Analog Circuits Test 4

Number of Questions: 25 **Time: 60 min.**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

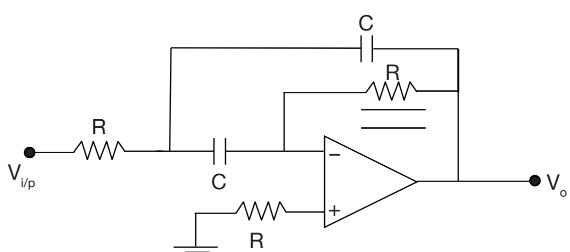
1. At higher frequency (>1MHz), the phase shift of an *RC*-coupled amplifier is

(A) equal to 180° (B) above 180°
(C) below 180° (D) None of the above

2. An amplifier with open loop voltage gain $A_V = 800 \pm 50$ is available. It is required to have an amplifier whose gain varies by not more than ±0.5%. Find reverse transmission factor β of the feedback network.

(A) 1.43% (B) 2.5%
(C) 4% (D) 3.7%

3. Below network represents a



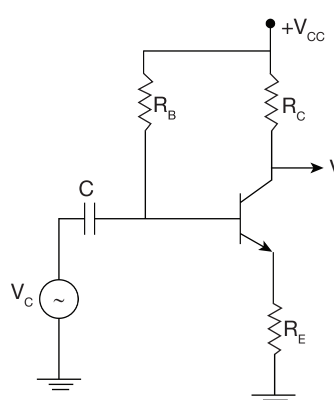
(A) low pass filter (B) high pass filter
(C) band pass filter (D) band stop filter

4. Match List-I with List-II where List-I contains type of feedback and List-II have input impedance ($Z_{i/p}$) and output impedance ($Z_{o/p}$)

List-I	List-II
(p) current series	(1) $Z_{i/p}$ increases and $Z_{o/p}$ decreases
(q) current shunt	(2) $Z_{i/p}$ increases and $Z_{o/p}$ increases
(r) voltage series	(3) $Z_{i/p}$ decreases and $Z_{o/p}$ decreases
(s) voltage shunt	(4) $Z_{i/p}$ decreases and $Z_{o/p}$ increases

(A) *p*–2, *q*–4, *r*–1, *s*–3 (B) *p*–4, *q*–2, *r*–3, *s*–1
(C) *p*–3, *q*–1, *r*–2, *s*–4 (D) *p*–2, *q*–3, *r*–4, *s*–1

5. Below circuit configuration indicates which type of feedback connection?

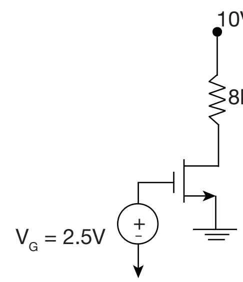


(A) Voltage series feedback
(B) Voltage shunt feedback
(C) Current series feedback
(D) Current shunt feedback

6. The cascode amplifier is a multistage configuration of

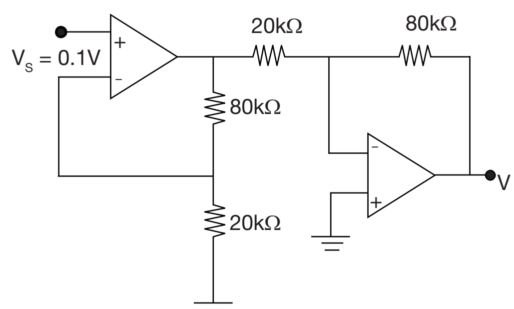
(A) *CE-CC* (B) *CE-CB*
(C) *CC-CB* (D) *CB-CC*

7. For FET shown in below figure has $V_{TN} = 1.5V$, $k_n = 2\ mA/V^2$. The *FET* is in saturation and $I_D = 1mA$ then small signal voltage gain A_V is



