Exam Date & Time: 28-Sep-2023 (08:00 AM - 10:00 AM)

MANIPAL ACADEMY OF HIGHER EDUCATION

B.Tech 1st Semester Midterm Examination September 2023

BASIC ELECTRONICS [ECE 1071]

Marks: 30 **Duration: 120 mins.**

MCQ

Answer all the questions. Section Duration: 20 mins

1) An Op-amp as a voltage follower has a voltage gain of _________

1) Infinity 2) Zero 3) Less than unity 4) Unity (0.5)

Correct option is: 4

2) If the differential voltage gain and common mode gain of the differential amplifier are 48dB and 2dB, respectively, then the common mode rejection ratio is ____________

1) 23 dB 2) 25 dB 3) 46 dB 4) 50 dB (0.5)

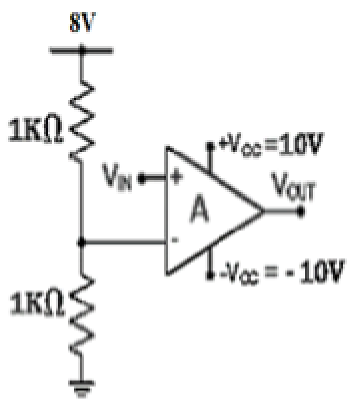
Correct option is: 3

3) Output of a certain circuit is applied as input to the OPAMP-based inverting amplifier. If the amplifier output voltage desired is +10V, then the input voltage applied to the amplifier must be _______. Assume that ±Vcc =15V, R_F=10 kΩ and R_1=5 kΩ. (0.5)

1)	1V		2)	-1V		3)	5V		4)	-5V	

Correct option is: 4

4) For the comparator circuit shown in the figure, if the input voltage V_{IN} is 3V, the output voltage V_{OUT} is ________ (0.5)



1)	+10V		2)	-10V		3)	+3V		4)	-8V	

Correct option is: 2

5) Which of the following is not the ideal characteristic of Op-amp? (0.5)

1) Infinite open-loop gain 2) Infinite CMRR 3) Infinite bandwidth 4) Infinite output resistance

Correct option is: 4

6) The threshold voltage of an n channel MOSFET is 0.5V. When the device is biased at a gate voltage of 4V, pinch-off would occur at a drain voltage of ______

1) 2.5 V 2) 4 V 3) 0.5V 4) 3.5 V (0.5)

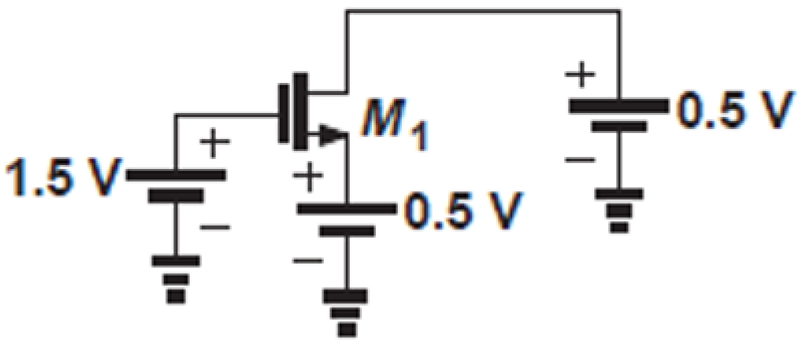
Correct option is: 4

7) When drain voltage equals the pinch-off-voltage, drain current _______ with the increase in drain voltage. Assume that λ=0

1) decrease 2) increase 3) remains constant 4) none of the above (0.5)

Correct option is: 3

8) The M1 in the given circuit is operating in _____ region, if its $VTH = 0.6$ V?



