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ANALOG ELECTRONICS

ELECTRICAL ENGINEERING

Date of Test : 14/08/2026

ANSWER KEY

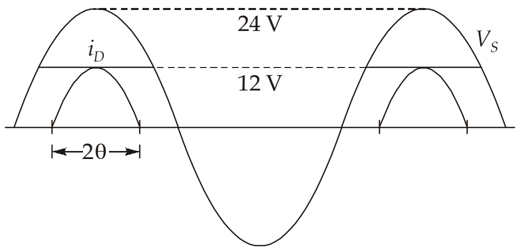
1.	(a)	7.	(d)	13.	(c)	19.	(d)	25.	(a)
2.	(b)	8.	(d)	14.	(b)	20.	(c)	26.	(c)
3.	(b)	9.	(c)	15.	(b)	21.	(a)	27.	(d)
4.	(b)	10.	(d)	16.	(d)	22.	(a)	28.	(c)
5.	(c)	11.	(c)	17.	(b)	23.	(b)	29.	(c)
6.	(a)	12.	(c)	18.	(c)	24.	(c)	30.	(b)

DETAILED EXPLANATIONS

1. **(a)**

∵ The feedback is voltage-series feedback, so the amplifier will be a voltage amplifier.

2. **(b)**



The diode conducts when V_s exceeds 12 V, as shown above,

The conduction angle is 2 θ, where θ is given by

$$24 \cos\theta = 12$$
$$\theta = 60°$$

and the conduction angle is 120°

That is $\frac{1}{3}$ of a cycle.

3. **(b)**

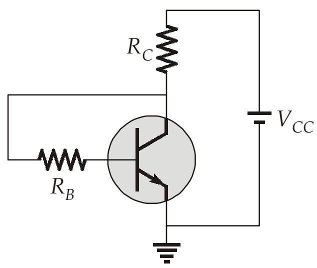
Transconductance (g_m) of a JFET is

$$g_m = g_{mo}\left[1 - \frac{V_{GS}}{V_P}\right]$$

where, $$g_{mo} = \frac{2I_{DSS}}{|V_P|}$$

4. **(b)**

Applying KVL, we get



$$-V_{CC} + (I_B + I_C)R_C + I_BR_B + V_{BE} = 0$$

$$I_B = \frac{V_{CC} - I_CR_C - V_{BE}}{R_C + R_B}$$

Now, $$\frac{dI_B}{dI_C} = \frac{-R_C}{R_C + R_B}$$

∴ $$S = \frac{1+\beta}{1-\beta\left(\frac{dI_B}{dI_C}\right)} = \frac{1+\beta}{1+\frac{\beta R_C}{(R_C + R_B)}}$$

5. **(c)**

$$I_{in} = \frac{V_{in} - V_Z}{1\text{k}} = \frac{40-10}{1\text{ k}} = 30\text{ mA}$$

$$I_{in} = I_Z + I_L$$

$$I_{L\,(min)} = I_{in} - I_{Z\,(max)} = 30 - 24 = 6\text{ mA}$$

$$I_{L\,(max)} = I_{in} - I_{Z\,(min)} = 30 - 5 = 25\text{ mA}$$

6. **(a)**

As we know,

$$\text{Gain} \times \text{Bandwidth} = \text{Constant} \quad \text{...(1)}$$

Closed loop gain with –ve feedback is

$$A_{CL} = \frac{A_{OL}}{1+A_{OL}\beta} \qquad (A_{OL} = \text{Open loop gain; } \beta = \text{Feedback factor})$$

Given : $A_{OL} = 100,\ (BW)_{OL} = 100\text{ kHZ}$

From eqn. (1), $A_{OL}(BW)_{OL} = A_{CL}(BW)_{CL}$

$$100 \times 10^5 = \frac{100}{1+100\beta}\times 10^6$$

$$1 + 100\beta = 10$$

$$\beta = 0.09$$

7. **(d)**

Let $V_o(t) = V_m \sin \omega_m t$

$$\text{S.R.} = \left|\frac{dV_o(t)}{dt}\right|_{\max} = V_m\omega_m \cos \omega_m t = V_m\omega_m$$

$$5 = V_m(2\pi \times 10^7)$$

$$V_m = \frac{5}{20\pi} = \frac{1}{4\pi} \text{ Volts}$$

So, the largest since wave output possible at a frequency of 10 MHz is $\frac{1}{4\pi}$ volts.