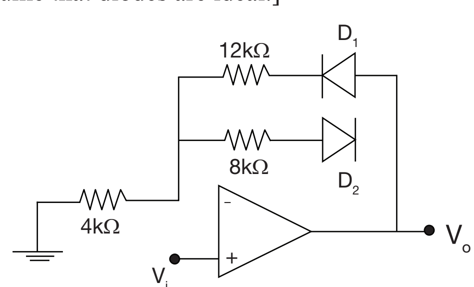
(A) –64 (B) –32
(C) 16 D) 48

8. Find out output voltage (V_o), assume that the op-Amps in below circuit are ideal.



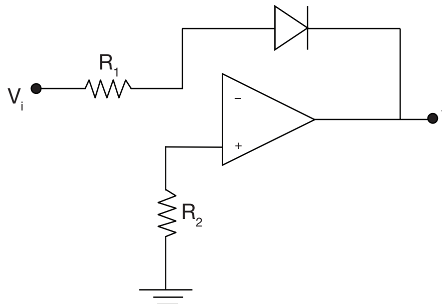
(A) 2 V (B) 0.5 V
(C) –0.5 V (D) –2V

9. Find output voltage V_o at $V_i = 4V$ for below circuit. [Assume that diodes are ideal.]



(A) –12V (B) 16V
(C) 4V (D) –8V

10. In below Op-Amp circuit, the output voltage (V_o) for $V_i > 0$, is proportional to

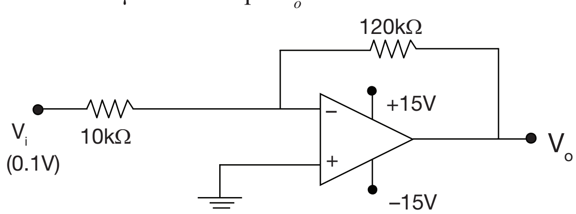


(A) V_i (B) $\sqrt{V_i}$
(C) $\ln(k\,V_i)$ (D) e^{kV_i}

11. Differential amplifier is invariably used in input stage of all Op-Amps. This is done to provide the Op-Amp with a very high

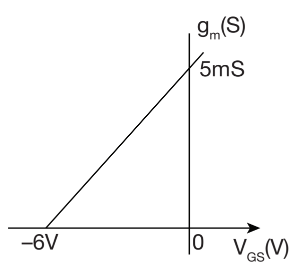
(A) open-loop gain (B) Bandwidth
(C) CMRR (D) slew rate

12. If the frequency of operation is 0.5 MHz and Op-Amp slew rate is 0.8 V/μs. Then output V_o is



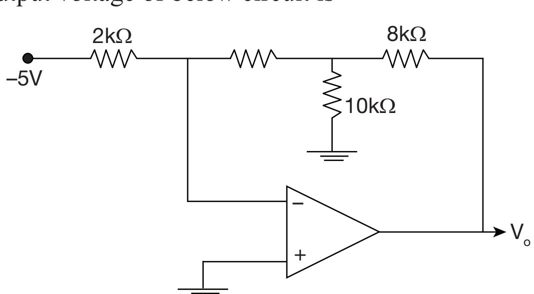
(A) more distorted (B) 15V
(C) No distortion (D) –15V

13. Plot g_m versus V_{GS} for the JFET, find drain current I_D at $V_{GS} = -4\text{V}$



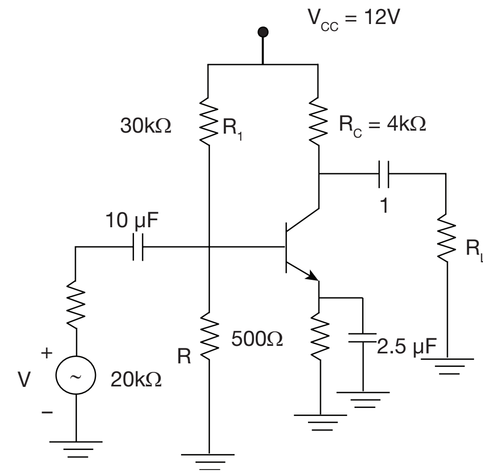
(A) 30 mA (B) 20 mA
(C) 1.67 mA (D) 15 mA

