S.No. : 01 ND_EC_NW_160619

Analog Electronics

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CLASS TEST 2019-2020

ELECTRONICS ENGINEERING

Date of Test : 16/06/2019

ANSWER KEY ➤ Analog Electronics

1.	(b)	7.	(d)	13.	(a)	19.	(b)	25.	(c)
2	(a)	8.	(b)	14.	(b)	20.	(d)	26.	(b)
3.	(a)	9.	(c)	15.	(c)	21.	(c)	27.	(b)
4	(c)	10.	(c)	16.	(a)	22.	(b)	28.	(a)
5.	(a)	11.	(c)	17.	(d)	23.	(a)	29.	(d)
6.	(c)	12.	(a)	18.	(b)	24.	(c)	30.	(c)

DETAILED EXPLANATIONS

1. (b)
Common collector transistor has input impedance seen at output and output impedance seen at input.

2 (a)
The duty cycle of the above astable multivibrator (designed using 555 timer) is

$$\because \quad \frac{T_{on}}{T} = \frac{R_A + R_B}{R_A + 2R_B} = \frac{2}{3} \quad \text{thus Duty cycle} > 50\%$$

3. (a)
Since there are 3 capacitors the maximum phase shift that can be provided will be 270° but due to the presence of the *RC* circuit the phase shift is equal to 60° for the individual *RC* circuit, making the phase shift of the feedback network equal to 180°. Thus the amplifier should be an inverting amplifier so that it can be a positive feedback circuit and because the amplifier is a practical amplifier thus $|A\beta| > 1$ for the circuit to work.

4 (c)
Since all the voltage are positive all the diodes will try to be forward biased but only the diode with highest voltage will be switched on rest will be in off state.

5. (a)

$$A_f = \frac{A}{1+A\beta} \quad \text{...(i)}$$

$$\frac{\partial A_f}{\partial A} = \frac{1}{(1+A\beta)^2} \quad \text{...(ii)}$$

$$\frac{\partial A_f}{A_f} = \frac{\partial A}{A}\left(\frac{1}{1+A\beta}\right)$$

$$\frac{1}{100} = \frac{10}{100}\left(\frac{1}{1+100\beta}\right)$$

$$1 + 100\beta = 10$$

$$100\beta = 9$$

$$\beta = \frac{9}{100} = 0.09$$

6. (c)

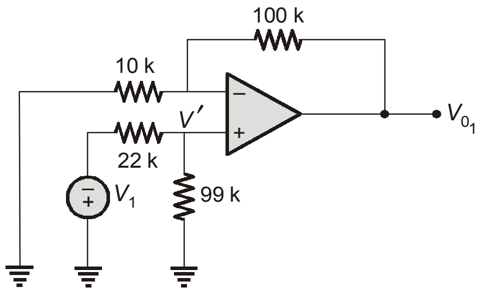
$$A_{CL} = \frac{A_{OL}}{1+A_{OL}\cdot\beta}$$

$$0.75 = \frac{A_{OL}}{1+A_{OL}\cdot\beta}$$

$$\beta = 1$$

$$\Rightarrow \quad A_{OL} = 3$$

7. (d)



Set, $V_2 = 0$

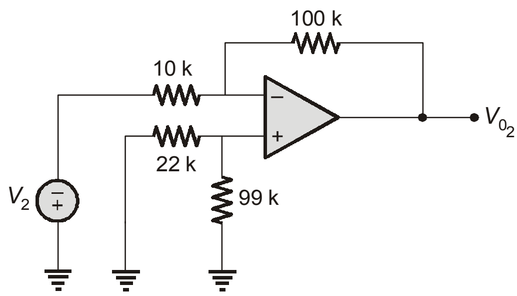
then $\dfrac{V_{0_1}}{V'} = \left(1+\dfrac{R_F}{R_1}\right)$

where $V' = \dfrac{99k}{99k+22k}\times(-V_1)$

so, $V_{0_1} = -\left(1+\dfrac{100}{10}\right)\times\dfrac{99}{99+22}\times V_1$

$V_{0_1} = -9\,V_1$

Now, set $V_1 = 0$



then $\dfrac{V_{0_2}}{V_2} = -\dfrac{100}{10}$

$V_{0_2} = -10\,V_2$

hence $V_0 = V_{0_1} + V_{0_2}$

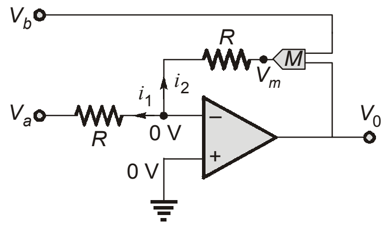
$V_0 = -9\,V_1 - 10\,V_2$

∴ $A_1 = -9, \quad A_2 = -10$

8. (b)

The feedback is directly to connected to output, hence voltage sampling. The feedback is also directly connected to input, hence shunt mixing.