(0.5)

1) Linear Region 2) Saturation Region 3) Cut-off Region 4) Edge of saturation region

Correct option is: 1

9) Find the PIV rating of the diode used for proper working of a full-wave bride rectifier when it is supplied with 230V, 50Hz AC mains through a step-down transformer with turns ratio =10:1

1) 32.52 V 2) 46 V 3) 12.5 V 4) 0 V (0.5)

Correct option is: 1

10) A sinusoidal secondary voltage of peak value of 10 V and frequency 50 Hz is applied to HWR. If the load resistance is 800Ω. Assume ideal diode. Calculate average load voltage.

1)	3.18 V		2)	3.96 V		3)	2.18 V		4)	2.96 V	

(0.5)

Correct option is: 1

DESCRIPTIVE

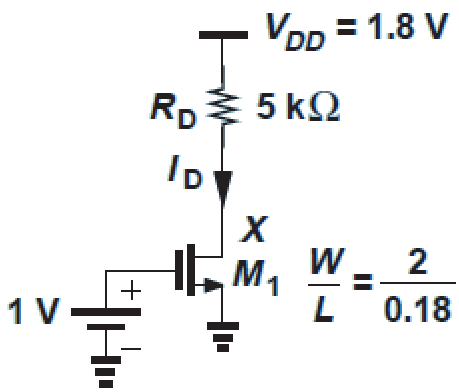
Answer all the questions.

11) Derive the expression for drain current in an n-channel MOSFET. Draw and explain different regions of operation. (4)

12) Explain the operation of centre-tap type FWR with neat circuit and waveform. Derive the expressions for V_{dc}, V_{rms} and efficiency. (4)

13) In a Zener network, R_S= 120Ω, R_L= 250Ω, V_Z= 5V. Calculate the minimum and maximum Zener current when input voltage is varied between 9V to 15V. (3)

14) Calculate the bias current of M_1. Assume $\mu_n C_{ox} = 100\ \mu A/V^2$ and $V_{TH} = 0.4$ V. What choice of R_D places the transistor at the edge of the triode region. (3)



15) A germanium diode carries a current of 10mA when a forward bias of 0.2V is applied at room temperature 27^0C.

(a) Estimate the reverse saturation current

(b) Calculate bias voltage needed for a diode current of 100mA. (3)

(c) Estimate reverse saturation current at 20^0C above room temperature.

16) Define CMRR. Calculate CMRR for an OPAMP, when V_1 is 0.25 mV, and V_2 is – 0.25 mV, output voltage is 4V. For the same op-amp, when $V_1 = V_2 = 0.5$ mV, the output voltage is 6 mV. (3)

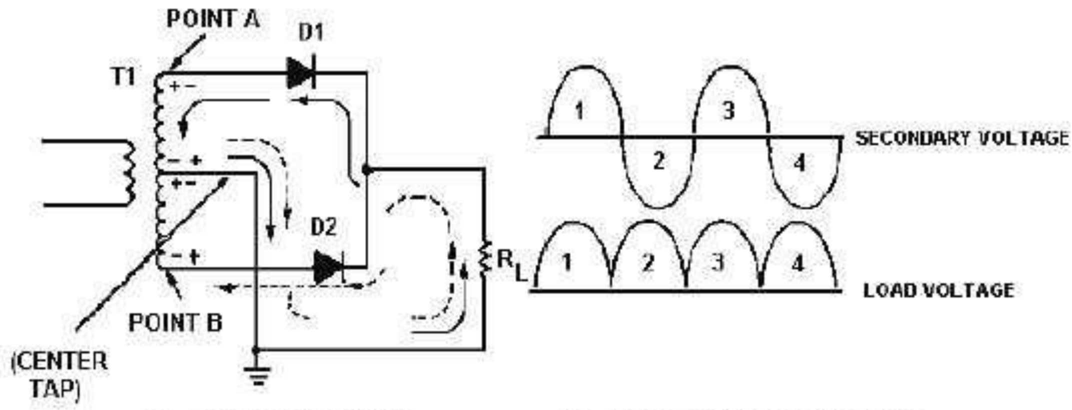
17) Design the circuit using two OPAMPs to obtain: $V_0 = 3V_1 - 6V_2 + 9V_3$. Choose R_f=10KΩ. (V_1, V_2 and V_3 are the inputs) (3)

