Reverse Classroom: Op Amps Quiz 1

REV 0; August 18, 2019

1 Using an Op Amp in Open Loop Mode

We can model an operational amplifier as follows:

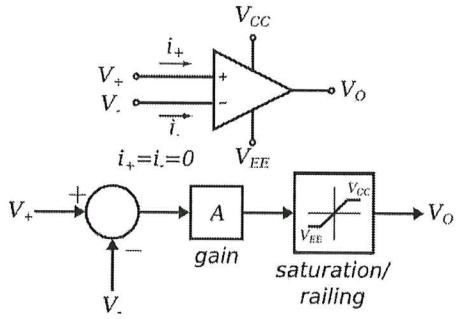


Figure 1: Model of an Operational Amplifier

The op amp has an output voltage that proportional to the difference between the inputs: $V_O = A*(V_+ - V_-)$, The "open loop gain" (A) is usually a fairly large value.

However, V_O cannot be more than than V_{CC} or less than V_{EE}. That is, the output is constrained by the power supply rails. When the output is limited by the supply voltages, we often say the op amp is "saturated" or "railing."

1.1 Design

Assume you have the following circuit:

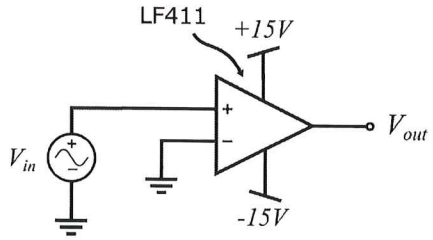


Figure 2: An Operational Amplifier Circuit

The LF411 op amp has a typical open loop gain of 200,000. What is the maximum peak-to-peak input voltage V_{in} you can apply in this circuit without causing the output voltage V_{out} to be clipped?

A

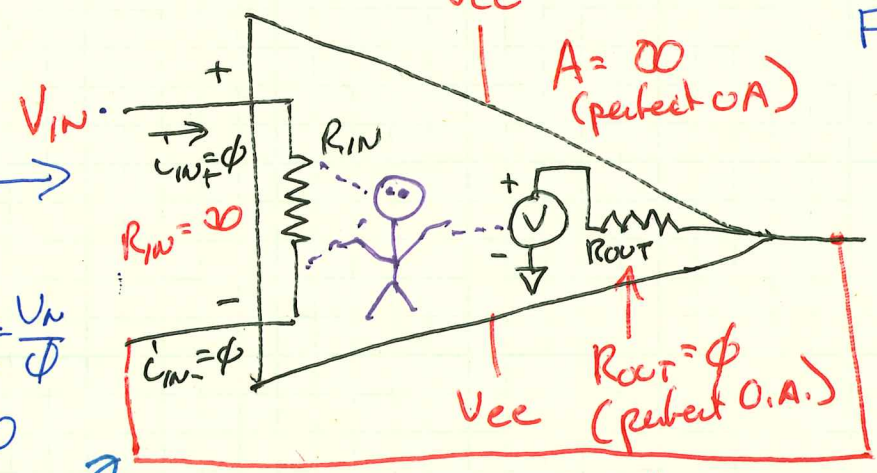
+15 to -15 ⇒ $\frac{30\,V_{PP}}{200{,}000} = 150\,\mu V$ Peak to Peak

Now complete Lab 6 through part 6L.2

not very useful since we may have larger signals (and A is not well controlled)

NON-INVERTING CONFIGURATION

UNITY GAIN FOLLOWER (BUFFER)



$$Z_{IN} = \frac{V_N}{I_{IN+}} = \frac{V_N}{\phi}$$

$$Z_{IN} = \infty$$

$V_{OUT} = V_{IN}$

??? What good is it? Look

$R_{OUT} = \phi \Omega$

$V_{OUT} = 1 \cdot V_{IN}$

check to make sure this is true first!

