INDIAN INSTITUTE OF TECHNOLOGY DHARWAD
Dharwad, 580 011

Wednesday 03^{rd} Nov. 2021	**EE 202: Introduction to Analog Circuits** Quiz 2 - Part B	Time: 1630 to 1700 Marks: 15

Make suitable assumptions where you deem necessary and state them in the answerbook.

Write the question number clearly before every answer and show the intermediate steps to demonstrate your thought process.

Write page numbers on all your answer sheets.

You should stop writing at 1620. Take pictures of your answer sheet with the page numbers visible and submit it on Moodle before 1830 Hrs. Your submission could be a zip file of all images or a single PDF file. Please note that Moodle submission link will automatically get disabled at 1630. I will not accept any email submissions.

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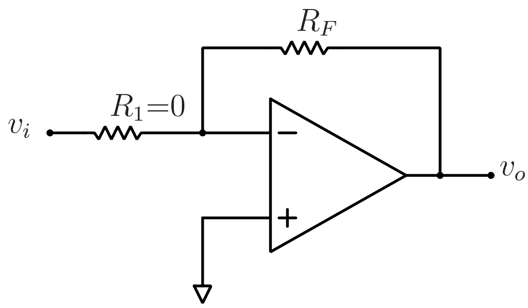
1. Explain how we can design an amplifier to have zero input impedance. Give one example where this circuit would be useful. $\boxed{5}$

Solution: We can design an amplifier with zero input impedance by using an opamp as an inverting amplifier



In a standard inverting amplifier, the input impedance is R_1. By short circuiting this resistance, we can make the amplifier have zero input impedance.

(3 marks)

This circuit is useful in interfacing sensors whose output is in the form of a current. For example, photodetectors have a high output impedance and the output signal is a current whose value is directly proportional to the intensity of light impinging on the detector.

(2 marks)

2. In the circuit shown in Figure 1, find an expression for the current I_z through the feedback impedance Z. $\boxed{4}$

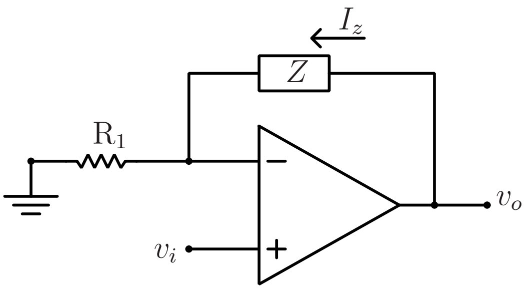


Figure 1: Circuit for question 2.

> **Solution:** This is a negative feedback circuit. The opamp will drive the output to make the potentials at its two inputs equal, i.e. $v^- = v^+ = v_i$.
>
> (2 marks)
>
> The current through the resistor R_1 can therefore be written as $I = v_i/R_1$. Due to the high input impedance of the opamp input terminals, the current drawn by the input terminals of the opamp is negligible. Therefore the current $I_z = v_i/R_1$.
>
> (2 marks)

3. For the circuit shown in Figure 2, is the overall feedback negative or positive? Find an expression for V_o/V_{in} $\boxed{6}$

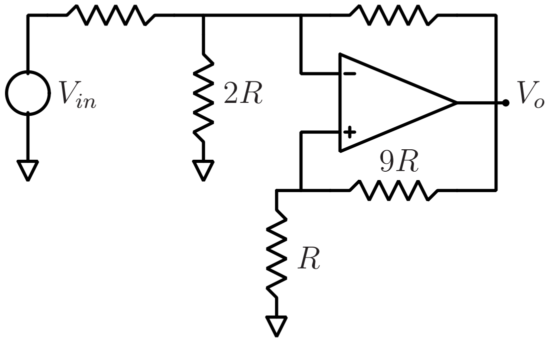


Figure 2: Circuit for question 3

> **Solution:** This circuit has both positive and negative feedback. The respective feedback factors can eb written as
>
> $$\beta_{positive} = \frac{R}{R+9R} = \frac{1}{10}$$
> $$\beta_{negative} = \frac{R}{3R} = \frac{1}{3}.$$

Since $\beta_{negative} > \beta_{positive}$, the overall feedback is negative.

(2 marks)

Since the overall feedback is negative, we know that the opamp will drive the output in such a way that $v^- = v^+$.

v^+ can be written as

$$v^+ = V_o \frac{1}{10}.$$

We will now write KCL at v^- as

$$\begin{aligned} \frac{V_{in} - v^-}{2R} &= \frac{v^-}{2R} + \frac{v^- - V_o}{2R} \\ \Rightarrow v^- &= \frac{V_{in} + V_o}{3}. \end{aligned}$$

We can now solve for V_o/V_{in} as

$$\begin{aligned} v^- &= v^+ \\ \frac{V_{in} + V_o}{3} &= V_o \frac{1}{10} \\ \frac{V_o}{V_{in}} &= -\frac{10}{7}. \end{aligned}$$

(4 marks)