14. Output voltage of below circuit is



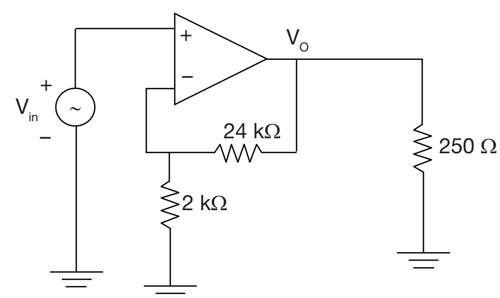
(A) –40.5 V (B) 12.5 V
(C) 42.5 V (D) 35 V

15. Find f_β where junction capacitances are C_π = 25 pF, C_μ = 8 pF, C_{ce} = 2 pF and β = 150.



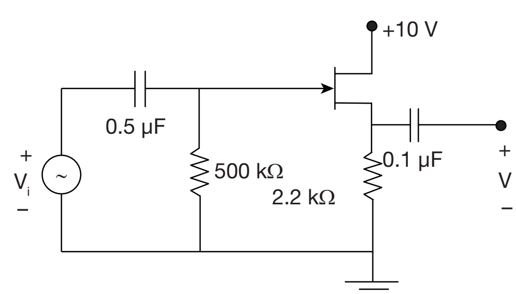
(A) 9.1 MHz (B) 11.13 MHz
(C) 30 MHz (D) 20.5 MHz

16. An Op-amp having the following parameters is connected as a non inverting amplifier, $A = 2 \times 10^5$, R_i = 5 MΩ, R_o = 150 Ω, f_o = 10*Hz*. Then output impedance after feedback (R_{0F}) is



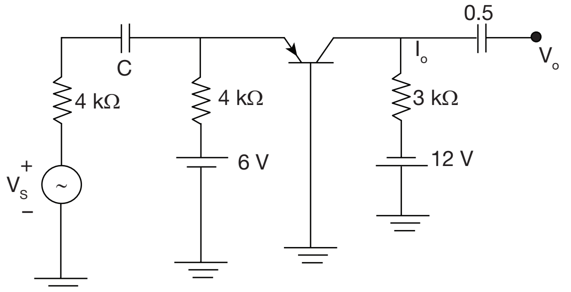
(A) 7.8 mΩ (B) 9.75 mΩ
(C) 2.3 mΩ (D) 3.25 mΩ

17. A dc analysis of the source follower network has V_{GSQ} = –2.5 V and I_{DQ} = 2.36 mA. Then find voltage gain A_V. [I_{DSS} = 12 mA, V_P = –5 V, Y_{OS} = 74 μ*s*]



(A) 0.48 (B) 0.84
(C) 0.24 (D) 1.2

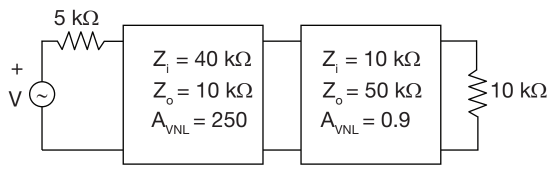
18. For the common-base amplifier, output impedance is



[∵ $h_{ib} = 15\ \Omega$, $h_{rb} = 88.3 \times 10^{-6}$, $h_{fb} = -0.9$, $h_{ob} = 0.18\ \mu s$]

