EE 435
Homework 1
Spring 2025
Due Wednesday Jan 29

Problem 1   Identify one operational amplifier that has been published in one of the following in the past 5 years:

        IEEE Journal of Solid State Circuits
        IEEE Trans. On Circuits and Systems (Part 1 or Part 2)
        IEEE International Symposium on Circuits and Systems

Give the circuit schematic, citation information, and briefly summarize the useful properties that the author claims for the circuit that you identify.

Problem 2   Identify one operational amplifier that has been patented in the past 5 years.   Give the circuit schematic, patent number, and briefly summarize the useful properties that the author claims for this circuit.

Problem 3   A block diagram of what is often termed a voltage-series feedback amplifier[1] is shown below where it is assumed that the forward A amplifier is a voltage amplifier with an input impedance of R_{IN}, an output impedance of R_0 and a forward voltage gain of A_V.   The internal feedback amplifier, denoted with the symbol β, is assumed to be an ideal voltage amplifier (likely an attenuator) with infinite input impedance and zero output impedance with feedback signal $\mathcal{V}_F = \beta \mathcal{V}_{OUT}$.   The desensitivity, D, of a feedback amplifier is defined by the expression $D = 1 + A_V \beta$.   The voltage gain A_V can itself be frequency dependent and modeled by the expression

$$A_V(s) = \frac{A_{V0}}{\frac{s}{BW} + 1}$$ where A_{V0} is the dc gain of the forward amplifier and BW is the

bandwidth of the forward amplifier.
Under these assumptions, show analytically that
    a) The input impedance of the feedback amplifier is improved by D (i.e. $R_{INF} = R_{IN} \cdot D$)
    b) The output impedance of the feedback amplifier is improved by D (i.e. $R_{OF} = R_O / D$)
    c) The closed loop bandwidth is improved by D (i.e. $BW_{FB} = BW*D$)
    d) The sensitivity of A_{FB} with respect to A_V has improved by D (i.e. $S_{A_V}^{A_{FB}} = \dfrac{S_{A_V}^{A_V}}{D}$)

Voltage Feedback Amplifier
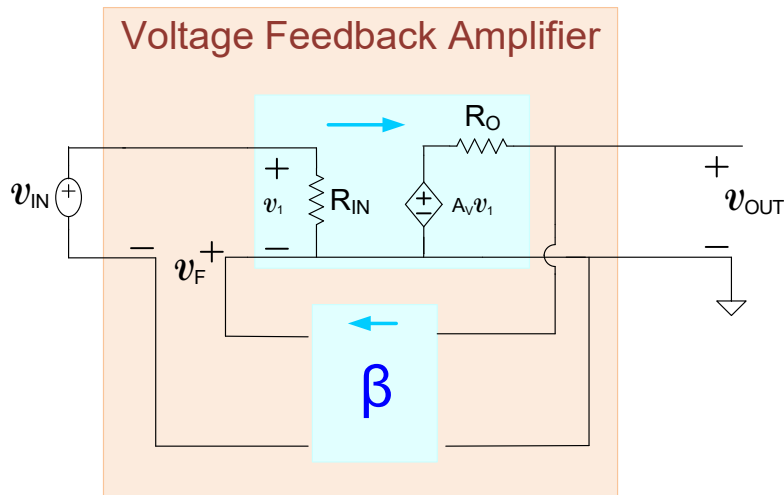
Note: The improvements in this amplifier appear to be dramatic since the desensitivity D can be very large. But the improvements might not be quite as good as the calculations suggest since the assumptions of ideality of the β amplifier may be difficult to completely meet and because it may be difficult to get perfect summing of V_{IN} and V_F. But in good feedback designs, the improvements in these parameters can be really significant.

[1]Notation associated with feedback amplifiers is often a bit cumbersome since the whole structure comprised of the "A" and "β" networks is often called a feedback amplifier. And internal to this structure, there is a "β" network which is an amplifier that provides a feedback signal so it is often referred to as a feedback amplifier as well. In this problem, the term "feedback amplifier" will refer to the whole structure and "local feedback amplifier" will refer to the "β" network to avoid possible confusion.

Problem 4   In the previous problem, feedback was used to build a voltage feedback amplifier with improvements in four key characteristics. Consider now the current feedback amplifier shown below where it is assumed that the β amplifier is an ideal current amplifier with zero input impedance and infinite output impedance characterized by the equation $i_F = \beta i_{OUT}$. The desensitivity is now defined by the expression $D = 1 + A_I \beta$. Express R_{INF} in terms of the desensitivity and the parameters in the feedback amplifier and comment on these results relative to what was obtained for the voltage feedback amplifier in the previous problem.