8. **(d)**

As we know,

$$V_o = A_{OL}(V^+ - V^-)$$

Since, $A_{OL} = \infty$ (for ideal Op-Amp)

So, $V^+ = V^- = V_{in}$

On applying KCL at inverting terminal

$$\frac{V^-}{3} + \frac{V^- - V_o}{2} = 0$$

$$2V^- + 3V^- - 3V_o = 0$$

$$5V_{in} = 3V_o$$

$$V_o = \frac{5}{3}V_{in} = A_V . V_{in}$$

$$\frac{V_o}{V_{in}} = A_V = \frac{5}{3}$$

9. **(c)**

It is non-inverting amplifier.

The gain, $$K = 1 + \frac{R_F}{R_1}$$

where, $$R_F = R_Y$$
$$R_1 = R_X$$

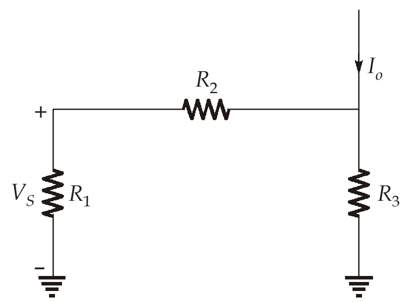
So, $$\text{gain } K = 1 + \frac{R_Y}{R_X}$$

10. **(d)**

The coupling capacitors in an amplifier prevents dc mixing with input and output. These capacitors block unwanted dc components and decouple or isolate dc from input and output.

11. **(c)**

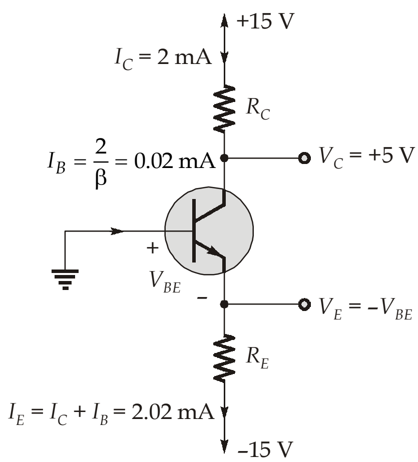
On neglecting the drop V_{BE}, then the voltage across R_1 is V_S.
Equivalent circuit diagram :



$$V_S = \frac{I_o R_3}{R_1 + R_2 + R_3} \times R_1 = \frac{I_o R_1 R_3}{R_1 + R_2 + R_3}$$

$$\frac{I_o}{V_S} = \frac{R_1 + R_2 + R_3}{R_1 R_3} = \frac{1}{R_3} + \frac{R_2}{R_1 R_3} + \frac{1}{R_1}$$

12. **(c)**



Given, $V_C = +5$ V

The CBJ will be reverse biased and the BJT will be operating in the active mode,

To obtain voltage, $V_C = +5$ V

The voltage drop across R_C must be 15 – 5 = 10 V

$$R_C = \frac{10}{2\text{ mA}} = 5\text{ k}\Omega$$

Since, $V_{BE} = 0.7$ V at $i_C = 1$ mA

The value of V_{BE} at $i_c = 2$ mA is

$$V_{BE} = 0.7 + V_T \ln\left(\frac{2}{1}\right) = 0.717\text{ V}$$

Since the base is at 0 V, the emitter voltage should be

$$V_E = -0.717\text{ V}$$

For $\beta = 100$,

$$\alpha = \frac{100}{101} = 0.99$$

$$I_E = \frac{I_C}{\alpha} = \frac{2}{0.99} = 2.02\text{ mA}$$

Now, $$R_E = \frac{V_E - (-15)}{I_E} = \frac{15 - 0.717}{2.02} = 7.07\text{ k}\Omega$$

13. (c)

In the transistor $V_{GS} = V_{DS}$

Since, the gate and drain terminals are shorted,

the transistor will always be in saturation mode.

thus, $$I_D = \frac{\mu_n C_{ox}}{2}\left(\frac{W}{L}\right)(V_{GS} - V_t)^2$$

now, $$I_D = \frac{V_0}{R} = \frac{3}{3} \times 10^{-3} = 1\text{ mA}$$

thus, $$1 \times 10^{-3} = \frac{50 \times 10^{-3}}{2}\left(\frac{W}{L}\right) \times (2-1)^2$$

$$\left(\frac{W}{L}\right) = \frac{1}{25} = 0.04$$

14. (b)

