Name: SOLUTION **Roll No.** **Batch:**

Signature :

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MS101 – Makerspace

2023-24/I (Autumn Semester)

Aug 23, 2023 (Wed) **EE Quiz - 1** **Time: 45 min**

Marks: 30

1. This **Question-cum-Answer Booklet** has 4 pages and 12 questions.
2. Write your **answers only in the space provided for answers**. Answers written at any other place will not be checked. You may use the page margins for rough work.
3. No explanations / clarifications will be given to any of the questions.
4. No negative marks for wrong answers, however steps are required for all numerical answers.

1. State whether the following statement is TRUE or FALSE. Justify your answer in just *one* sentence.

   A step-up transformer can be considered as an amplifier since its secondary voltage is larger than the primary voltage.

Marks: 2 (= 1+1)

Answer: ~~TRUE~~ / **FALSE**

One-sentence justification: **In a transformer there is no power gain and hence it does not qualify to be called an amplifier.**

2. A practical voltage source has an open circuit voltage of 10 V. When a 1.75 kΩ resistor is connected as load across its terminals, the terminal voltage drops to 8.75 V. What is the source resistance in ohms?
   No marks without steps.

Marks: 3

V_S = Source open circuit voltage, R_S = source resistance, R_L = Load resistance,
V_L = voltage across R_L , $_{IL}$ = current through R_L.

Method 1: R_L = 1. 75 kΩ, V_L = 8.75 V, Hence I_L = 8.75/1.75 = 5 mA.
$V_L = V_S - I_L \times R_S$. Substituting, 8.75 = 10 – (5 mA) x R_S; R_S = 1.25 V/5 mA = 250 Ω

Method 2: $V_L = V_S \times R_L/(R_S + R_L)$; Hence, $R_S = R_L \{ (V_S - V_L)/V_L\}$ = 1.75 kΩ x (10-8.75)/8.75 = 0.25 kΩ

Answer: **250 Ω**
Partial marks given only in case of minor mistakes, and when the steps are leading to the correct answer.

3. A practical current source is modelled as an ideal current source of 100 mA in parallel with a resistor of 240 kΩ. A load resistance of 10 kΩ is connected across this source. What is the load current?
   No marks without steps.

Marks: 2

I_S = Source current, R_S = source resistance, R_L = Load resistance.

Load current $I_L = I_S \times R_S/(R_S + R_L)$ = 100 mA x 240 kΩ /(240 + 10) kΩ = 96 mA

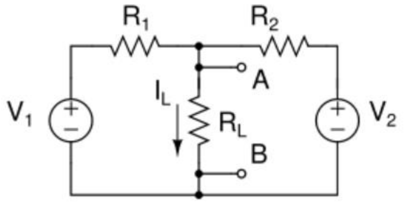
Answer: **96 mA**
Partial marks given only in case of minor mistakes, and when the steps are leading to the correct answer.

4. A resistive network is shown below.

$R_1 = R_2 = R_L = 3000\ \Omega$. $V_1 = -15$ V, and $V_2 = 6$ V.

Using superposition theorem, calculate V_{AB} and I_L **.**

No marks without steps.



Marks: 4 (= 2+2)

Answers:

$V_{AB} =$ **− 3 V**

(*2 marks if obtained using superposition theorem*)

$I_L =$ **− 1** mA

(*2 marks if obtained using superposition theorem*)

(*Answers without applying superposition theorem will be given only very little credit*).

Solution:

Method 1: Find V_{AB} and I_L considering V_1 alone, with $V_2 = 0$. Since $R_1 = R_2 = R_3$, $V_{AB1} = (1/3)\ V_1 = -5$ V

Hence, $I_{L1} = -5/3000 = -0.001666$ A or -1.66 mA.

