Started on	Tuesday, 10 December 2024, 1:15 PM
State	Finished
Completed on	
Time taken	
Grade	**18.50** out of 33.00 (**56.06**%)

Question 1

Mark 0.50 out of 0.50 Correct

The magnitude of power gain in a two-port is said to change −3 dB. This change approximately corresponds to

- a. Reduction of 30 % of its original value
- b. Reducing the gain to 1/2 of its original value ✓
- c. Reducing the gain to 1/4 of its original value

Your answer is correct.

The correct answer is:
Reducing the gain to 1/2 of its original value

Question 2

Mark 0.50 out of 0.50 Correct

A cylindrical conductor has DC resistance of 1 Ω. When is the resistance halved?

- a. When the length of the conductor is halved ✓
- b. When the diameter of the conductor is doubled
- c. When resistivity is doubled

Your answer is correct.

The correct answer is:
When the length of the conductor is halved

Question 3

Mark 0.50 out of 0.50 Correct

Norton equivalent is characterized as follows:

- a. It has a current source in parallel with a resistor ✓
- b. It has a current source equal to the current source of Thévenin equivalent
- c. It has a voltage source in series with a resistor

Your answer is correct.

The correct answer is:
It has a current source in parallel with a resistor

Question 4

Mark 0.50 out of 0.50 Correct

Power transfer to load resistor R_{L} from Thévenin equivalent with internal resistance of R_{S} is maximized when

- a. $R_{\mathrm{L}} \ll R_{\mathrm{S}}$
- b. $R_{\mathrm{L}} \gg R_{\mathrm{S}}$
- c. $R_{\mathrm{L}} = R_{\mathrm{S}}$ ✓

Your answer is correct.

The correct answer is:
$R_{\mathrm{L}} = R_{\mathrm{S}}$

Question 5

Mark 0.50 out of 0.50 Correct

RMS value of 3.54 V corresponds to voltage

- a. $v = 3.54\sin(2\pi ft)V$
- b. $v = 5\sin(2\pi ft + \Theta)V$ ✓
- c. $v = 12.5\sin(2\pi ft)V$

Your answer is correct.

The correct answer is:
$v = 5\sin(2\pi ft + \Theta)V$

Question **6**

Mark 0.50 out of 0.50 Correct

A type of sensor has output impedance of 100 kΩ and its output voltage is amplified for digital readout without loading the sensor. What should the input impedance of the amplifier be?

- a. The input impedance should be equal to the sensor output impedance
- b. The input impedance should be smaller than the sensor output impedance
- c. The input impedance should be much larger than the sensor output impedance ✓

Your answer is correct.

The correct answer is:
The input impedance should be much larger than the sensor output impedance

Question **7**

Mark 0.50 out of 0.50 Correct

An operational amplifier is characterized by equations: $v_- = v_+$, $i_- = 0$, and $i_+ = 0$. Why are these assumptions valid?

- a. The output impedance is very small so the current to inputs is small
- b. The input terminals are virtually grounded, so there is equal voltage and zero currents
- c. The input impedance and gain of operational amplifier are very large ✓

Your answer is correct.

The correct answer is: The input impedance and gain of operational amplifier are very large

Question **8**

Mark 0.50 out of 0.50 Correct

Voltage follower realized with an operational amplifier has

- a. Inverted output, because feedback is connected to inverting input
- b. Low input impedance, because the feedback has zero resistance and inputs are virtually shorted
- c. Non-inverted output, because the both inputs are at same potential ✓

Your answer is correct.

The correct answer is:
Non-inverted output, because the both inputs are at same potential

Question **9**

Mark 0.50 out of 0.50 Correct

Parallel-plate capacitor is charged to 1 C with a 5-V voltage source. After charging, the voltage source is disconnected. Then, the distance between the plates is doubled. What is the capacitor voltage after the change in plate distance?

- a. 10 V ✓
- b. 5 V
- c. 2.5 V

Your answer is correct.

The correct answer is:
10 V

Question **10**

Mark 0.00 out of 0.50 Incorrect

An air-filled coil has inductance of 1 μH with 100 loops, how the inductance can be doubled?

- a. Reducing the diameter of the loops by about 41 %
- b. Adding approximately 100 more loops ✓
- c. Adding approximately 41 more loops

Your answer is correct.