9. (c)



Output of multiplier is $V_m = V_0 \cdot V_b$
Applying KCL at inverting input node

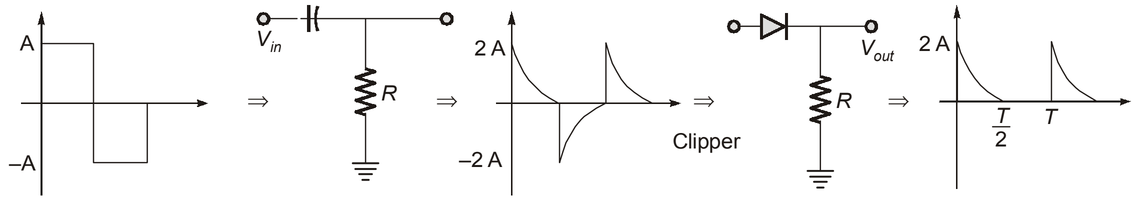
$$\frac{0 - V_a}{R} + \frac{0 - V_m}{R} = 0$$

$$V_a + V_m = 0$$

$$V_a + V_0 \cdot V_b = 0$$

$$V_0 = -\frac{V_a}{V_b}$$

10. (c)
The above circuit can be viewed as H.P.F followed by a clipper
thus for $RC << T$ the output of the H.P.F. to a square wave is



11. (c)

$$\beta = \frac{V_f}{I_0} = \frac{R_1 R_3}{R_1 + R_2 + R_3} = \frac{4k \times 3k}{10k} = \frac{12k}{10} = 1.2k$$

12. (a)
In saturation

$$I_{DS} = k(V_{gs} - V_T)^2$$

Since, $V_{DS} = 0$ (i.e. drop across the MOSFET)

$$V_{gs} - V_T = 0 \quad (\because \text{in saturation region})$$

or, $V_{gs} = V_T$

Thus, $V_g - V_s = 1$

$$V_s = V_g - 1 = 5 - 1 = 4 \text{ V}$$

Current through source $= \dfrac{4-2}{2} + i = i_D$ (where, i_D is the drain current)

$\because$ $V_0 = 4$

$\therefore$ $i_D = \dfrac{10-4}{2\text{ k}\Omega} = 3 \text{ mA}$

$\Rightarrow$ $i = 2 \text{ mA}$

13. (a)

Time period of oscillation is $T = 2RC\,ln\left(\frac{1+\beta}{1-\beta}\right)$

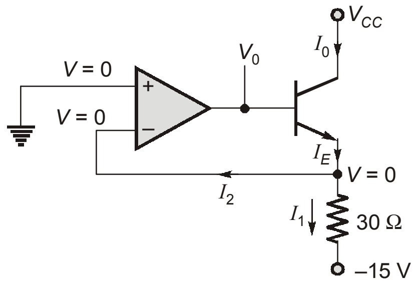
Here, β = feedback factor $= \frac{R}{R+R} = \frac{1}{2}$

$$\Rightarrow \quad T = 2\times 10^3 \times 10^{-3} ln\frac{\left(1+\frac{1}{2}\right)}{\left(1-\frac{1}{2}\right)}$$

$$= 2ln3$$

$$T = 2.19 \text{ sec}$$

14. (b)