18) Briefly explain the working of: (i) Photodiode (ii) LED (2)

-----End-----

Q.12. Explain the operation of centre tape type FWR with neat circuit and waveform. Derive the equation for V_{dc}, V_{rms} and efficiency. (4 Marks)

Answer:



A. RECTIFIER CIRCUIT B. ASSOCIATED WAVEFORMS

2M

$$V_{dc} = \frac{1}{\pi}\int_0^{\pi} V_m \sin \omega t \, d(\omega t) = \frac{V_m}{\pi}\left[-\cos \omega t\right]_0^{\pi} = \frac{2V_m}{\pi}$$

0.5M

$$V_{rms} = \left[\frac{1}{\pi}\int_0^{\pi} V_m^2 \sin^2 \omega t \, d(\omega t)\right]^{1/2} = \frac{V_m}{\sqrt{2}}$$

0.5M

$$\eta = \frac{dc\ output power}{ac\ input power} = \frac{P_{dc}}{P_{ac}}$$

$$\frac{V_{dc}^2 / R_L}{V_{rms}^2 / R_L} = \frac{\left[2V_m/\pi\right]^2}{\left[V_m/\sqrt{2}\right]^2} = 8/\pi^2 = 0.812 = \underline{\underline{81.2\%}}$$

1M

Q.15. A germanium diode carries a current of 10mA when a forward bias of 0.2V is applied at room temperature 27^0C.
(a) Estimate the reverse saturation current
(b) Calculate bias voltage needed for a diode current of 100mA.
(c) Estimate reverse saturation current at 20^0C above room temperature.

(3 Marks)

Answer:

The diode current I_D=10mA,
Temperature T = 273+27 = 300K
The diode is Germanium η=1
Forward bias voltage V_D = 0.2V
The equation for the diode current I_D is given by

$$I_D = I_0\left(e^{\frac{V_D}{\eta V_T}} - 1\right) \text{ and } V_T = \frac{T}{11600} = \frac{300}{11600}$$

(a) I_0 = 4.38μA 1M

(b) $V_D = 0.25$ V when $I_D = 100$ mA 1M

(c) $I_{02} = 1.75 * 10^{-5}$ A, given $t_1 = 27^0C$ & $t_2 = 47^0C$ 1M

Q13. In a Zener network, R_S= 120Ω, R_L= 250Ω, V_Z= 5V. Calculate the minimum and maximum Zener current when input voltage is varied between 9V to 15V. (3)

$I_L = \frac{V_L}{R_L} = \frac{V_Z}{R_L} = 20mA$ 1M

$I_{RS} = \frac{V_i - V_Z}{R_S}$

$I_{RS\,max} = \frac{V_{i\,max} - V_Z}{R_S} = 83.33mA$ 0.5M

$I_{RS\,min} = \frac{V_{i\,min} - V_Z}{R_S} = 33.33mA$ 0.5M

$I_{RS\,max} = I_{Z\,max} + I_L$

$I_{Z\,max} = I_{RS\,max} - I_L = 63.33mA$ 0.5M

$I_{RS\,min} = I_{Z\,min} + I_L$

$I_{Z\,min} = I_{RS\,min} - I_L = 13.33mA$ 0.5M

Q 11.

Derive the expression for drain current –

$I = Q \cdot v$ —(1) $\quad v = \mu \dfrac{dv}{dx}$ —(a)

$Q_{ch} = WC_{ox}(V_{GS} - V_{th} - V(x))$ —(b)

2M

Using (a) & (b) in eqn (1)

$I_D = W C_{ox}\left[V_{GS} - V_{th} - V(x)\right] \mu_n \cdot \dfrac{dV(x)}{dx}$

$\int_0^L I_D \cdot dx = \mu_n C_{ox} \cdot W \int_0^{V_{DS}} (V_{GS} - V_{th} - V(x))\, dv$

$\boxed{I_D = \mu_n C_{ox} \cdot \dfrac{W}{L}\left[(V_{GS} - V_{th}) V_{DS} - \dfrac{1}{2} V_{DS}^2\right]}$ is drain current.

