214 homework 4

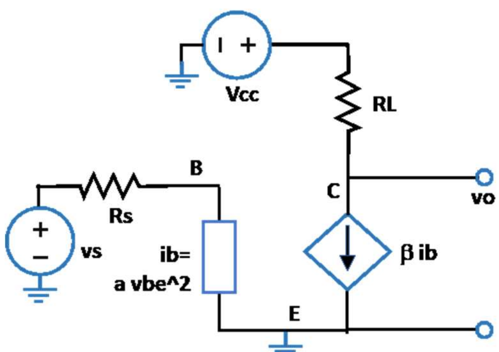
1. According to zybooks, a diode can be modelled with a quadratic dependence of current vs input voltage. Therefore the base-to-emitter diode in a transistor can be modelled the same way ib = a vbe^2 (for Vbe > 0), as shown in the circuit diagrams below. For the op amp model its output is vo1=A(vp-vn) where vn and vp are the voltages at the negative and positive terminal respectively. When plots are required choose a=0.001, Rs=100 Ohm, RL=10 Ohm, beta=100, Vcc=5 V.

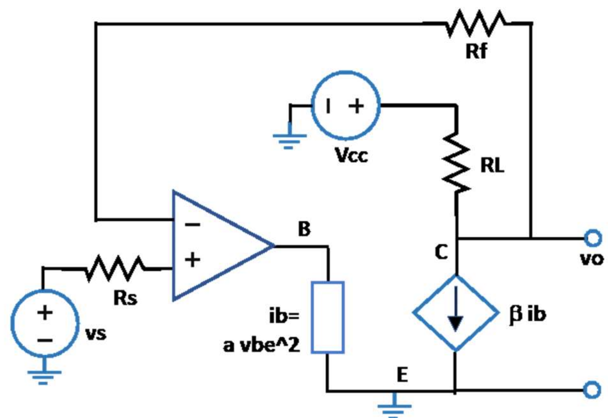
A) For the circuit diagram on the left write all the equations needed to find the output voltage vo as a function of the source voltage vs.

B) Plot vo for vs in the range 0 to 2 V.

C) For the circuit diagram on the right write all the equations needed to find the output voltage vo as a function of the source voltage vs.

D) What does the expression for the output voltage as a function of the source voltage become in the limit of large op amp gain?





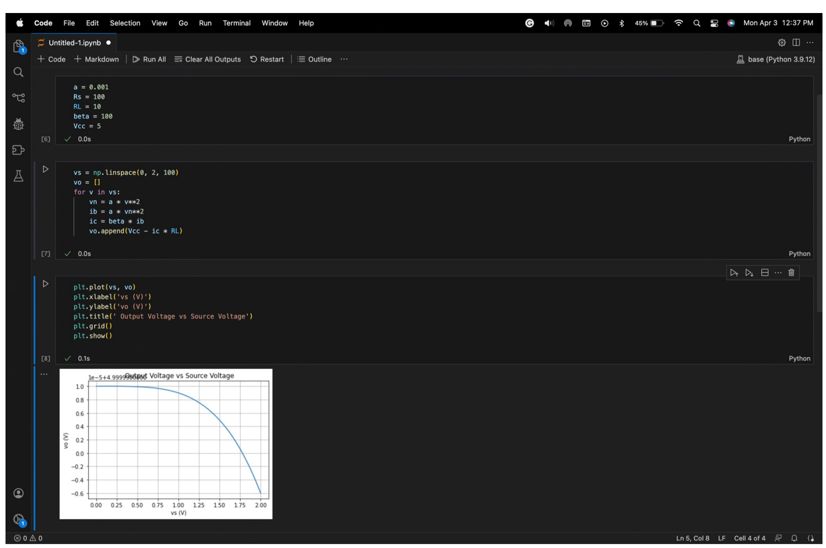
A.) $I_1 = \frac{V_s - V_n}{R_s}$

$I_2 = I_o$

$I_c = \beta I_b$

$V_o = V_{cc} - I_c \cdot R_L$

B.