(A) 5 MΩ (B) 6 MΩ
(C) 7 MΩ (D) 4 MΩ

19. Find total current gain for the system

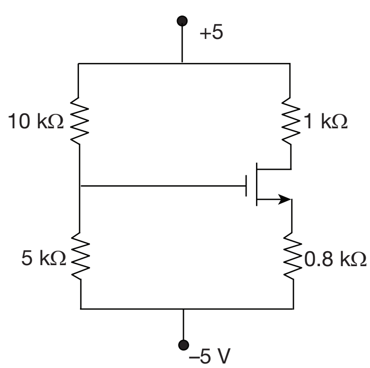


(A) –497.5 (B) 277.7
(C) –208 (D) 187

20. An amplifier with a lower cut-off frequency of 50*Hz* is to be employed for amplification of square waves for the tilt on the output waveform not to exceed 5%. The lowest input frequency that can be amplified is

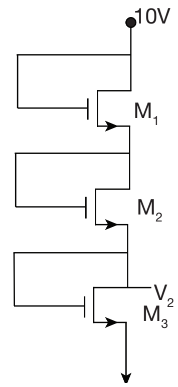
(A) 2.5 kHz
(B) 3.14 kHz
(C) 10 kHz
(D) 17.5 kHz

21. In below circuit the transistor parameters are $V_{Th} = -1.2$V and $K_n = 0.8$ mA/V² then find drain current



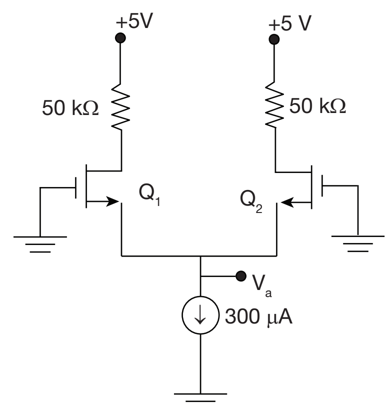
(A) 1.27 mA (B) 1.75 mA
(C) 1.55 mA (D) 1.97 mA

22. In below circuit, the EMOSFET parameters are $V_{Th} = 1$V, $V_{GS} = 3$V and $k_n^1 = 30\ \mu A/V^2$. If $I_D = 1$ mA, $V_2 = 2$V. Then width to length ratio required in EMOSFET M_1, is



(A) 4.16 (B) 3.67
(C) 2.82 (D) 5.32

23. In the following circuit, transistors Q_1 and Q_2 has the following parameters. [Transistors are in saturation]



$$\left(\frac{W}{L}\right)_1 = \left(\frac{W}{L}\right)_2 = 15$$

$(V_{Th})_1 = (V_{Th})_2 = 1$ V

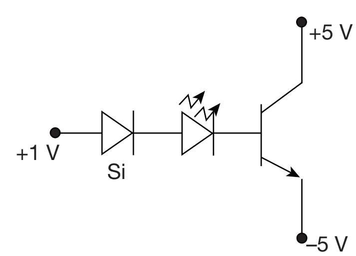
$(k_n^1)_1 = (k_n^1)_2 = 75\ \mu A/V^2$

Then find V_a.

(A) 1.365 V (B) –2.14 V
(C) 2.14 V (D) –1.516 V

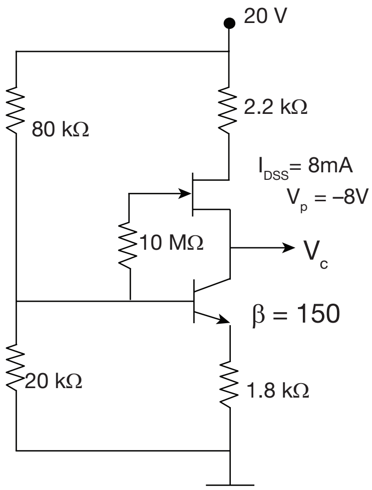
24. The transistor in below circuit is in

$[V_{\gamma_{si}} = 0.7V, V_{\gamma_{red}} = 1.8V]$



(A) active region
(B) saturation region
(C) cut-off region
(D) None of the above

25.



Determine the value of V_C in above given network?