Similarly, Find V_{AB} for $V_1 = 0$. $V_{AB2} = (1/3)\ V_2 = 2$ V ; $I_{L2} = 2/3000 = 0.00066$ A or 0.66 mA

Hence, $V_{AB} = V_{AB1} + V_{AB2} = -5\text{ V} + 2\text{ V} = \mathbf{-3\ V}$; $I_L = I_{L1} + I_{L2} = -1.66\text{ mA} + 0.66\text{ mA} = \mathbf{-1\ mA}$

(2 marks for V_{AB}, 2 marks for I_L)

Method 2: Find I_L and V_{AB} considering V_1 alone, with $V_2 = 0$. $I_{L1} = 0.5 \times V_1/(R_1 + [R_2 \parallel R_L])$

$= 0.5 \times (-15)/(3000+1500) = -0.001666\text{ A} = -1.66\text{ mA}$; $V_{AB1} = I_{L1} \times R_L = -1.666 \times 3\text{ k}\Omega = -5$ V

Similarly, find I_L for $V_1 = 0$. $I_{L2} = 0.5 \times V_2/(R_2 + [R_1 \parallel R_L]) = 0.5 \times 6/(3000+ 1500) = 0.00066\text{ A} = 0.66$ mA

$V_{B2} = I_{L2} \times R_L = 2$ V

Hence, $I_L = I_{L1} + I_{L2} = -1.66\text{ mA} + 0.66\text{ mA} = \mathbf{-1\ mA}$

$V_{AB} = V_{AB1} + V_{AB2} = -5\text{ V} + 2\text{ V} = \mathbf{-3\ V}$;

[2 (=1+1) marks for V_{AB}, 2 (=1+1) marks for I_L]

5. The current through a *pn* junction diode in the forward region can be approximated as:

$i_d = I_S \cdot \exp[v/V_T]$,

where v is the voltage across the diode, I_S is the reverse-saturation current and V_T is the thermal voltage.

If $V_T = 25$ mV, and $I_S = 10^{-13}$ A.

Calculate i_d for $v = 0.6$ V. Your current should be precise to the first decimal place.

Marks: 2

$i_d = I_S \cdot \exp[v/V_T]$,

$= 10^{-13} \times \exp[600/25]$

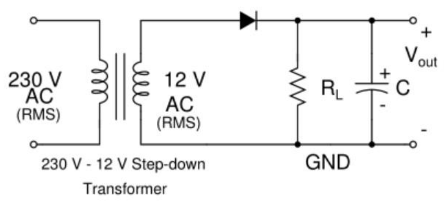
$= 2.6489$ mA

Answer: $i_d =$ **2.6 mA**

(*No partial marks for writing values in the given equation; partial marks only for numerical answers close to the answer*)

6. The circuit diagram of an unregulated DC power supply which employs a capacitive filter is shown below. The secondary voltage of the transformer is 12 Vrms.

If resistor R_L is removed from the circuit, what will be V_{out} in volts? Justify your answer in *one* sentence.



Marks: 3 (= 1 + 2)

Answer:

$V_{out} = \text{sqrt}(2) \times 12 = 1.414 \times 12 = 16.97 =$ **17 V**

(1 mark)

(No marks for $V_{out} = 12$ V. But $V_{out} = 17$ – one diode drop (0.6 or 0.7 V) will also be accepted as a valid answer)

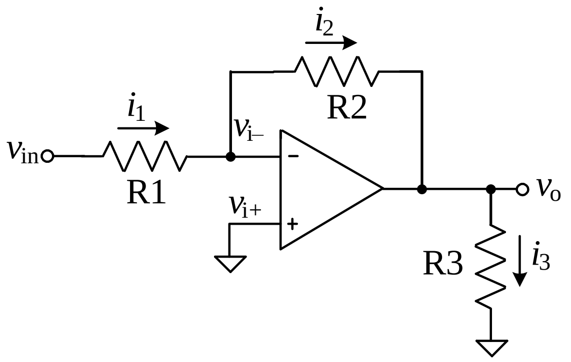
Justification (*one* sentence):

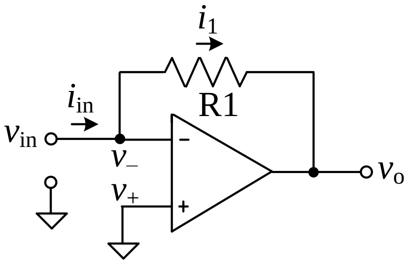
Since R_L is removed, there is no discharge and the capacitor will charge to the peak secondary voltage, which is $12\sqrt{2} = 17$ V.

