THE UNIVERSITY OF BRITISH COLUMBIA
Department of Electrical and Computer Engineering
EECE356 Quiz 4 – December 2, 2011

Time: 30min.
This examination consists of 5 pages. Please check that you have a complete copy. You may use both sides of each sheet if needed.

READ THIS

Surname First

Solutions

Student Number

Page #	MAX	GRADE
1	60	
2	40	
TOTAL	100	

IMPORTANT NOTE: The announcement "stop writing" will be made at the end of the examination. Anyone writing after this announcement will receive a score of 0. No exceptions, no excuses.

All writings must be on this booklet. The blank sides on the reverse of each page may also be used.

Each candidate should be prepared to produce, upon request, his/her Library/AMS card.

*Read and observe the following **rules**:*
Candidates are not permitted to ask questions of the invigilators, except in cases of supposed errors or ambiguities in examination-questions.

***Caution** - Candidates guilty of any of the following, or similar, dishonest practices shall be immediately dismissed from the examination and shall be liable to disciplinary action:*

- *Making use of any books, papers or memoranda, calculators, audio or visual cassette players or other memory aid devices, other than as authorized by the examiners.*
- *Speaking or communicating with other candidates.*
- *Purposely exposing written papers to the view of other candidates.*

The plea of accident or forgetfulness shall not be received.

NOTE: NO PROGRAMMABLE CALCULATORS, NO CELLPHONES, NO OTHER ELECTRONIC AIDS, NO NOTES, NO FORMULA SHEET and NO BOOKS ARE PERMITTED.

1. The op amp in figure 1 has an open-loop gain of 2×10^5 and a bandwidth of 20Hz.
   (a) Identify the type of feedback for the circuit (for the input mixing node, and for the output, sampling node). Based on this compute the feedback network gain β.
   (b) Use feedback techniques to calculate the gain and bandwidth for the closed loop configuration

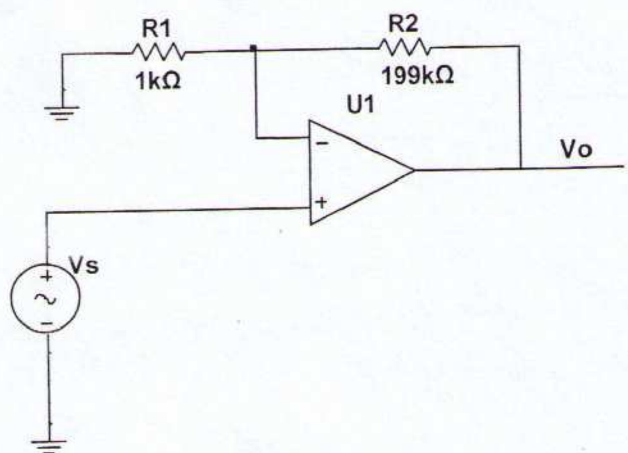
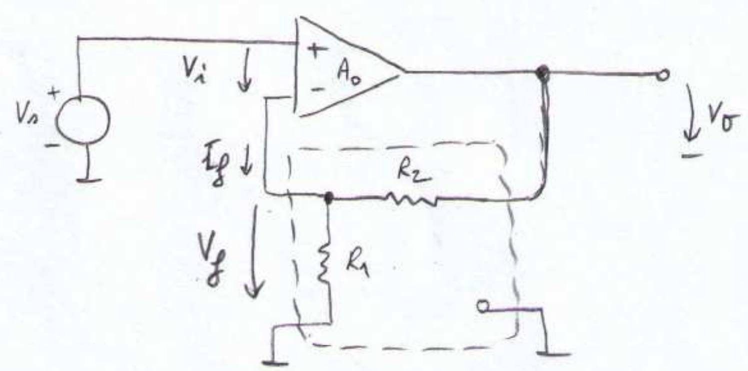


Figure 1

(a)



Sampling node → V_o is the common variable ⇒ shunt-type of feedback at output

Mixing node: $V_s = V_i + V_f$ ⇒ feedback in voltage ⇒ series type of feedback at input ⇒

$$\left(x_s = x_i + x_f \qquad x_s \longrightarrow \oplus \longrightarrow x_i \right), \quad \uparrow x_f$$

⇒ The circuit has a series-shunt feedback

$$\beta = \left.\frac{V_f}{V_o}\right|_{I_f = 0} = \frac{R_1}{R_1 + R_2} = \frac{1}{1 + \frac{R_2}{R_1}}$$

(b) We know already that for a high gain

$$A_f \approx \frac{1}{\beta} = 1 + \frac{R_2}{R_1}$$

A more detailed computation: $A_f = \dfrac{A_0}{1 + A_0\beta} = \dfrac{1}{\beta + \frac{1}{A_0}} = \dfrac{1}{\beta} \cdot \dfrac{1}{1 + \frac{1}{\beta A_0}}$

$$A_f = \left(1 + \frac{199}{1}\right) \cdot \frac{1}{1 + \frac{1 + \frac{199}{1}}{2 \cdot 10^5}} = 200 \cdot \frac{1}{1 + \frac{200}{2 \cdot 10^5}} = \frac{200}{1 + 0.001} \approx 200$$