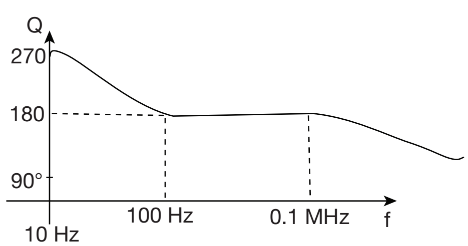
(A) 4 V
(B) 6 V
(C) 8 V
(D) zero V

Answer Keys

1. C	**2.** A	**3.** C	**4.** A	**5.** C	**6.** B	**7.** B	**8.** D	**9.** B	**10.** C
11. C	**12.** A	**13.** C	**14.** C	**15.** A	**16.** B	**17.** B	**18.** A	**19.** A	**20.** B
21. B	**22.** A	**23.** D	**24.** A	**25.** C					

Hints and Explanations

1.



Phase plot for an *R*-*C* coupled amplifier Choice (C)

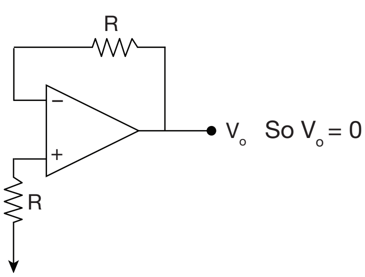
2. $A_V = 800 \pm 50$

$$\frac{\partial A_F}{A_F} = \pm 0.5\%\,; \quad \frac{\partial A_F}{A_F} = \frac{\partial A}{A}\left(\frac{1}{1+\beta A}\right)$$

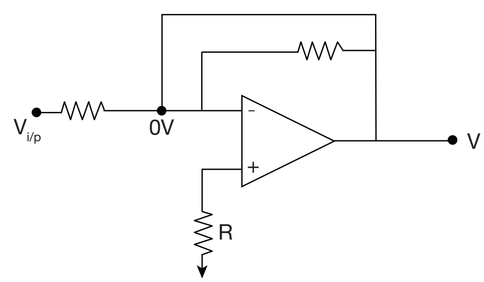
$$\Rightarrow \frac{0.5}{100} = \frac{50}{800}\left(\frac{1}{1+\beta(800)}\right)$$

$\Rightarrow$ β = 1.43%. Choice (A)

3. If $f \to 0$, capacitor is open circuited then *n*/*w* looks like



If $f \to \infty$, capacitors will short circuited then n/w looks like



So it represents a band pass filter Choice (C)

4. Choice (A)

5. The current through R_E results in a feedback voltage that opposes the source signal applied, so that V_o is reduced. It has current series feedback connection. Choice (C)

6. CASCODE amplifier is CE – CB configuration. Choice (B)

7. $A_V = -g_m R_D$

$\Rightarrow$ $g_m = 2k(V_{GS} - V_{Th})$

$\Rightarrow$ $V_{GS} = 2.5V$

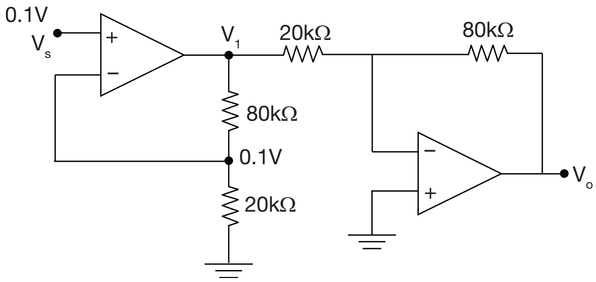
$\Rightarrow$ $g_m = 2 \times 2 \times 10^{-3}\,[2.5 - 1.5]$

$= 4ms$

$A_V = -4 \times 10^{-3} \times 8 \times 10^3$

$= -32$ Choice (B)

8.