Golden Rules for perfect Op Amps

1) if there is negative feedback

2) if 1) is true
the op amp will try to keep the V_- input $= V_+$ input

add negative feed back "close the loop" to make op amp useful

expected closed loop gain

$V_{EE} \leq V_{OUT} \leq V_{CC}$

$V_{EE} \leq V_+$ and $V_- \leq V_{CC}$

Actual (non perfect) op amp

$V_+ = V_{IN}$

$V_- = V_{OUT} = A(V_+ - V_-)$

$V_{OUT} = A(V_{IN} - V_{OUT})$

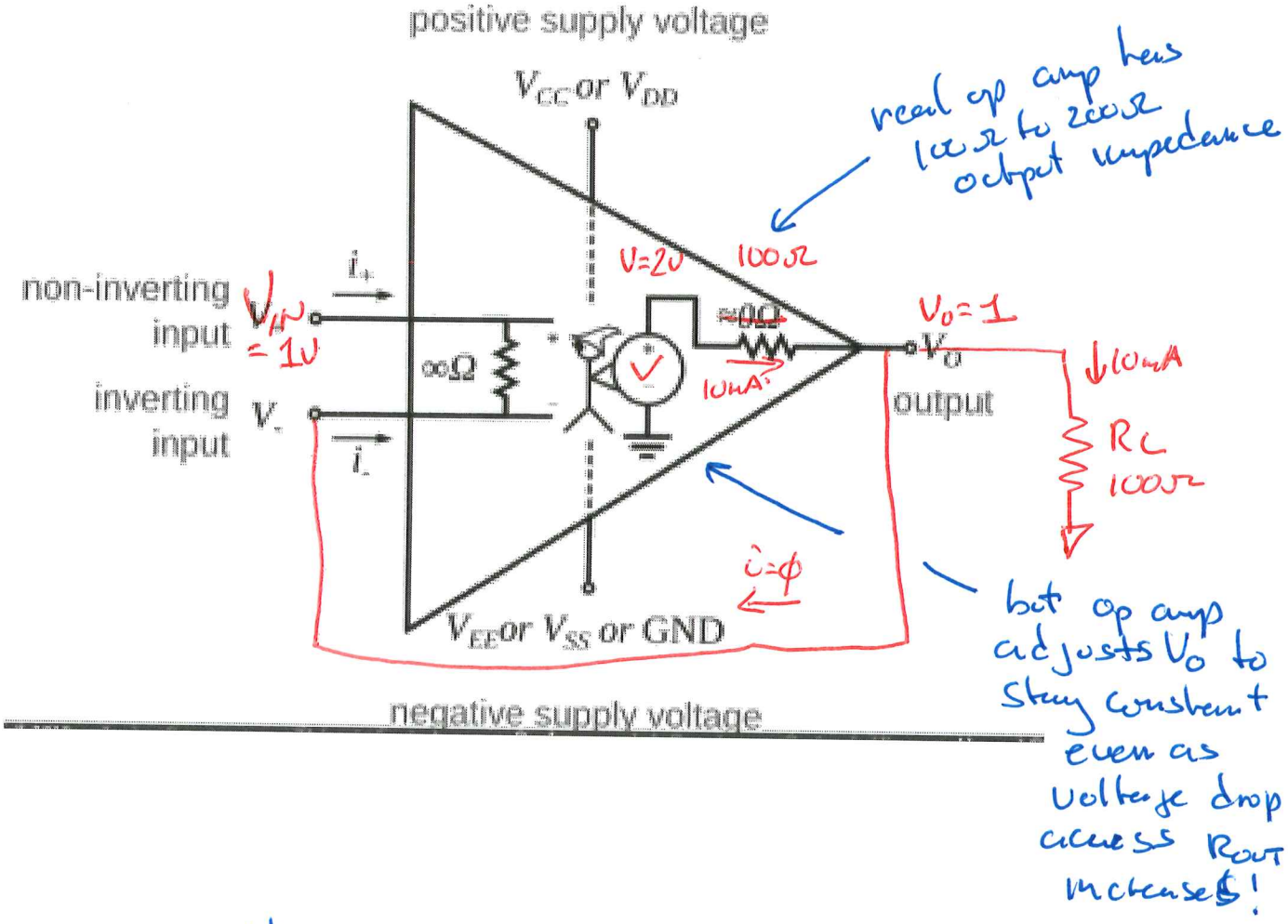
$V_{OUT}(1+A) = AV_{IN}$

actual closed loop gain

CF 411

$$\frac{V_{OUT}}{V_{IN}} = \frac{A}{1+A} = \frac{200{,}000}{200{,}001} = .999995$$

pretty close to perfect O.A.

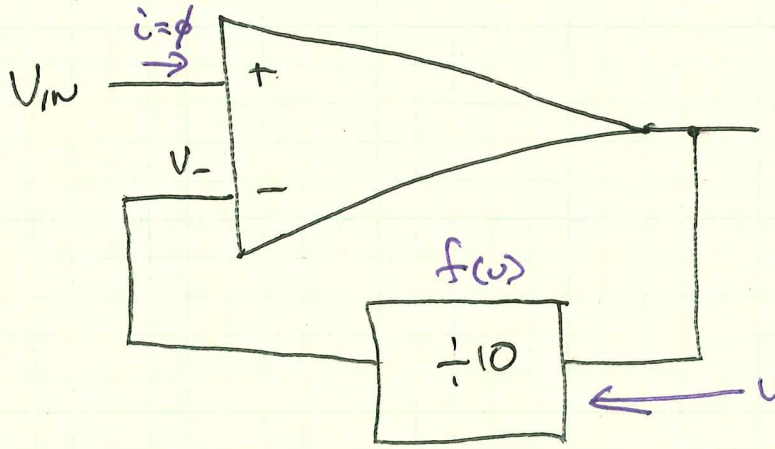


real op amp has 1Ω to 200Ω output impedance

but op amp adjusts V_O to stay constant even as voltage drop across R_{OUT} increases!