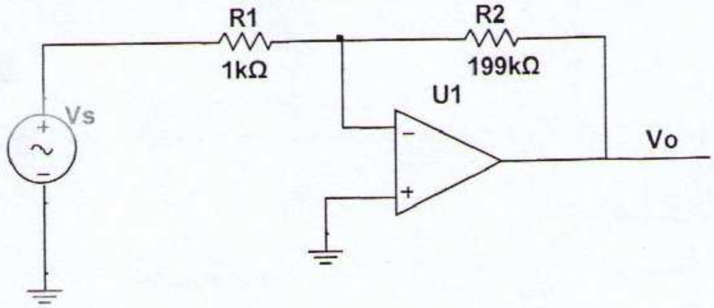
• For the bandwidth:

$$\omega_{H,f} = \omega_H (1 + A_0\beta)$$

$$\Downarrow$$

$$f_{H,f} = f_H (1 + A_0\beta) = 20\,Hz \cdot \left(1 + 2 \cdot 10^5 \cdot \frac{1}{1 + \frac{199}{1}}\right) = 20\,Hz \left(1 + \frac{2 \cdot 10^5}{200}\right) = 20\,Hz \cdot 10^3 = 20\,kHz$$

2. Given the circuit in figure 2
    a. Redraw the circuit such that to identify the type of feedback configuration, and compute the feedback network gain β.
    b. Use feedback theory to compute the closed loop gain, considering that the amplifier has an open loop gain $A=10^5$. (other types of computation will not get any points)

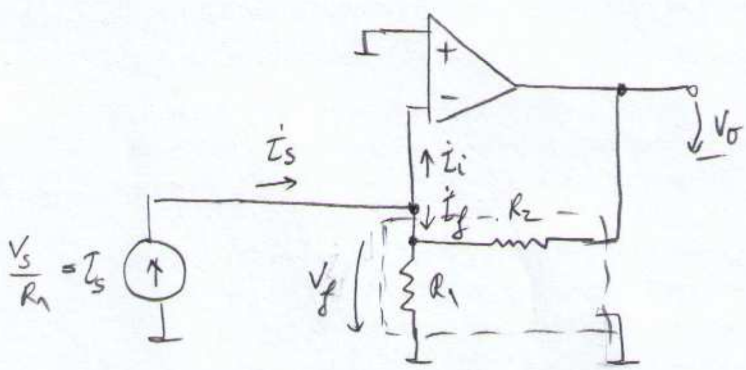


(a) Figure 2

. The feedback < sampling node – shunt
mixing node – shunt → this becomes obvious if we redraw the circuit:

⇓

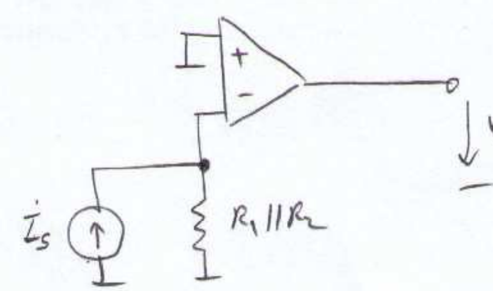
shunt – shunt feedback type



$$\beta = \left.\frac{I_f}{V_o}\right|_{V_f = 0} = -\frac{1}{R_2}$$

(b)

$$R_{if} = \left.\frac{V_f}{I_f}\right|_{V_o = 0} = R_1 \| R_2$$



$$A_z = \frac{V_o}{I_s} = -(R_1 \| R_2)\cdot A_o \gg 1$$

⇓

$$A_{z,f} \approx \frac{1}{\beta} = -R_2 = \frac{V_o}{I_s} = \frac{V_o}{V_s}\cdot R_1 \Rightarrow \boxed{\frac{V_o}{V_s} = -\frac{R_2}{R_1}}$$

· A more detailed computation

$$A_{z,f} = \frac{A_z}{1+\beta A_z} = \frac{-(R_1 \| R_2)\cdot A_0}{1+\left(-\frac{1}{R_2}\right)\cdot\left(-R_1\|R_2\right)\cdot A_0} = \frac{1}{\beta}\,\frac{1}{1+\frac{1}{A_z\cdot\beta}}$$

$$A_{z,f} = (-R_2)\cdot\frac{1}{1+\frac{1}{(R_1\|R_2)A_0\cdot\frac{1}{R_2}}} = \left(-199\cdot 10^3\,\Omega\right)\cdot\frac{1}{1+\frac{199\cdot\cancel{10^3}}{\cancel{10^3}\cdot 10^5}} = \frac{-199\cdot 10^3}{1+2\cdot 10^{-3}}$$

$$A_{z,f} = \frac{-199\cdot 10^3}{1{,}002} \approx -199\cdot 10^3$$

$$\Downarrow$$

$$A_{v,f} = -\frac{R_2}{R_1} = -199$$