The correct answer is:
Adding approximately 100 more loops

Question **11**

Mark 0.50 out of 0.50 Correct

A port has voltage across it $\tilde{V} = 0.6\ \mathrm{V}\ \angle 45^\circ$ and current $\tilde{I} = 5\ \mathrm{mA}\ \angle{-45^\circ}$. What is the impedance seen across the port?

- a. $\tilde{Z} = 120\ \Omega\ \angle 0^\circ$
- b. $\tilde{Z} = 120\ \Omega\ \angle 90^\circ$ ✓
- c. $\tilde{Z} = 120\ \Omega\ \angle{-90^\circ}$

Your answer is correct.

The correct answer is:
$\tilde{Z} = 120\ \Omega\ \angle 90^\circ$

Question 12

Mark 0.50 out of 0.50 Correct

Small-signal conductance of a diode describes

- a. The conductance seen when the diode is reverse biased
- b. Slope of the diode current versus its voltage at the bias point ✓
- c. The leakage conductance parallel to the PN junction in the diode

Your answer is correct.

The correct answer is:
Slope of the diode current versus its voltage at the bias point

Question 13

Mark 0.50 out of 0.50 Correct

NMOS transistor is in saturation when

- a. $V_{\mathrm{GS}} > V_{\mathrm{T}}$
- b. $V_{\mathrm{DS}} > V_{\mathrm{GS}} - V_{\mathrm{T}}$ ✓
- c. $V_{\mathrm{DS}} < V_{\mathrm{T}}$

Your answer is correct.

The correct answer is:
$V_{\mathrm{DS}} > V_{\mathrm{GS}} - V_{\mathrm{T}}$

Question 14

Mark 0.50 out of 0.50 Correct

Channel-length modulation is modeled as

- a. Finite input impedance in transistor equivalent model
- b. Finite output impedance in transistor equivalent circuit ✓
- c. Reduction of transconductance in transistor equivalent model

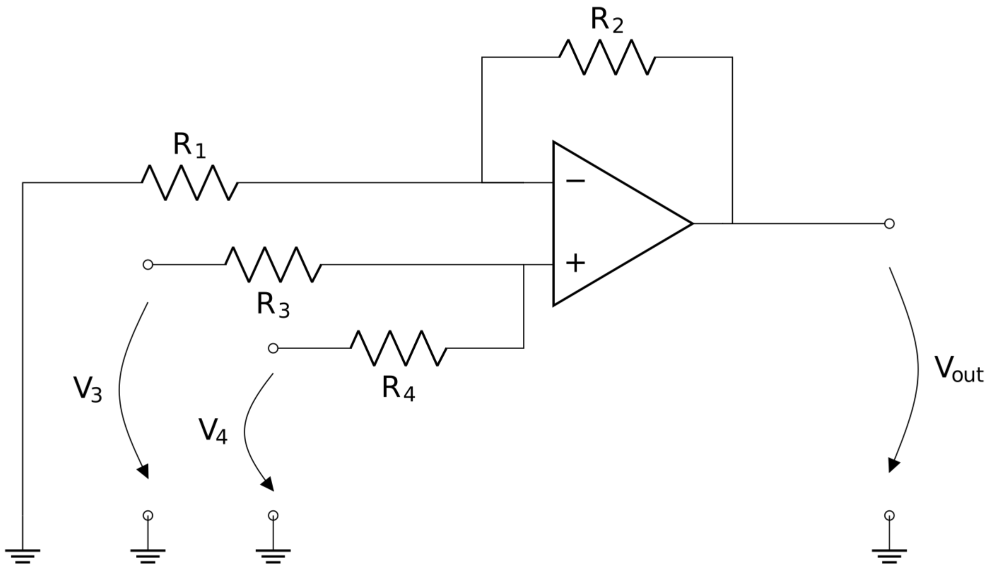
Your answer is correct.

The correct answer is:
Finite output impedance in transistor equivalent circuit

Question 15

Mark 0.00 out of 6.00 Incorrect

Find the output voltage V_{out}.