$$I_1 = \frac{0-(-15)}{30} = 0.5 \text{ A}$$

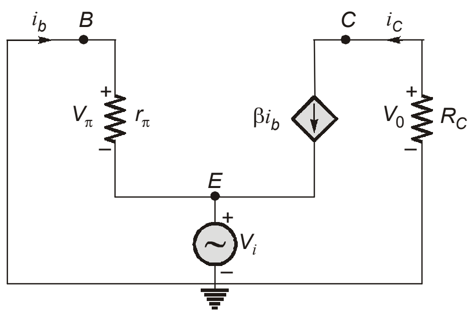
$$I_E = I_1 + I_2$$

since $I_2 = 0$

$$I_E = I_1$$

$$I_C = \frac{\beta}{\beta+1} I_E = \frac{30}{31} \times 0.5 = 0.483 \text{ A}$$

15. (c)



$$V_0 = -\beta\, i_b\, R_c$$

$$i_b = \frac{V_\pi}{r_\pi} = \frac{-V_i}{r_\pi}$$

So, $$V_0 = \frac{\beta R_c}{r_\pi} V_i$$

$$r_\pi = (1+\beta) r_e$$

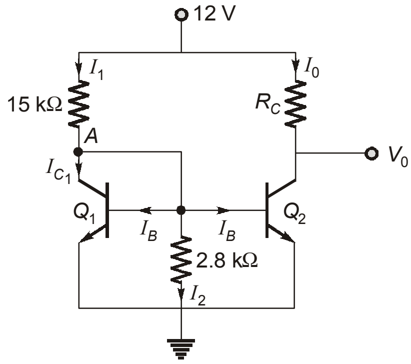
$$A_v = \frac{V_0}{V_i} = \left(\frac{\beta}{1+\beta}\right)\frac{R_c}{r_e} = \frac{\alpha R_c}{r_e}$$

$$A_v = 0.98 \times \frac{5\times 10^3}{70} = 70$$

16. (a)

$$I_1 = \frac{12 - 0.7}{15\,k} = 0.753 \text{ mA}$$

$$I_2 = \frac{0.7}{2.8k} = 0.25 \text{ mA}$$



KCL at node '*A*'

$$I_1 = I_{C_1} + 2I_B + I_2$$

$$I_1 = I_{C_1}\left(1 + \frac{2}{\beta}\right) + I_2$$

$$0.7533 = I_{C_1}\left(1 + \frac{2}{200}\right) + 0.25$$

from here $\quad I_{C_1} = 0.498$ mA

since the circuit is current mirror circuit.

$$I_{C_1} = I_{C_2} = I_0$$

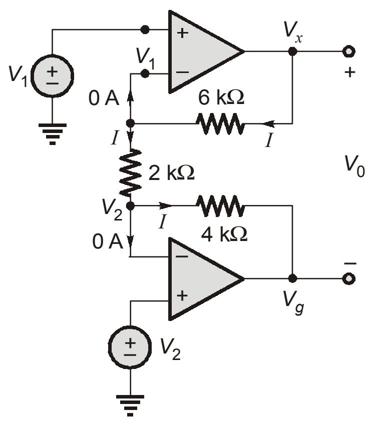
$\Rightarrow \quad I_0 = 0.498$ mA

17. (d)

$$R_A = 1 \text{ k}\Omega,$$
$$R_B = 2 \text{ k}\Omega$$

$$\text{Duty cycle} = \frac{R_A + R_B}{R_A + 2R_B} \times 100 = \frac{1+2}{1+4} \times 100 = 60\%$$

18. (b)



$$V_0 = I(6\text{ k} + 2\text{ k} + 4\text{ k}) = I(12\text{ k})$$

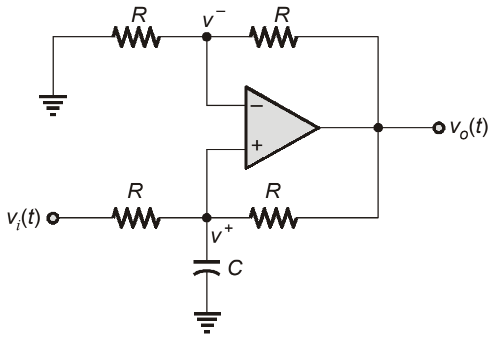
$$I = \frac{V_1 - V_2}{2k}$$

$$V_0 = \frac{V_1 - V_2}{2k}(12\text{ k})$$

So, $\quad A_{vd} = \dfrac{V_0}{V_1 - V_2} = 6$

19. (b)