C.) $V_1 = V_n$

$V_n = a \cdot V_{out}^2$

$V_2 = V_s$

$V_o = A \cdot (V_2 - V_1)$

D.) $V_o = A \cdot (V_s - a \cdot V_{out}^2)$

$V_1 = V_n = a \cdot V_{out}^2$

$V_o = A \cdot (V_p - V_n) = A(V_2 - V_1)$

$= A(V_s - aV_{out}^2)$

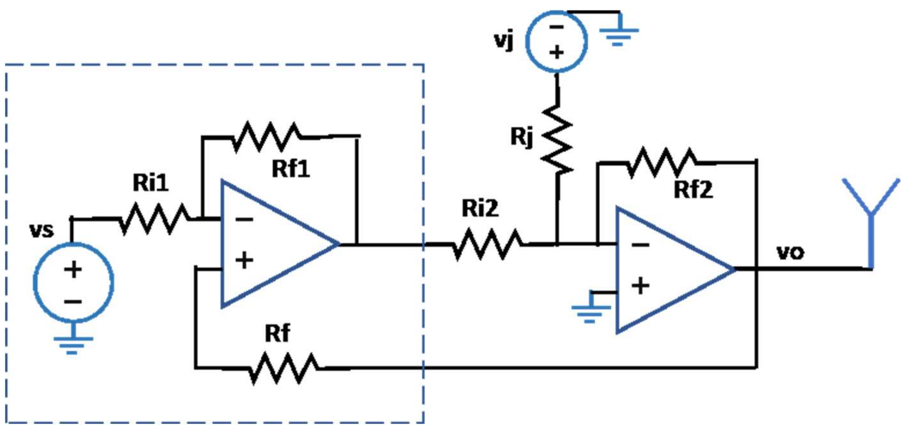
2. Consider a dual stage op amp amplifier, shown below that drives a transmitter antenna. The first amplifier is high gain and operates inside a protective enclosure. The second op amp is lower gain but can produce a higher output power and is placed outside the enclosure. As shown, feedback is applied by sampling the second op amp output and applying it to the input of the first op amp. Consider the case when a jamming signal is applied to the outside amplifier. For simplicity model this as a voltage vj applied through a resistor Rj, as shown below. When plots are required choose Ri1=100 Ohm, Ri2=100 Ohm, Rj=100 Ohm, Rf2=1 kOhm, Rf=10 kOhm, vs=1 V, vj=100 V, Vcc=10 V.

A) Write all the equations needed to find the output voltage vo as a function of the source voltage vs and the jammer voltage vj.

B) What is the equation for vo as a function of vs and vj in the limit of a large gain of the first stage op amp?

C) What is the output voltage if the first stage has a gain of 1?

D) Plot the output voltage as a function of gain of the first op amp from gain of 1 to 1000.



A) $V_o = -V_{o1}\left(\frac{Rf_2}{Ri_2}\right) - V_j\left(\frac{Rf2}{R_j}\right)$

B) Equation –

$$V_o = \frac{A}{A^2 - 2.1A + 1.1}\left[A\ 10V_s - (1.1 - 0.1A)10V_j\right]$$

C) $A = 1$

$$V_o = \frac{10A - (1.1 - 0.1A)10^3}{A^2 - 2.1A + 1.1}$$

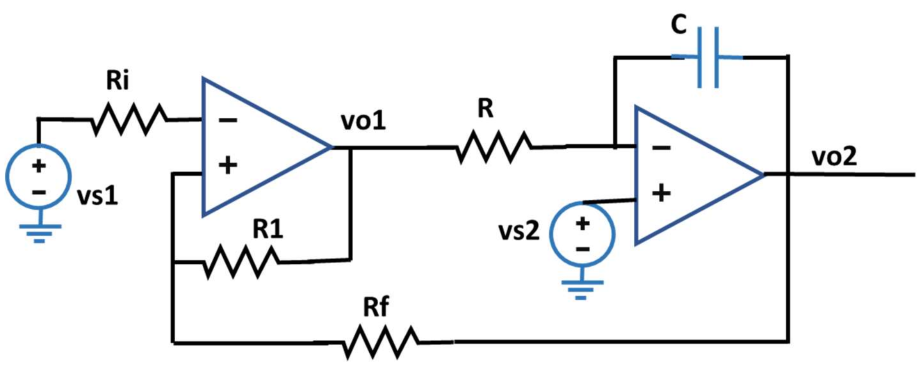
3. The dual op amp circuit below has two outputs vo1 and vo2. Note that the first op amp has positive feedback and so is saturated to +Vcc or –Vcc. Because of this the two input voltages, vn1 and vp1, are not necessarily equal. Begin with Vs1=0=Vs2.

A) Find the equations for both outputs as a function of time. Assume initial values of vo1(0)=+Vcc, vo2(0)=0 V.

B) Plot the output of both op amps for two cycles. For this choose vs1=0 V, vs2=0 V, Ri=100 Ohm, R1=200 Ohm, R=100 Ohm, Rf=100 Ohm, C=0.01 mF, Vcc=10 V

C) What happens to the waveform as Vs2 is increased?

D) What happens when Vs1 is increased?



a) Made up of INTEGRATOR CIRCUIT AND NON-INVERTING AMP..

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

$$V_{out2}(t) = \frac{1}{R_{in} C} \int_0^t V_{in} dt \quad \text{AND} \quad V_{out1}(0) = +V_{cc}$$