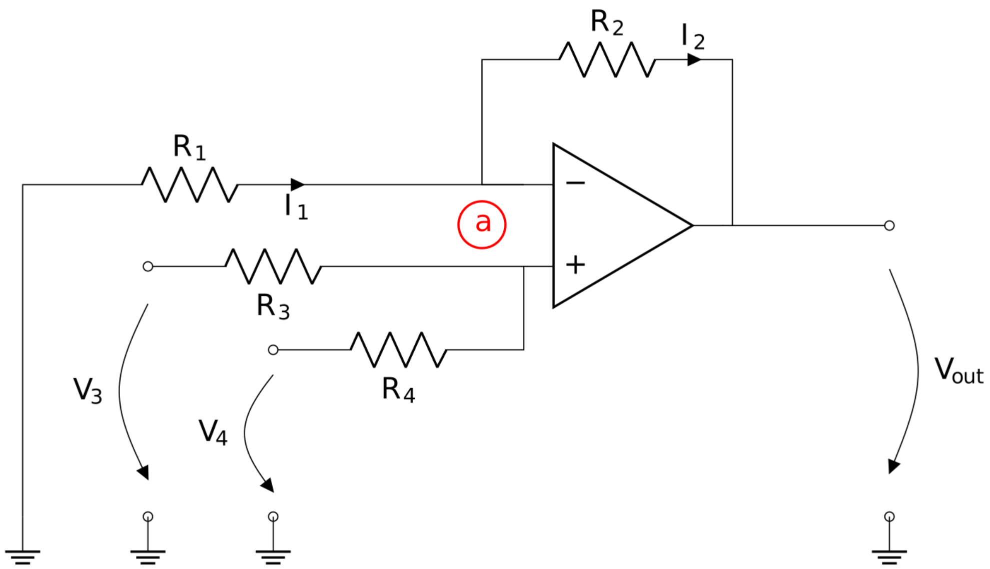
$R_1 = 4\,\text{k}\Omega, \quad R_2 = 5\,\text{k}\Omega, \quad R_3 = 4\,\text{k}\Omega, \quad R_4 = 2\,\text{k}\Omega, \quad V_3 = 4\,\text{V}, \quad V_4 = 2\,\text{V}$

V_{out} = 6 V

Your last answer was interpreted as follows:

$$1.5$$

The operational amplifier is assumed ideal so there is virtual short between the inputs and $V_- = V_+$.



The voltage at node a is then given with voltage division:

$V_a = V_4 + \frac{R_4}{R_3+R_4}(V_3 - V_4)$

The current through resistor R_1 is $I_1 = -v_a/R_1$. The current to inverting input is zero, so $I_2 = I_1$. The output voltage is

$V_{\text{out}} = -(R_1 + R_2)I_1 = \frac{R_1+R_2}{R_1}V_{\text{a}}$

$V_{\text{out}} = \frac{R_1+R_2}{R_1}(V_4 + \frac{R_4}{R_3+R_4}(V_3 - V_4))$

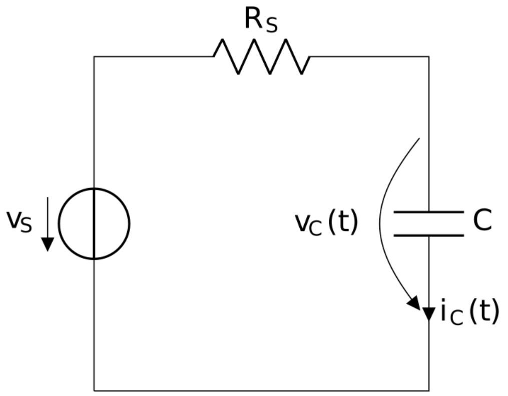
$V_{\text{out}} = \frac{R_1+R_2}{R_1}(\frac{R_3}{R_3+R_4}V_4 + \frac{R_4}{R_3+R_4}V_3) = \frac{4\,\text{k}\Omega+5\,\text{k}\Omega}{4\,\text{k}\Omega}(\frac{4\,\text{k}\Omega}{4\,\text{k}\Omega+2\,\text{k}\Omega}2\,\text{V} + \frac{2\,\text{k}\Omega}{4\,\text{k}\Omega+2\,\text{k}\Omega}4\,\text{V}) \approx 6\,\text{V}$

The answer 6, which can be typed as `6`, would be correct.

Question 16

Mark 0.00 out of 4.00 Incorrect

The voltage $v_C(t)$ across and current $i_C(t)$ through a capacitor are shown in the figure below. What is the capacitance of the capacitor?