Taking Laplace transform and applying nodal analysis



$$\frac{v^+}{1/sC}+\frac{v^+-v_o}{R}+\frac{v^+-v_i}{R} = 0$$

$$v^+\left(sC+\frac{2}{R}\right) = \frac{v_o}{R}+\frac{v_i}{R}$$

$$v^+(sCR+2) = v_o + v_i$$

$$v^+ = \frac{v_o+v_i}{2+SCR}$$

$$\frac{v^-}{R}+\frac{v^--v_o}{R} = 0$$

$$v^- = \frac{v_o}{2}$$

$v^+ = v^-$ (ideal op-amp)

$$\frac{v_o+v_i}{2+sCR} = \frac{v_o}{2}$$

$$v_o = \frac{2v_i}{sCR}$$

$$v_o(t) = \frac{2}{CR}\int v_i(t)dt \qquad \text{(taking inverse laplace transform)}$$

20. (d)

$$V^- = \frac{4}{4+6}\times 10\text{ V} = 4\text{ V}$$

for $V_i > 4$ V, $\quad V_o = +V_{sat} \Rightarrow$ LED is in 'ON' state

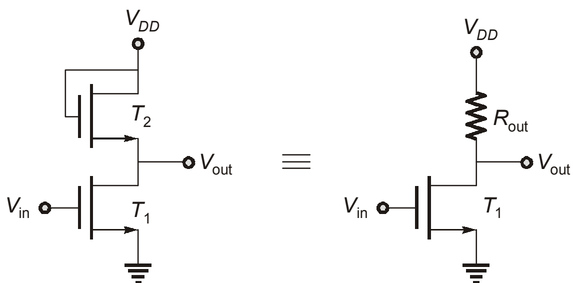
for $V_i < 4$ V, $\quad V_o = -V_{sat} \Rightarrow$ LED is in 'OFF' state

$V_i > 4$ V for $2s < t < 6s$ and $18s < t < 22s$

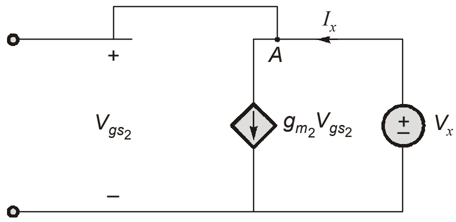
so, LED will be in ON state for 8 seconds.

21. (c)

MOS T_2 serve as drain resistance for T_1



Calculating R_{out} of T_2

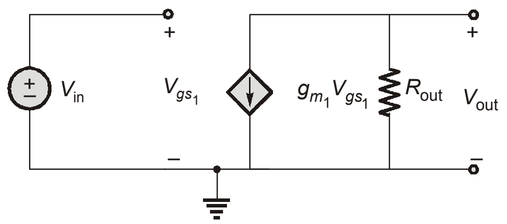


Applying KCL at node, A

$$I_x = g_m V_{gs}$$
$$V_{gs_2} = V_x$$

Thus
$$\frac{V_x}{I_x} = \frac{1}{g_{m_2}} = R_{out}$$

for transistor T_1



$$V_{out} = -g_{m_1} V_{gs_1} R_{out}$$
$$V_{gs_1} = V_{in}$$
$$\frac{V_{out}}{V_{in}} = -g_{m_1} R_{out}$$
$$A_v = -\frac{g_{m_1}}{g_{m_2}}$$

$\because$
$$R_{out} = -\frac{1}{g_{m_2}}$$

22. (b)

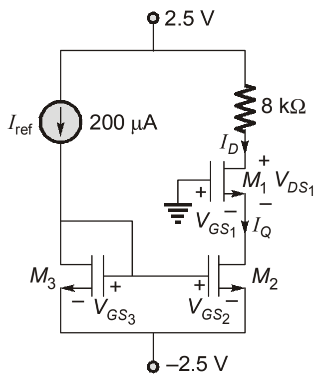
$$I_1 = \frac{I_{ref}}{1+\frac{2}{\beta}} \Rightarrow \frac{I_{ref}}{I_1} = 1+\frac{2}{\beta}$$

where $I_{ref} = 27\ \mu A$

$$1+\frac{2}{\beta} = \frac{27}{25}$$
$$\frac{2}{\beta} = \frac{2}{25}$$

$\Rightarrow$
$$\beta = 25$$

23. (a)