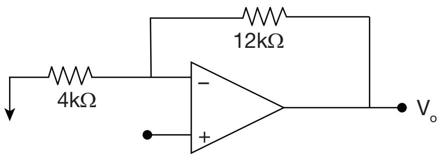


$$0.1\text{V} = \frac{V_1 \times 20}{80+20}$$

$V_1 = 0.5V$

$$\Rightarrow V_0 = \frac{-R_F}{R_1} \times V_1 = -2\text{V}$$ Choice (D)

9. Input is given to positive terminal so output V_o is $+ve$. The D_1 is on and D_2 is off



$$V_o = V_i\left(1+\frac{12}{4}\right) = 16\text{V}$$ Choice (B)

10. Given circuit is logarithmic amplifier

$$V_o = V_T \ln\left(\frac{V_i}{R_S I_S}\right)$$

So $V_o \alpha\, 1_n(kV_i)$ Choice (C)

11. Differential amplifier reduced common mode gain then CMRR will increases. Choice (C)

12. $A_{CL} = -\left(\frac{120}{10}\right) -12$

$SR \geq \omega |A_{CL}| V_i$

$$\frac{0.8}{10^{-6} \times 12 \times 0.1} \geq \omega$$

$$\Rightarrow \omega \leq \frac{2}{3}\text{MHz} \Rightarrow f_{max} = 0.106\text{MHZ}$$

Frequency of operation is greater than maximum frequency so output has distortion. Choice (A)

13. $g_m = \frac{2I_{DSS}}{|V_P|}\left[1-\frac{V_{GS}}{V_P}\right]$

from graph $V_P = -6$ at $V_{GS} = 0$V

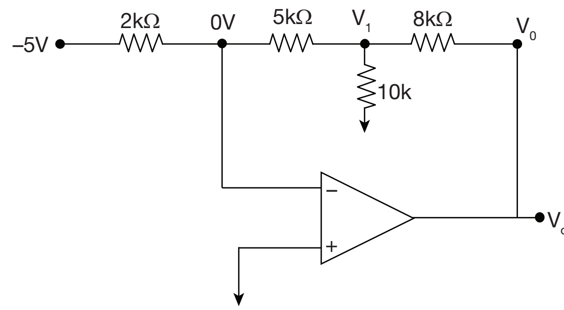
$$\Rightarrow I_{DSS} = \frac{5\times10^{-3}\times 6}{2} = 15\text{mA}$$

$$I_D = I_{DSS}\left[1-\frac{V_{GS}}{V_P}\right]^2$$

$$\Rightarrow I_D = 15\times10^{-3}\left[1-\frac{4}{6}\right]^2$$

$$= \frac{15}{9}\times10^{-3} = 1.67\text{mA}$$ Choice (C)

14.



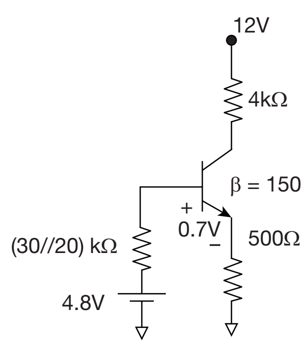
KCL at Node 0V is $\frac{0-(-5)}{2} + \frac{0-V_1}{5} = 0$; $\frac{25}{2} = V_1$

$\Rightarrow$ KCL at Node V_1 is $\frac{V_1 - 0}{5} + \frac{V_1}{10} + \frac{V_1 - V_0}{8} = 0$

$$\Rightarrow V_1\left[\frac{1}{5}+\frac{1}{10}+\frac{1}{8}\right] = \frac{V_0}{8}$$

$\Rightarrow$ $V_o = 42.5$V Choice (C)

15. $f_\beta = \frac{1}{2\pi\beta r_e\left(C_{be}+C_{be}\right)}$



$$r_e = \frac{V_T}{I_E}$$

$I_E = 7.0\ 7$mA

$$\Rightarrow r_e = \frac{25\text{mV}}{7.07\text{mA}} = 3.53$$

$$f_\beta = \frac{1}{2\pi \times 150 \times 3.53 \times (25+8)\times 10^{-12}} = 9.1\text{ MHz}$$

Choice (A)