$v_C(t) = V_0 \cos(2\pi f t), \quad i_C(t) = -I_0 \sin(2\pi f t)$

$V_0 = 12$ V, $I_0 = 4$ mA, and $f = 50$ kHz

C = 1.061 nF

Your last answer was interpreted as follows:

$$1$$

For a capacitor $i_C(t) = C\frac{dv(t)}{dt}$. Derivative of the voltage is:

$\frac{dv_C(t)}{dt} = -2\pi f V_0 \sin(2\pi f t)$

Therefore, capacitance can be solved:

$-I_0 \sin(2\pi f t) = C(-2\pi f V_0 \sin(2\pi f t))$

$-I_0 = -2\pi f C V_0$

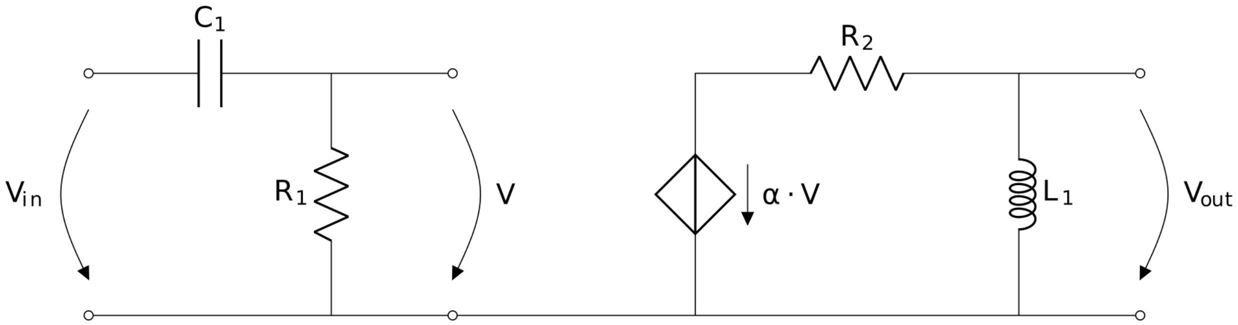
$C = \frac{I_0}{2\pi f V_0} = \frac{4\ \mathrm{mA}}{2\pi \times 50\ \mathrm{kHz} \times 12\ \mathrm{V}} \approx \frac{10}{3 \cdot \pi}$ nF.

The answer 1.061, which can be typed as `1.061`, would be correct.

Question **17**

Mark 8.00 out of 8.00 Correct

Find the poles of the transfer function $H(s) = \frac{V_{out}}{V_{in}}$ for the circuit below. Place your answer so that p_1 corresponds to the lowest angular frequency.



$\alpha = 5 \quad R_1 = 100\,\Omega \quad R_2 = 200\,\Omega \quad C_1 = 10\,\mu\text{F} \quad L_1 = 10\,\text{mH}$

$p_1 =$ -1000 $1/s$

Your last answer was interpreted as follows:

$$-1000$$

$p_2 =$ -20000 $1/s$

Your last answer was interpreted as follows:

$$-20000$$

Voltage $V(s)$ by voltage division:

$V(s) = \frac{R_1}{\frac{1}{sC_1}+R_1} V_{in}(s) = \frac{sR_1C_1}{1+sR_1C_1} V_{in}(s)$

Output voltage $V_{out}(s)$ by voltage division:

$V_{out}(s) = \frac{sL_1}{sL_1+R_2} \alpha V(s) = \alpha \frac{sL_1}{sL_1+R_2} \frac{sR_1C_1}{1+sR_1C_1} V_{in}(s)$

$V_{out}(s) = \alpha \frac{s^2 L_1 R_1 C_1}{(sL_1+R_2)(1+sR_1C_1)} V_{in}(s) = \alpha \frac{s^2}{(s+R_2/L_1)(s+1/R_1C_1)} V_{in}(s)$

$\Rightarrow H(s) = \frac{V_{out}(s)}{V_{in}(s)} = \frac{\alpha s^2}{(s+R_2/L_1)(s+1/R_1C_1)}$

Hence, poles are $p_1 \approx -1000$ and $p_2 \approx -20000$.