$$I_D = I_{ref} = 200\ \mu A \qquad \text{[by current mirror action]}$$
$$I_{D_3} = k_{n_3}(V_{GS_3} - V_{TH})^2$$

$$V_{GS_3} = \sqrt{\frac{I_{DS}}{k_{n_3}}} + V_{TH} = \sqrt{\frac{0.2}{0.15}} + 0.4 = 1.555 \text{ V}$$

$$V_{GS_3} = V_{GS_2} = 1.555 \text{ V}$$

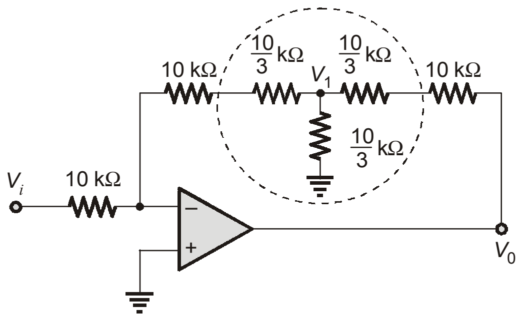
$$V_{GS_1} = \sqrt{\frac{I_Q}{k_{n_1}}} + V_{Th} = \sqrt{\frac{0.2}{0.25}} + 0.4 = 1.29 \text{ V}$$

$$V_{DS_1} = V^+ - I_D R_D - (V_{GS_1}) = 2.5 - 0.2 \times 8 - (-1.29)$$

$$V_{DS_1} = 2.19 \text{ V}$$

24. (c)

Redrawing the circuit



Applying KCL at inverting node

$$\frac{V_i - 0}{10\text{k}} = \frac{0 - V_1}{\left(10 + \frac{10}{3}\right)\text{k}} \quad \text{...(i)}$$

Applying KCL at V_1 node

$$\frac{V_1 - 0}{\left(10 + \frac{10}{3}\right)\text{k}} + \frac{V_1}{\frac{10}{3}\text{k}} + \frac{V_1 - V_0}{\left(10 + \frac{10}{3}\right)\text{k}} = 0$$

from here $\frac{V_0}{V_i} = -8$

25. (c)

Assuming all the diodes are forward biased

$$V_B = -0.7 \text{ V}$$

$$V_A = 0 \text{ V}$$

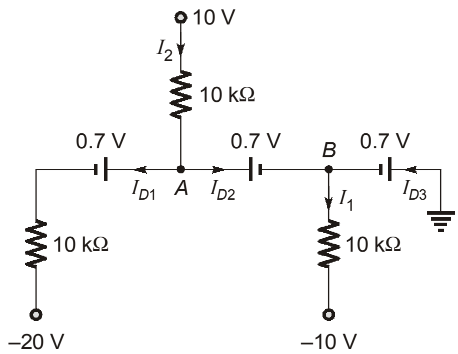
$$I_2 = \frac{10}{10\text{ k}} = 1 \text{ mA}$$

$$I_1 = \frac{-0.7 - (-10)}{10\text{ k}} = 0.93 \text{ mA}$$

$$I_2 = I_{D_1} + I_{D_2}$$

$$I_1 = I_{D_2} + I_{D_3}$$

$$10\text{k}I_2 + 0.7 + 10\text{k}I_{D_1} - 20 = 10$$



$$10\,\text{k}(I_{D_1} + I_{D_2}) + 10\,\text{k}\,I_{D_1} = 30 - 0.7 = 29.3$$

$$20\,\text{k}I_{D_1} + 10\text{k}\,I_{D_2} = 29.3$$

$$2I_{D_1} + I_{D_2} = 2.93\text{ mA} \quad \text{...(i)}$$

$$I_{D_1} + I_{D_2} = 1\text{ mA} \quad \text{...(ii)}$$

from (i) and (ii)