How large open loop gain of op amp makes actual output ≠ of op amp negligible

How about this Circuit?



undoes whatever we put in feedback

is there neg feedback? Yes

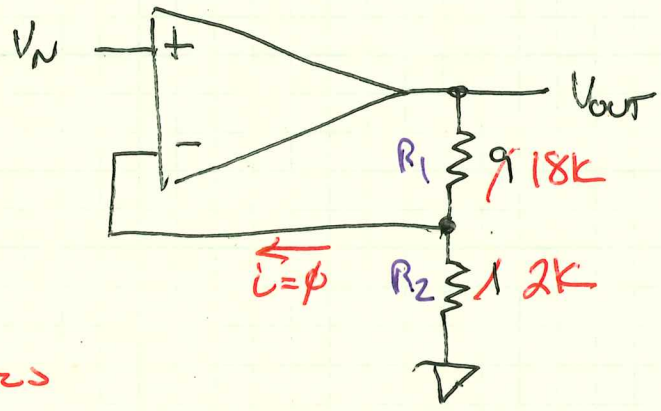
$V_{IN} = V_+ = V_-$

$V_- = \frac{V_{OUT}}{10}$

$V_{IN} = \frac{V_{OUT}}{10}$

non inverting gain of 10 amplifier

$Gain = \frac{V_{OUT}}{V_{IN}} = 10$ ← op amp must undo what ever the feedback does so $V_- = V_+$



since no current flows into V−

$\frac{R_2}{R_1+R_2} V_{OUT} = V_-$

$\frac{V_{OUT}}{V_{IN}} = \frac{R_1+R_2}{R_2}$

$Gain = \left(1 + \frac{R_1}{R_2}\right)$

Closed loop min gain is 1 for non-inverting configuration

in general keep resistors
≥ 1k
≤ 1Meg
so don't have to worry about imperfections