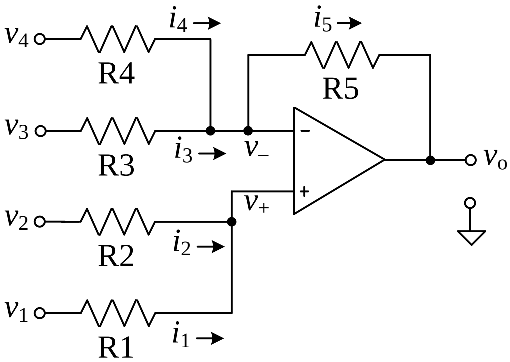
(2 marks)

7. How many conductors are needed for 8 single-ended signals?	Marks: 1 Answer: **9**

8. A function generator having source resistance of 50 Ω is connected to an amplifier. Which of the following options gives the highest voltage at the amplifier's input? A) R_{in} = 50 Ω B) R_{in} >> 50 Ω C) R_{in} << 50 Ω	Marks: 1 Answer: ~~A~~ B √ ~~C~~
9. Mark <u>all true</u> statements regarding <u>virtual short</u> across the input terminals of an op amp. (A) Virtual short means zero input currents into the input terminals and zero voltage across them. (B) Virtual short is not applicable if the op amp output reaches its higher or lower saturation voltage. (C) Virtual short requires the positive and negative supply voltages to have the same magnitude. (D) Virtual short requires the non-inverting input to be grounded.	Marks: 2 All correct statements: A √ B √ C D (*Fully correct: 2 marks; 1 mistake: 1 mark; 2 mistakes: 0.5 marks; All options chosen : 0 marks*)

10. In the op-amp circuit shown in the figure, R1= 100 kΩ, R2 = 50 kΩ, R3 = 100 Ω. Find the voltage, current, and power gains. Is it serving as an amplifier? 	Marks: 4 (= 1 x 4) Answer: (*Steps required in the spaces provided*) Voltage gain $A_v = v_o / v_{in}$ = – R2/R1 = – 50 kΩ /100 kΩ = **<u>– 0.5</u>** (*deduct 0.5 marks for wrong sign*) Current gain $A_i = i_3 / i_1$ = (v_o/R3)/ (v_{in}/R1) = (v_o/v_{in}) x (R1/R3) = – 0.5 x 1000 = **<u>– 500</u>** (*deduct 0.5 marks for wrong sign*) Power gain $A_p = A_v A_i$ = – 0.5 x – 500 = **<u>250</u>** (*deduct 0.5 marks for wrong sign*) Amplifier? **Yes** √ ~~No~~ (*No marks for this part without the above three parts as justification*)

11. In the I/V converter shown in the figure, R_1 = 100 kΩ. Find its trans-resistance and input resistance.  	Marks: 2 (= 1 + 1) Answer: $R = v_o/i_{in} =$ **R1 = 100 kΩ** (*No penalty* for *wrong sign*) $R_{in} = v_{in}/i_{in} = 0/i_{in}$ = **0 ohms** (*No partial marks*)

12. In the summer circuit shown in the figure, $R_1 = R_2 = R_3$ = 10 kΩ, $R_4 = R_5$ = 100 kΩ. Find the voltage gain and input resistance for the first and third inputs.  	Marks: 4 (= 1 x 4) Answer: (show steps) $A_{v1} = v_o/v_1$ = [(R2/(R1+R2)]x[1+R5/(R3 ‖ R4)] = 0.5 x [1 + 100k/(100k ‖ 10k)] =0.5 x [1+ 100/(100x10/(110))] = 0.5 x [1 + 11] = **6** $R_{in1} = v_1/i_1$ = R1 + R2 = **20 kΩ** $A_{v3} = v_o/v_3$ = – R5/R3 = – 100 kΩ/10 kΩ = **– 10** $R_{in3} = v_3/i_3$ = **R3 = 10 kΩ**