16. Feedback factor is $= \frac{2}{2+24} = \frac{2}{26}$

$$R_{OF} = \frac{R_o}{1+A\beta} = \frac{150}{1+2\times10^5\times\frac{2}{26}} = 9.75\text{ m}\Omega$$ Choice (B)

17. $g_m = \frac{2I_{DSS}}{|V_P|}\left[1-\frac{V_{GSQ}}{V_P}\right] = \frac{2\times12}{5}\left[1-\frac{(-2.5)}{(-5)}\right] = 2.4 \text{ mS}$

$$A_V = \frac{g_m R_s}{1+g_m R_s} = \frac{2.4\times10^{-3}\times2.2\times10^{3}}{1+2.4\times10^{-3}\times2.2\times10^{3}}$$

$= \frac{5.28}{6.28} = 0.84.$ Choice (B)

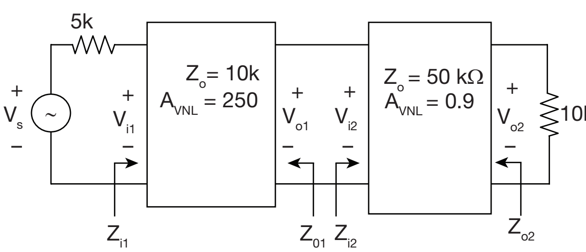
18. $Z_O = Z_L \| Z_O^1$

Where $Z_o^1 = \frac{1}{h_{ob} - \left[h_{fb}\, h_{rb}/\left(h_{ib}+R_s\right)\right]}$

$$Z_o = \frac{1}{0.18\times10^{-6} - \left[\frac{(-0.9)\left(88.3\times10^{-6}\right)}{(0.015+4)\times10^{3}}\right]} = 5 \text{ M}\Omega$$

Choice (A)

19.



$$A_{V_1} = \frac{V_{o_1}}{V_{i_1}} = \frac{Z_{i_2}}{Z_{i_2}+Z_{o_1}} A_{VNL1} = \frac{10\times10^{3}\times250}{(10+10)\times10^{3}} = 125$$

$$A_{V_2} = \frac{R_L}{R_L+Z_{o_2}} A_{VNL2} = \frac{10^4}{10^4+50}\times0.9 = 0.99$$

$$A_{V_T} = A_{V_1}.A_{V_2} = 124.37$$

$$\Rightarrow A_{i_T} = -A_{V_T}\frac{Z_i}{R_L} = 124.37\times\frac{40}{10} = -497.5$$

Choice (A)

20. $\frac{\pi f_L}{f} < \frac{5}{100}$

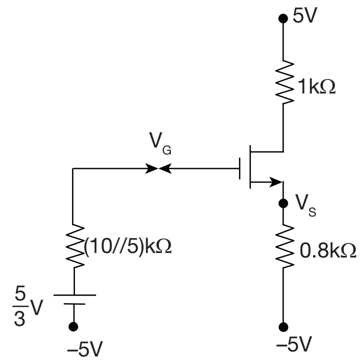
$\Rightarrow \frac{100\pi\times50}{5} < f;\ 3.14 \text{ kHz} < f$ Choice (B)

21. $V_{th} = \frac{5\times5}{15} = \frac{5}{3}\text{V}$

$5 + V_G = \frac{5}{3}$

$V_G = \frac{-10}{3}\text{V}$

$V_{GS} = V_G - V_S$



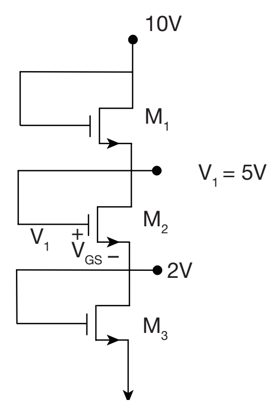
$$I_D = \frac{V_S+5}{0.8k\Omega} = k_n[V_{GS(on)} - V_T)^2$$

$$\frac{(V_S+5)}{0.8} = 0.8\left[\frac{-10}{3} - V_S + 1.2\right)^2$$

$\Rightarrow V_S = -3.6$

$\Rightarrow I_D = \frac{(-3.6+5)10}{8}\text{mA} = 1.75 \text{ mA}$ Choice (B)

22.



