İTÜ-EEF ANALOG ELECTRONIC CIRCUITS 2013

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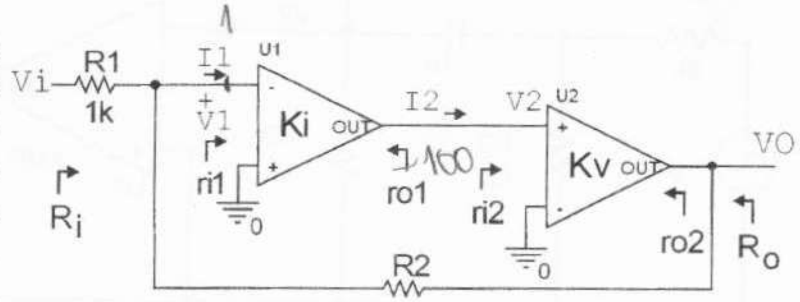
MİDTERM EXAM Nov. 27, 2013

1)- For the circuit given, U1 & U2 are differential amplifiers (*but not operational amps*) with input resistance r_{i1}=2k, output resistance r_{o1}=100k, gain K_i=80, r_{i2}=3k, r_{o2}=5k, K_v=100. Input Vi is connected to an ideal voltage source. R2=33k.



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). Draw the small signal circuit diagrams for the open loop amplifier including the loading effect of the feedback circuit, and 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).

c)- Find the relevant closed loop gain and Vo/Vi at midband.

d)- Find R_i & R_o marked on the circuit.

e)- If the feedback resistance R2 is connected to the U1(+) terminal rather than the U1(-) *(U1+ no longer connected to ground; no other changes in the circuit!)*, find the feedback topology(*negative-positive & configuration*) and Vo/Vi for the new circuit.

f)- Repeat parts a-b-c-d when R1=0. (THINK FIRST!)

Solve parts a-b-c-d so that you can use the common part of the solution in part f.

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=10kHz, f_2 =100kHz, and f_3 =10MHz.

K_0=100,000 [V/V]

a)- Draw the open loop Bode magnitude and phase diagrams as accurately as possible, and mark the important points and slopes. When we apply feedback, find the gain and phase margins for unity feedback and mark on the Bode diagrams. Based on your findings, comment on the stability of the closed loop amplifier.

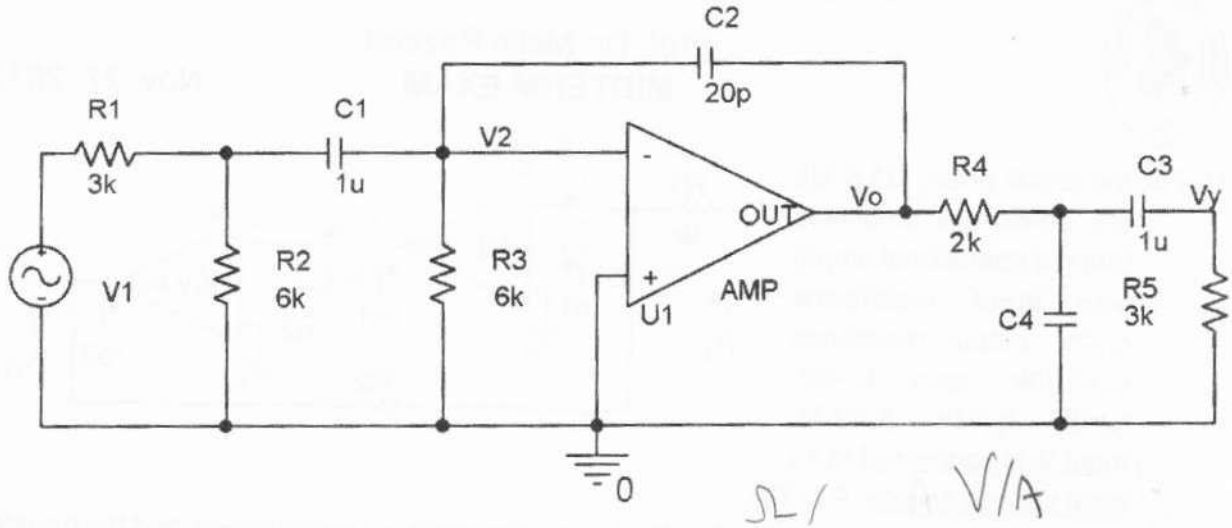
b)- Find the value range for the closed loop gain (A_f) where the amplifier stays stable.

c)- Find the value range for β so that the gain margin is better than 20dB.

d)- When we apply feedback, we desire the closed loop amplifier to have a worst case gain margin of 45°. In order to satisfy this condition, you will change the f_1 pole frequency for compensation. Find the frequency range for f_1 that satisfies PM ≥45°. Explain/show clearly why your choice of f_1 satisfies the requirement.

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

CONTINUED ON THE BACK- TURN OVER ☞



Ω / V/A

3)- For the circuit above: **U1 |gain|=120kΩ/A, input impedance:6kΩ, output impedance:0Ω**

a)- Findthe poles and zeroes due to C1, C2 & C3 (C4=0). 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; find a suitable value for C4 that satisfies this requirement.

c)- In order to reduce the bandwith of the circuit that you found in part (a) for C4=0, you are allowed to change the value of only one component. Identify and find the required value of this component (clearly explain why). If there is more than one solution, select the component with the smallest value. You may use C4 in this part.

d)- 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: 34 (7+8+4+5+4+6) + 34 (15+5+6+8) + 32 (18+4+5+5) = 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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