Feedback Amplifier

i_1

i_{IN}

i_F

i_F

R_{IN}

$A_i i_1$

R_O

i_{OUT}

R_L

+

−

β
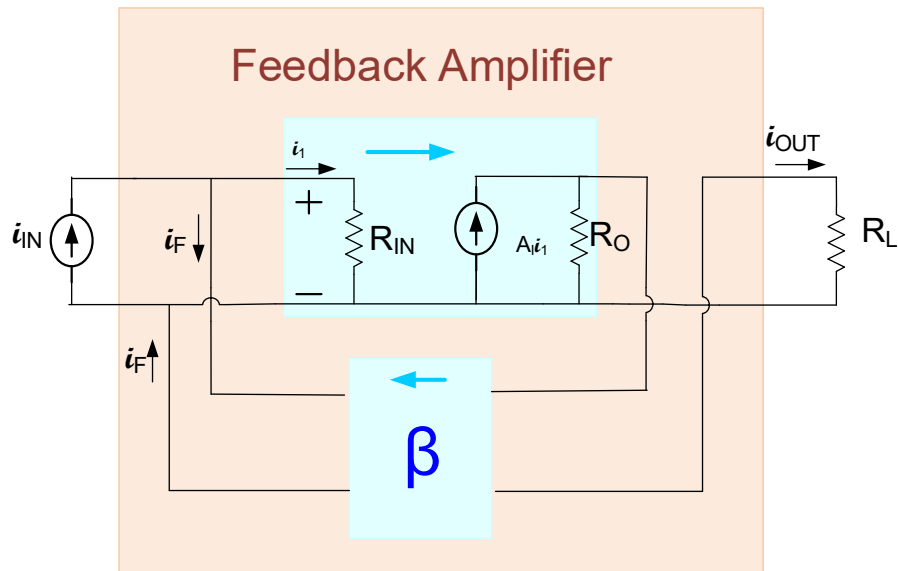
Problem 5   In most texts, data sheets, and circuit schematics the operational amplifier is represented as a 3-terminal device yet the two-port model of an operational amplifier has 4 terminals (i.e. nodes) as shown below.   It thus appears that one terminal has somehow vanished in the symbol or equivalently appeared in the two-port model. Correspondingly, the model of the operational amplifier that is described in the most recent version of the Sedra-Smith text shows four terminals (one designated with the ground symbol) yet this ground terminal does not appear to be on the op amp symbol or on the pinout of the operational amplifiers we are using in the laboratory. Rigorously reconcile this concept of the vanishing terminal !


Ideal Voltage Amplifier
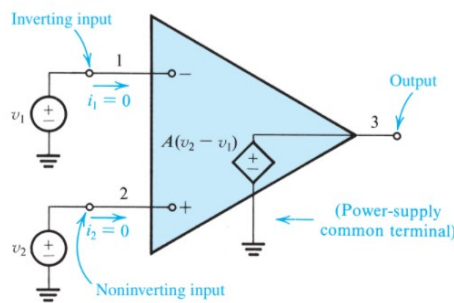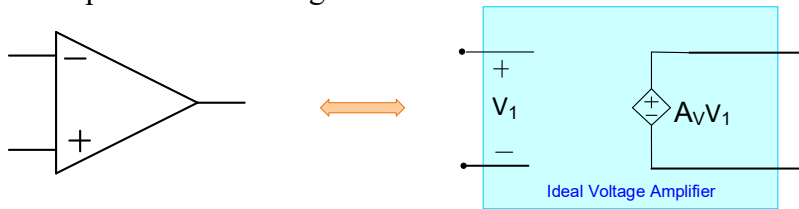
Problem 6   The actual op amp is a five-terminal device. After reconciling this issue of the vanishing terminal in the previous problem, give an expression for the nodal output voltage with respect to V_{SS} for the operational amplifier shown below which explicitly shows the 5 terminals of the device.
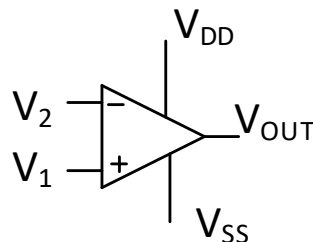
Problem 7   Two circuits that use a single operational amplifier are shown below.
   a) Using the model of the standard model of the operational amplifier that appears in the Sedra/Smith book, analyze the two circuits under the assumption that the voltage gain of the op amp, A_V, is finite.
   b) Compare the voltage gain of the two circuits as the voltage gain A_V goes to ∞

c) Although an engineer should be able to analyze any interconnection of basic devices and components, almost all basic electronics textbooks are silent on the existence of the simple circuit on the right. Why is this circuit is seldom discussed? Support your answer with sound analytical principles or concepts.
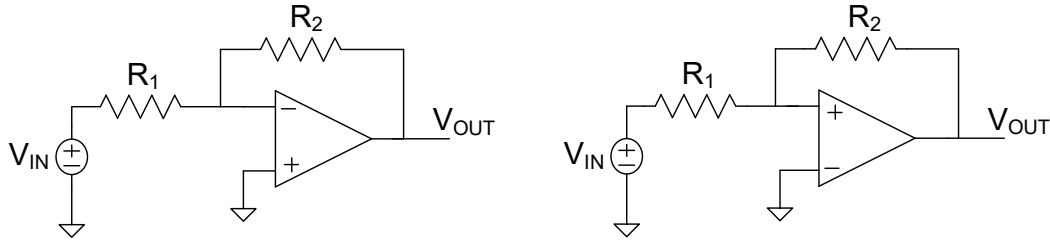
Problem 8 (Extra Credit)   One example was given in class where Conventional Wisdom does not correctly reflect reality and that was in describing the concept of the operational amplifier. Another example, also related to operational amplifiers, is the "vanishing ground" of Problem 5 in this homework assignment.   See if you can identify another example, preferably in the electronics field, where Conventional Wisdom is not correctly aligned with reality.