İTÜ-EEF ANALOG ELECTRONIC CIRCUITS 2014

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MİDTERM EXAM Nov. 12, 2014

1)- For the circuit given, U1 & U2 are differential amplifiers (*but not operational amps*) with input resistance r_{i1}=20k, output resistance r_{o1}=1k, gain Z_m=4kΩ, r_{i2}=3k, r_{o2}=5k, K_v=200. Connect a suitable signal source to the input.

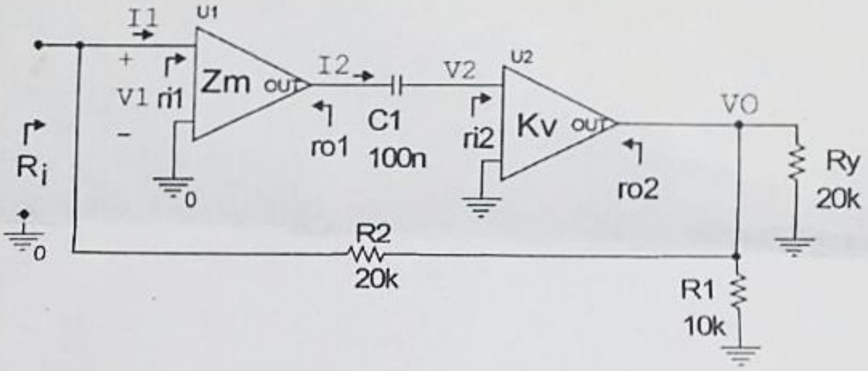
a)- Identify the type and topology of the feedback (*negative-positive & configuration*); find the transfer function types for the **relevant** forward gain and feedback gain (β). The (+) & (-) terminal labels of the amplifiers are missing in the circuit diagram: identify the input connections so that feedback is negative. Draw the small signal circuit diagrams for the open loop amplifier including the loading effect of the feedback circuit, and for the feedback circuit clearly.

b)- Write the transfer functions for the forward gain (A_0) and the feedback gain (β) for the midband frequencies and calculate the gain for each (open loop). Calculate the closed loop gain (A_f).

c)- Find the gain Vo/Vg of the circuit below when the input source is a voltage source Vg.

d)- Find R_i & R_o of the circuit below (clearly identify your R_o).

e)- If the only reactive component in the circuit is C1, find the associated poles and zeroes, and write the closed loop transfer function of the circuit $A_f(s)$.



2)- Feedback will be applied to a 3-pole amplifier with the transfer function:

$$K_v(f) = \frac{K_0}{(1+j\frac{f}{f_1})(1+j\frac{f}{f_2})(1+j\frac{f}{f_3})}$$

Poles are at f_1=4kHz, f_2=400kHz, and f_3=4MHz. K_0=14140.

a)- Draw the open loop Bode magnitude and phase diagrams as accurately as possible, and mark the important points and slopes. Find the gain and phase margins for unity feedback and mark on the Bode diagrams. Find and mark f_0 (0dB intercept) and f_{180} (180° phase intercept) Based on your findings, comment on the stability of the closed loop amplifier.

b)- Find the value range for the closed loop gain (A_f) and β where the amplifier stays stable.

c)- When we apply feedback, we desire the closed loop amplifier to have a worst case gain margin of 45°. Apply dominant pole compensation to the open loop amplifier to achieve this (i.e., find the frequency of the new 4th pole to achieve the worst case PM).

Hint: In this question, first look at the Bode diagrams and think, before writing and solving equations!

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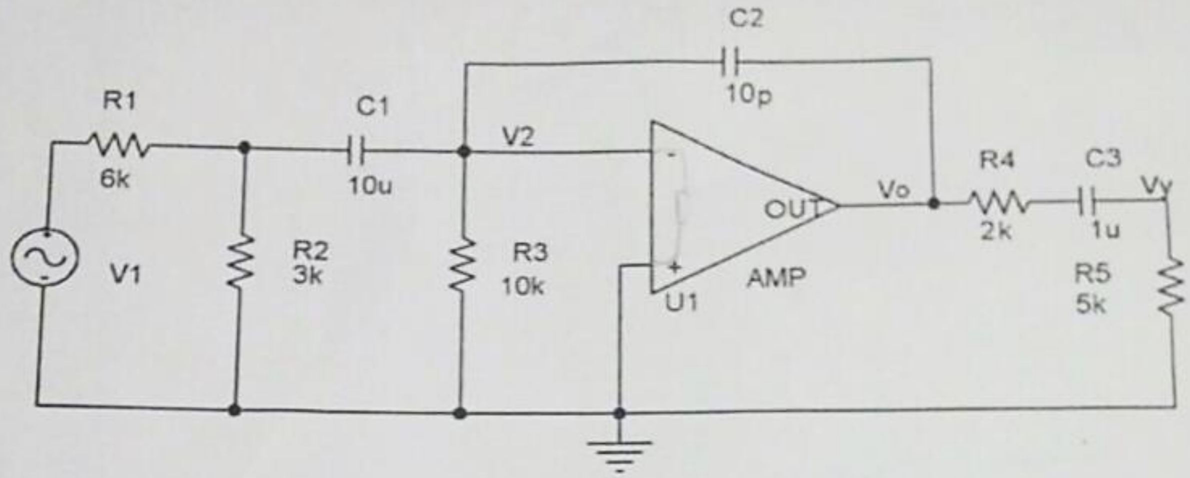

3)- For the circuit above:**U1 |gain|=10mA/V, input impedance:10kΩ, output impedance:0Ω**

a)- Find the poles and zeroes due to C1, C2 & C3. Write the transfer function of the circuit: H(s)=Vy(s)/V1(s) explicitly (*do not simplify the numerator and denominator; keep them as a product of poles and zeroes*). Draw the Bode plots for the transfer function(Vy/V1) as accurately as possible (*magnitude and phase*). Calculate the -3dB low and high cutoff frequencies and mark them on the Bode plots. Find the midband gain.

b)- It is desired to have a 40db/decade attenuation following the high cutoff frequency; connect a capacitor C4 to an appropriate point in the circuit (show on your circuit diagram) and find a suitable value for C4 that satisfies this requirement.

c)- If the input to the circuit is a pulse train, find the rise time; find the tilt when the input pulse width is 200μs. Approximately draw the output waveform.

Points: 36 (8+12+4+6+6) + 32 (16+4+10) + 32 (16+8+8) =100 **Time 110".**

Notes: Closed books & notes. No cellphones. You may use an A4 size (both sides allowed) formula sheet containing whatever you think you may need during the exam. You may make reasonable engineering approximations. All your approximations, roundings, and assumptions should be clearly visible. Be careful with your units.

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