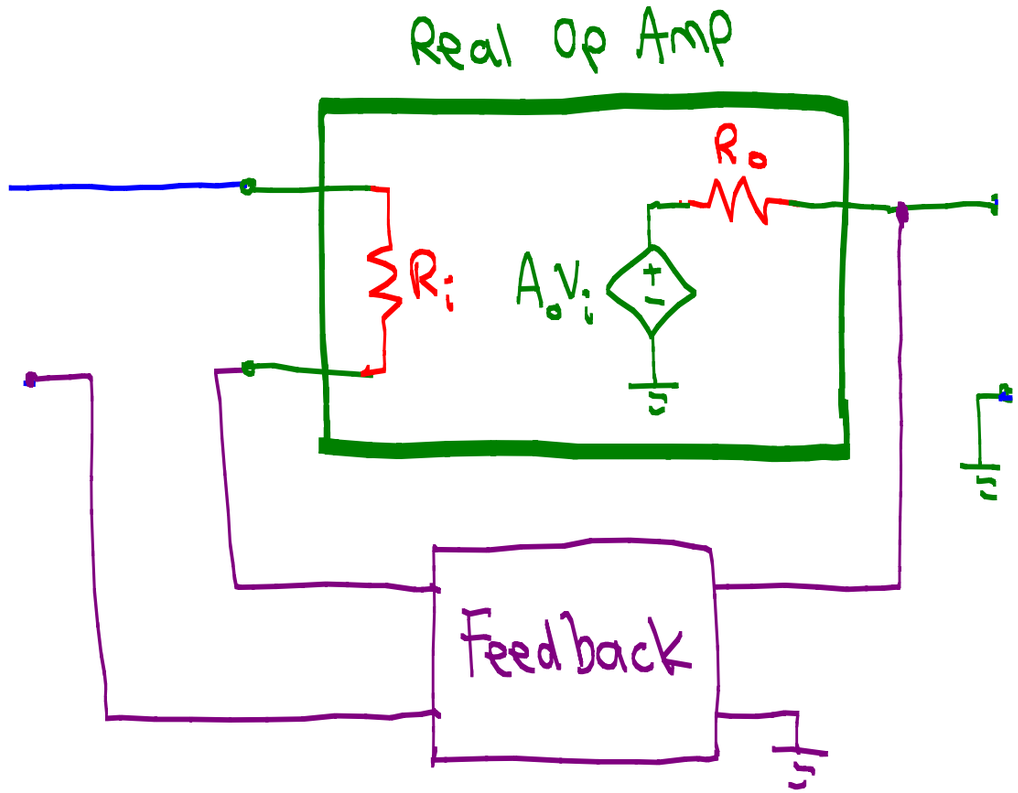


- Input impedance: Z_{IN}

$I_{IN} =$

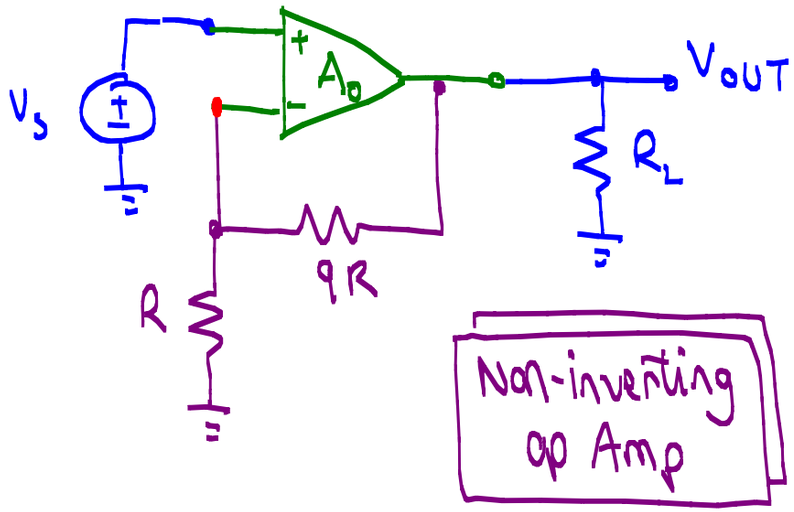


- Output Impedance R_{out}



Example Suppose $A_o = 10^4$ varies by +/- 50%. What is the variation in G ?