$$I_{D_1} = 1.93\text{ mA}; \qquad I_{D_2} = -0.93\text{ mA}$$

$$10\,kI_1 - 10 = -0.7$$

$$I_1 = 0.93\text{ mA}$$

$$I_{D_2} + I_{D_3} = 0.93\text{ mA}$$

$$I_{D_3} = -I_{D_2} + 0.93\text{ mA} = 1.86\text{ mA}$$

Here I_{D_2} is negative

$\Rightarrow D_2$ is reverse biased

I_{D_1} and I_{D_3} are positive

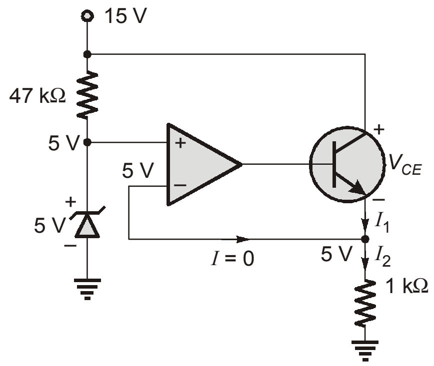
$\Rightarrow D_1, D_3$ are forward biased.

26. (b)

$$I_1 = \frac{5}{1\text{k}} = 5\text{ mA}$$

$$I_1 = I_E \cong I_C = 5\text{ mA}$$

$$V_{CE} = 15 - 5 = 10\text{ Volts}$$

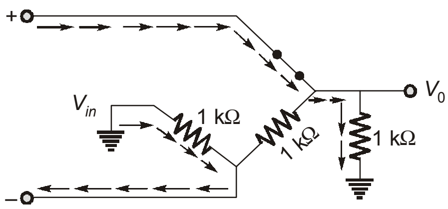


Power dissipated in transistor

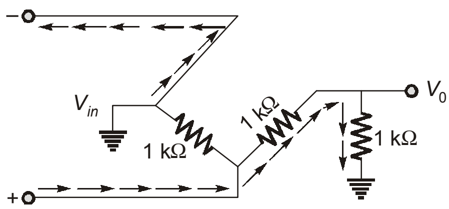
$$= V_{CE} \times I_C$$

$$= 10 \times 5\text{ mA} = 50\text{ mW}$$

27. (b)



For positive cycle of input



For negative cycle of input

thus the V_{in} will appear across the series combination of the two 1 kΩ resistors and we are taking output across 1 kΩ resistance only hence the output will be reduced by 50 % and the above circuit will work as a full wave rectifier with an attenuation of 1/2.

28. (a)

now, both the MOS will be in saturation region and $I_D = 4$ mA

$$\therefore \quad 4\text{ mA} = \mu_n C_{ox}\frac{W}{2L}(V_{GS} - V_t)^2$$

$$4 = \frac{20}{2}(V_{GS} - V_t)^2$$

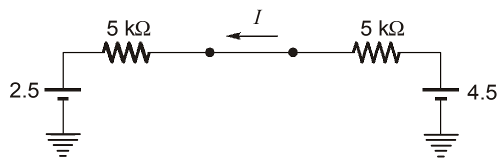
$$\sqrt{\left(\frac{4}{10}\right)} = V_{GS} - V_t$$

$$\therefore \quad V_{GS} = 1.132\text{ V}$$

now, $V_{out} = V_{GS} + I_D \cdot R = 1.132 + 1$

$= 2.132$ V

29. (d)



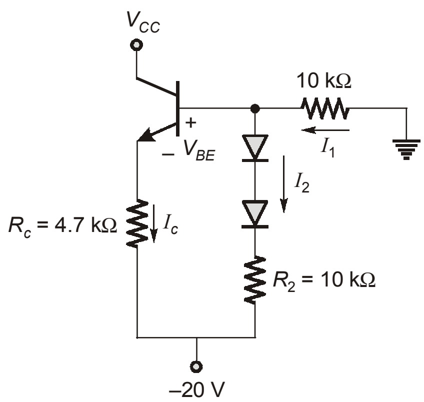
$$\therefore \quad I = \frac{2}{10\text{k}} = 0.2\text{ mA}$$

30. (c)

$\because \quad \beta >> 1$

$\therefore \quad I_c \approx I_E$

now, let drop across the diode be V_γ and voltage across the base emitter diode be V_{BE}



$$2V_\gamma + I_2R_2 = V_{BE} + I_cR_c$$

now, $I_2R_2 = 10 - V_\gamma$

$$\Rightarrow \quad 2V_\gamma + (10 - V_\gamma) = V_{BE} + I_c \times 4.7\text{ k}\Omega$$

$$\therefore \quad I_c = \frac{10}{4.7\text{ k}\Omega} = 2.12\text{ mA}$$

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