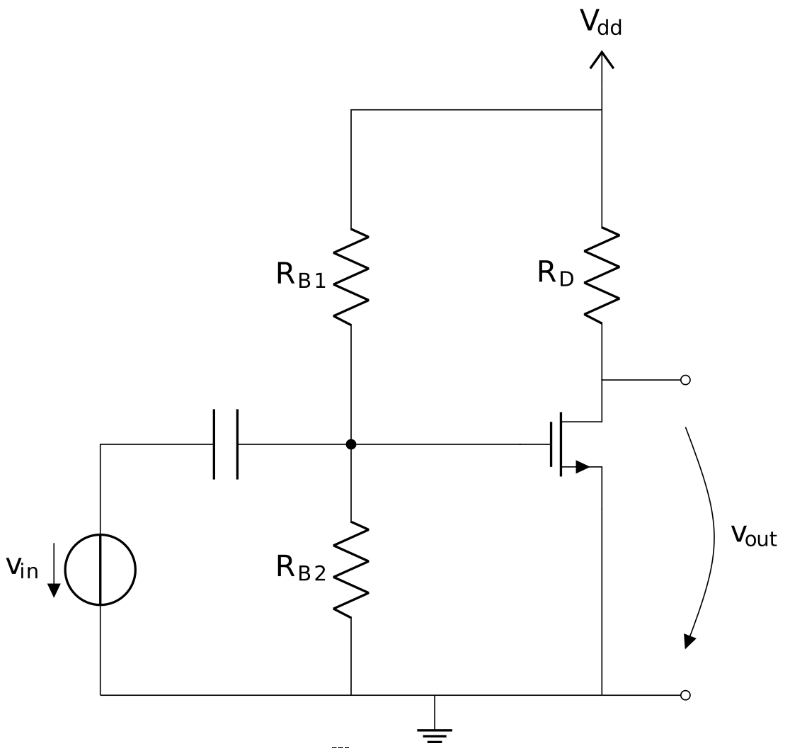
The answer -1000, which can be typed as `-1000`, would be correct.

The answer -20000, which can be typed as `-20000`, would be correct.

Question 18

Mark 4.00 out of 8.00 Partially correct

Below is a common-source amplifier. Zero channel-length modulation is assumed. The capacitor C can be assumed to be a short circuit for the small-signal input voltage. What is the voltage gain for small input voltage? What is the maximum positive input voltage swing when the transistor still remains in saturation? Depending on approximations, two solutions for the maximum positive voltage swing exist.



$V_T = 0.4\,\text{V}, \quad V_{dd} = 1.8\,\text{V}, \quad k_n' \frac{W}{L} = 3.5\,\text{mA/V}^2, \quad R_D = 9\,\text{k}\Omega, \quad R_{B1} = 7.5\,\text{k}\Omega, \quad R_{B2} = 4.5\,\text{k}\Omega$

$A_V =$ -8.663

Your last answer was interpreted as follows:

-8.7

$v_{gs,peak} <$ 34.56 mV

Your last answer was interpreted as follows:

1009

The voltage gain of a common-source amplifier is given by the derivative of V_{DS}:
$A_V = -R_D k_n (V_{GS} - V_T)$

Solving the V_{GS} from the voltage division:
$V_{GS} = \frac{R_{B2}}{R_{B1}+R_{B2}} V_{dd} = \frac{4.5\,\text{k}\Omega}{7.5\,\text{k}\Omega + 4.5\,\text{k}\Omega} 1.8\,\text{V} \approx 0.675\,\text{V}$

Then, the voltage gain is
$A_V = -9\,\text{k}\Omega \times 3.5\,\text{mA/V}^2 \times (0.675\,\text{V} - 0.4\,\text{V}) = -8.663$.

There are two alternative solutions to the maximum positive input voltage swing: solving with linearized model for gain (#1) and direct solving from drain-source voltage (#2).