↑ Textbook uses A_f



Non-inverting op Amp

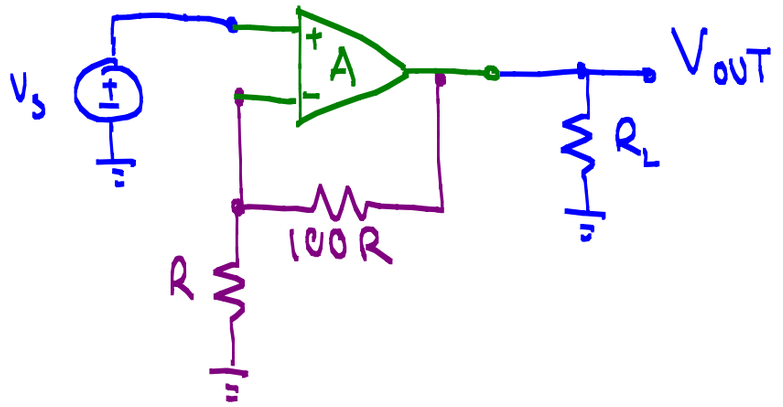
STEP 1: Find β

STEP 2: Find G

STEP 3: Let A_o vary

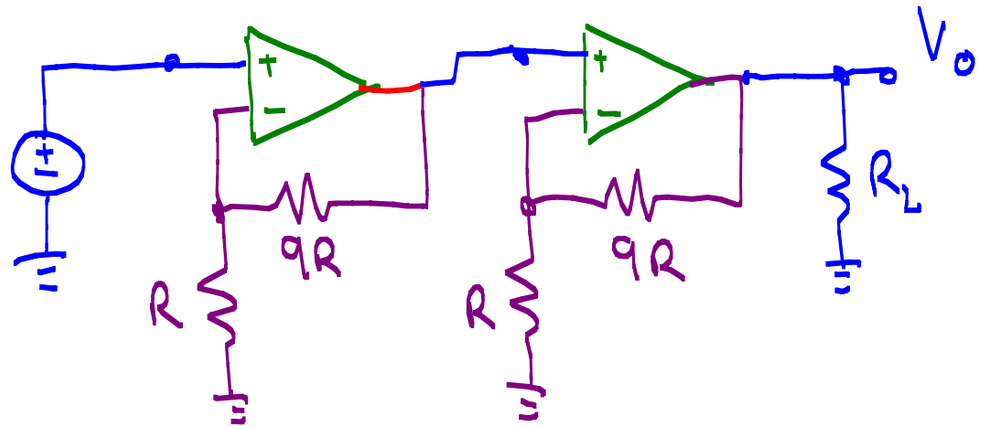
STEP 4: Compute $\Delta G/G$

Example Suppose $A_0 = 10^4$ varies by +/- 50%.
We want an amplifier with gain ~ 100.
Single or double stage more stable?



① Single Stage:

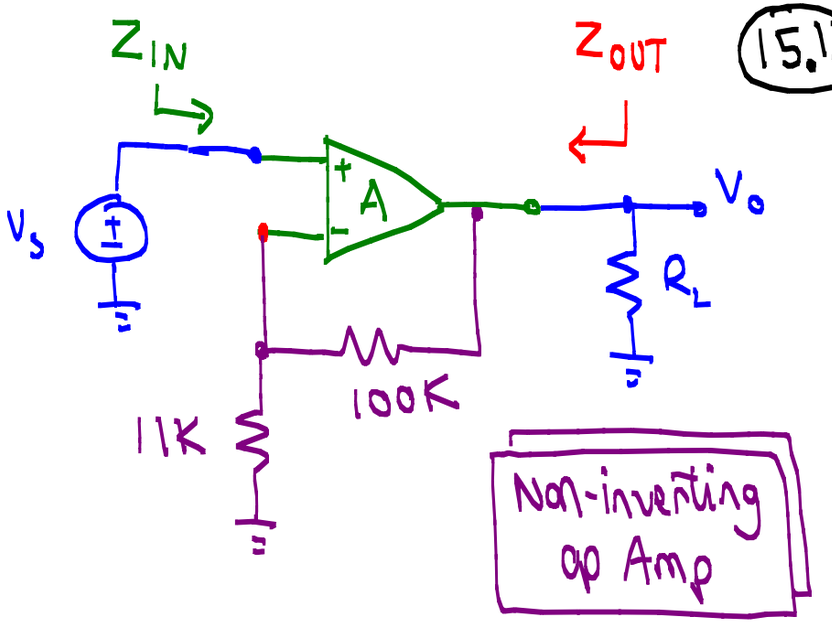
② Two stage:



worst-case variation:

Example Suppose $A=10^5$, $R_{id}=100K$, $R_o=100\Omega$

Compute Z_{IN} and Z_{OUT} of closed-loop circuit.



- Z_{IN} =
- Z_{OUT} =