For every EMOSFET in given problem $V_{GS} = V_{DS}$ and $V_{DS} > V_{GS} - V_{Th}$ so all are in saturation region

$V_{GS2} = 3 = V_{DS3}$

$V_{GS1} = V_{GS2} + 2 = 5\text{V}$

$\Rightarrow V_{GS1} = 5V$

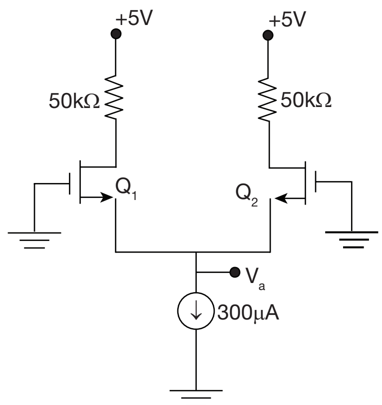
$$1\text{mA} = I_D = \frac{30\times10^{-6}}{2}[5-1]^2\left[\frac{W}{L}\right]_1$$

$$1\times10^{-3} = 15\times10^{-6}\times16\times\left(\frac{W}{L}\right)_1$$

$\Rightarrow 4.16 = \left(\frac{W}{L}\right)_1$ Choice (A)

23. $V_a = -V_{GS}$

Both transistors have same parameters so current flow in each transistor is equal to 150 μA



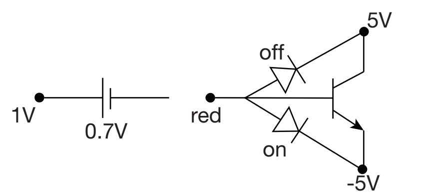
$$I_D = 150\times10^{-6} = \frac{(k_n^1)\left(\frac{W}{L}\right)}{2}(V_{GS}-1)^2$$

$\Rightarrow$ $300 \times 10^{-6} = 75 \times 10^{-6} \times 15\,(V_{GS} - 1)^2$

$\Rightarrow$ $\sqrt{\frac{20}{75}} + 1 = V_{GS} = 1.516 = -V_a$

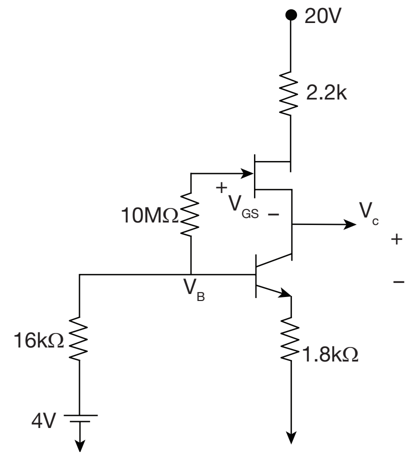
$\Rightarrow$ $V_a = -1.516.$ Choice (D)

24. Si diode is ON but other diode is off



So transistor is in active region Choice (A)

25. Reducing the network to



$\beta R_E > 10R_2$ so $I_C = \frac{4-0.7}{1.8k\Omega}$

$= \frac{3.3}{1.8}mA = 1.83\text{mA}$

$I_C = I_D = I_S = 1.83$ mA

$$I_D = I_{DSS}\left[1-\frac{V_{GS}}{V_P}\right]^2$$

$\Rightarrow$ $1.8 = 8\left[1+\frac{V_{GS}}{8}\right]^2$

$\Rightarrow$ $V_{GS} = -4.02 \Rightarrow$ KVL at V_B to V_C

$V_{GS} + V_C = V_B$

$V_C = 4 + 4.02 \simeq 8\text{V}.$ Choice (C)