Solution #1:

The transistor is in saturation as long as $v_{DS} > v_{GS} - V_T$ (limit to triode, negative output swing, positive input swing). For positive input swing (capital letter represents DC bias point):

$v_{DS} > v_{GS} - V_T$
$V_{DS} - |A_V| v_{gs} > V_{GS} + v_{gs} - V_T$
$v_{gs} < \frac{V_{DS} - V_{GS} + V_T}{1 + |A_V|}$

The drain-source voltage at the bias point is:
$V_{DS} = V_{dd} - \frac{R_D}{2} k_n' \frac{W}{L} (V_{GS} - V_T)^2$
$V_{DS} = 1.8\ \text{V} - \frac{9\ \text{k}\Omega}{2} \times 3.5\ \text{mA/V}^2 \times (0.675\ \text{V} - 0.4\ \text{V})^2 = 0.6089\ \text{V}$

At positive input signal just exceeding the limit, $v_{gs} = v_{gs,peak}$:
$v_{gs,peak} = \frac{V_{DS} - V_{GS} + V_T}{1 + |A_V|} = \frac{0.6089\ \text{V} - 0.675\ \text{V} + 0.4\ \text{V}}{1 + |-8.663|} \approx 34.56$ mV.

Solution #2:

The drain-source voltage at the threshold of going to triode mode is $v_{DS} = v_{GS} - V_T$. Then, writing the drain-source voltage with help of gate-source and threshold voltages, supply voltage and drain resistor, we get:
$V_{DS} = V_{dd} - \frac{R_D}{2} k_n (V_{GS} - V_T)^2$
$V_{GS} - V_T = V_{dd} - \frac{R_D}{2} k_n (V_{GS} - V_T)^2$
$V_{GS} - V_T = V_{dd} - \frac{R_D}{2} k_n (V_{GS}^2 - 2 V_T V_{GS} + V_T^2)$

$\frac{R_D}{2} k_n V_{GS}^2 + (1 - R_D k_n V_T) V_{GS} + \frac{R_D}{2} k_n V_T^2 - V_T - V_{dd} = 0$

The gate-source voltage is second order polynomial. In addition to the DC bias there is positive input voltage swing ($v_{GS} = V_{GS} + v_{gs,pos.peak}$):
$v_{GS} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
$a = \frac{R_D}{2} k_n$
$b = 1 - R_D k_n V_T$
$b^2 = 1 - 2 R_D k_n V_T + R_D^2 k_n^2 V_T^2$
$c = \frac{R_D}{2} k_n V_T^2 - V_T - V_{dd}$
$v_{GS} = \frac{R_D k_n V_T - 1 \pm \sqrt{1 - 2 R_D k_n V_T + R_D^2 k_n^2 V_T^2 - 4 \frac{R_D}{2} k_n \left(\frac{R_D}{2} k_n V_T^2 - V_T - V_{dd}\right)}}{2 \frac{R_D}{2} k_n}$
$v_{GS} = V_T + \frac{\pm \sqrt{1 - 2 R_D k_n V_T + R_D^2 k_n^2 V_T^2 - R_D^2 k_n^2 V_T^2 + 2 R_D k_n (V_T + V_{dd})} - 1}{R_D k_n}$
$v_{GS} = V_T + \frac{\pm \sqrt{1 + 2 R_D k_n V_{dd}} - 1}{R_D k_n}$

Clearly, the solution + is correct, since the gate-source voltage needs to be larger than the threshold voltage. Finally, writing with bias V_{GS} and input voltage $v_{gs,pos.peak}$:
$v_{gs,pos.peak} = V_T - V_{GS} + \frac{\sqrt{1 + 2 R_D k_n V_{dd}} - 1}{R_D k_n}$

$v_{gs,pos.peak} = 0.4\ \text{V} - 0.675\ \text{V} + \frac{\sqrt{1 + 2 \times 9\ \text{k}\Omega \times 3.5\ \text{mA/V}^2 \times 1.8\ \text{V}} - 1}{9\ \text{k}\Omega \times 3.5\ \text{mA/V}^2} \approx 32.8$ mV.

The solution with linearized model and gain gives slightly larger value as it does not consider the nonlinearity. Directly solving from drain-source voltage gives more realistic value for the maximum input signal. Both solutions are considered correct in the exam.

Voltage gain is $A_V \approx -8.663$ and maximum positive swing in input voltage (maximum negative swing in output) is $v_{gs,peak} < 34.56$ mV or $v_{gs,peak} < 32.8$ mV.

The answer -8.663, which can be typed as `-8.663`, would be correct.

The answer 34.56, which can be typed as `34.56`, would be correct.

Previous activity

◄ Exercise 12: Deadline on December 2