MOSFET is in triode region.

Case 1: If $V_{DS} << 2(V_{GS} - V_{th})$

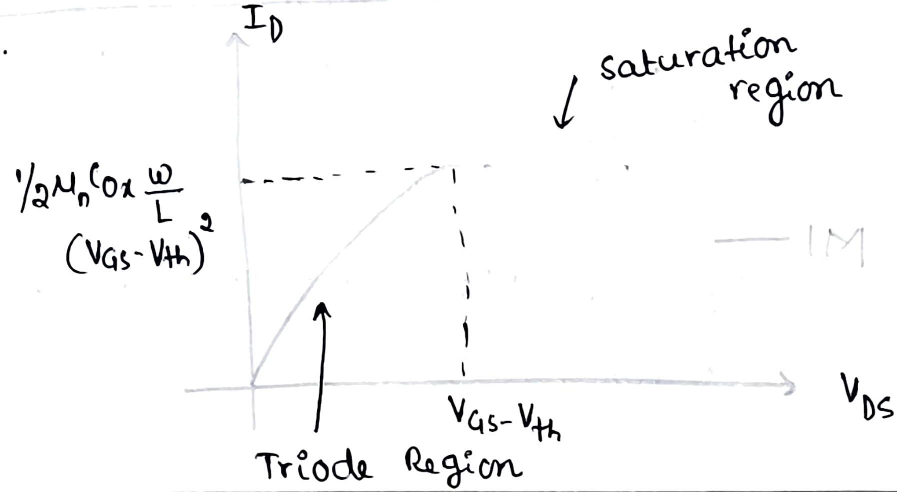
then $I_D \approx \mu_n C_{ox} \cdot \dfrac{W}{L} \cdot (V_{GS} - V_{th}) V_{DS}$ — 1M

MOSFET in Deep triode region.

Case 2: If $V_{DS} > V_{GS} - V_{th}$, channel is pinched off.

$\therefore \boxed{I_D = \dfrac{1}{2} \mu_n C_{ox} \cdot \dfrac{W}{L} (V_{GS} - V_{th})^2}$

Saturation region.



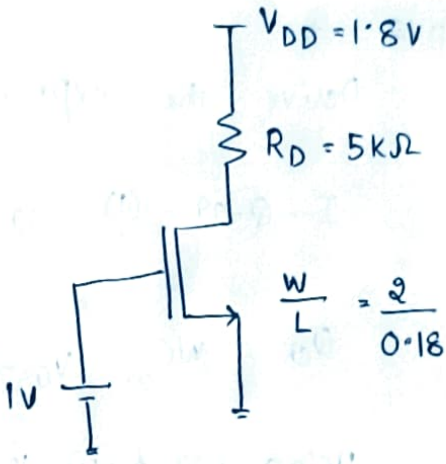
— 1M

Q14)

Given:

$\mu_n C_{ox} = 100 \mu A/V^2$

$V_{th} = 0.4 V$



Assuming M_1 operates in saturation,

$$I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{th})^2$$

$$= \frac{1}{2} \times 100 \times 10^{-6} \times \frac{2}{0.18} (1 - 0.4)^2$$

$$= \underline{\underline{200 \mu A}}$$ — 1M

$$V_{DS} = V_{DD} - I_D R_D = 1.8 - 200 \times 10^{-6} \times 5 \times 10^3$$

$$= \underline{0.8}$$

$V_{DS} > (V_{GS} - V_{th})$. Hence MOSFET operates in saturation region. — 1M

For edge of triode region:

$$V_{DS} = V_{GS} - V_{th} = 0.6V$$

ie $V_{DS} = V_{DD} - I_D R_D$

$$0.6 = 1.8 - 200 \times 10^{-6} \times R_D$$

$$R_D = \underline{\underline{6 k\Omega}}$$ — 1M

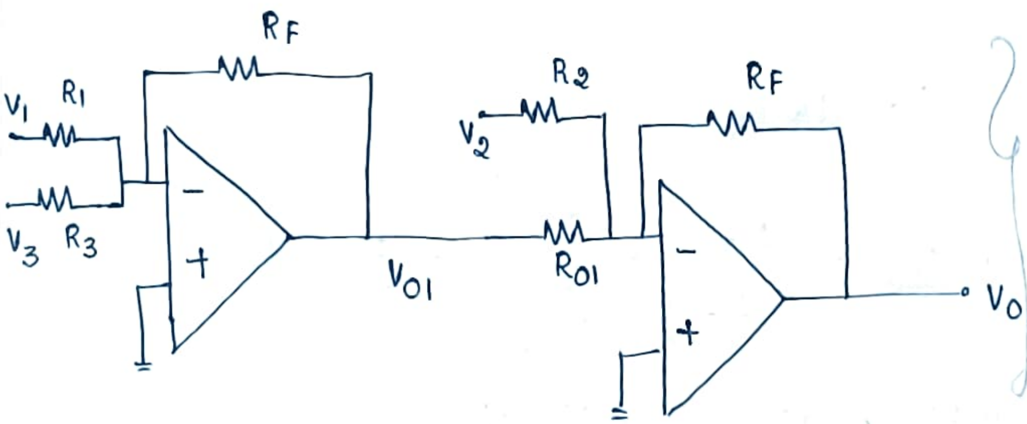
$R_D = 6k\Omega$ places MOSFET at the edge of triode region.

Q17) $V_0 = 3V_1 - 6V_2 + 9V_3$, V_1, V_2 & V_3 are inputs
Use 2 - opamps.

$$V_0 = -6V_2 - \left(-\left(3V_1 + 9V_3\right)\right)$$

$$= -6V_2 - V_{01}$$, where $V_{01} = -(3V_1 + 9V_3)$

Realize V_{01} using op-amp adder and
$V_0 = -6V_2 - V_{01}$ using another adder.



1.5M

Choose $R_F = 10k\Omega$,

$$V_{01} = -\left(\frac{R_F}{R_1} V_1 + \frac{R_F}{R_3} V_3\right) = -\left(3V_1 + 9V_3\right)$$

$$\therefore R_1 = \frac{R_F}{3} = \frac{10}{3} k\Omega = \underline{\underline{3 \cdot 33 k\Omega}}$$

$$R_3 = \frac{R_F}{9} = \frac{10}{9} k\Omega = \underline{\underline{1 \cdot 11 k\Omega}}$$

$$V_0 = -6V_2 - V_{01} = -\left(\frac{R_F}{R_2} V_2 + \frac{R_F}{R_{01}} \cdot V_{01}\right)$$

$\therefore R_2 = \frac{R_F}{6} = \frac{10}{6} k\Omega = 1 \cdot 67 k\Omega$, $R_{01} = R_F = 10k\Omega$

1.5M

Q 16) Definition of CMRR. — 1M

Output voltage of opamp $V_0 = A_d V_d + A_c V_c$

when $V_1 = 0.25\,mV$ & $V_2 = -0.25\,mV$, o/p voltage $= 4V$

$$4 = A_d \times 0.5 \times 10^{-3} + A_c(0)$$

$$A_d = 8 \times 10^{3}$$

when $V_1 = V_2 = 0.5\,mV$ o/p voltage is $6\,mV$ — 1.5M

$$6 \times 10^{-3} = A_d(0) + A_c \times 0.5 \times 10^{-3}$$

$$A_c = 12$$

$$CMRR = \frac{A_d}{A_c} = \frac{8 \times 10^{3}}{12} = 666.67$$

CMRR in dB = 56.47 dB — $\frac{1}{2}$ M