Voltage of non-inverting terminal,

$$V_P = \frac{6}{6+2} \times 2\text{ V}$$

$$= 1.5\text{ Volt}$$

$$V_o = A_{OL}[V_P - V_N]$$

$$V_N = V_P = 1.5\text{ Volt}$$

On applying KCL at inverting terminal,

$$\frac{V_N - 2}{2} + \frac{V_N - V_o}{6} = 0$$

$$3[V_N - 2] + V_N - V_o = 0$$

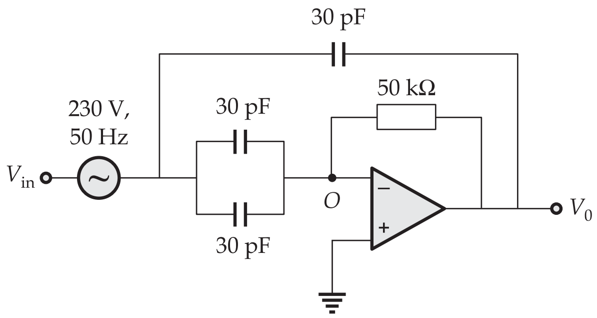
$$4V_N - 6 = V_o \qquad (\because V_N = 1.5\text{ V})$$

$$V_o = 4 \times 1.5 - 6 = 0\text{ V}$$

15. (b)

For V_0 due to AC source only, set V_{OC} to 0 volt/ground and from virtual grounding $V^+ = V^- = 0$

So,



$$1.3 \text{ pF} \,||\, 30 \text{ pF} = 31.3 \text{ pF}$$

KCL at V^-

$$\frac{0 - V_{in}}{1/j\omega C} + \frac{0 - V_0}{50 \times 10^3} = 0$$

$$V_0 = -50 \times j\omega C \times V_{in} \times 10^3$$

$$= -50 \times j2\pi \times 50 \times 31.3 \times 10^{-12} \times 230 \times 10^3$$

$$|V_0| = 113.08 \text{ mV}$$

16. (d)

Given,
$$R_1 = 14 \text{ k}\Omega,$$
$$R_2 = 6 \text{ k}\Omega,$$
$$R_S = 0.5 \text{ k}\Omega,$$
$$R_D = 1.2 \text{ k}\Omega$$

$$V_G = \frac{R_2}{R_1 + R_2} \times 10 + \frac{R_1}{R_1 + R_2}(-10)$$

$$= \frac{6 \times 10}{20} - \frac{14}{20} \times 10 = -4 \text{ V}$$

As transistor operating in saturation

$$I_D = \frac{V_S - (-10)}{R_S} = \frac{V_G - V_{GS} + 10}{R_S} = K_n(V_{GS} - V_{TN})^2$$

$$K_n = \frac{K_n'}{2}\frac{W}{L} = \frac{(60)(60 \times 10^{-6})}{2} = 1.8 \text{ mA/V}^2$$

$$(1.8 \times 10^{-3})(V_{GS} - 2)^2 \times 0.5 \times 10^3 = -4 - V_{GS} + 10$$

$$0.9(V_{GS}^2 + 4 - 4V_{GS}) = 6 - V_{GS}$$

$$0.9V_{GS}^2 + 3.6 - 3.6V_{GS} = 6 - V_{GS}$$

$$0.9V_{GS}^2 - 2.6V_{GS} - 2.4 = 0$$

$$\Rightarrow \quad V_{GS} = 3.62 \text{ V}, -0.73 \text{ V}$$

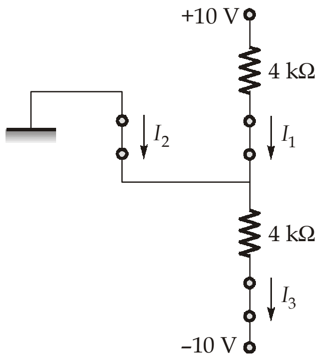
As V_{GS} is +ve so correct value $V_{GS} = 3.62$ V

$$I_D = \frac{V_G - V_{GS} + 10}{R_S}$$

$$= \frac{-4 - 3.62 + 10}{500} = 4.76 \text{ mA}$$

17. (b)

Assuming initially all diodes are ON and can be replaced by short circuit,



Current, $$I_1 = I_3 = \frac{10-(-10)}{8\,\text{k}\Omega} = \frac{20}{8\,\text{k}\Omega} = 2.5 \text{ mA}$$

as no current is drawn from ground

$$I_2 = 0$$

$\therefore$ D_2 is in off state.

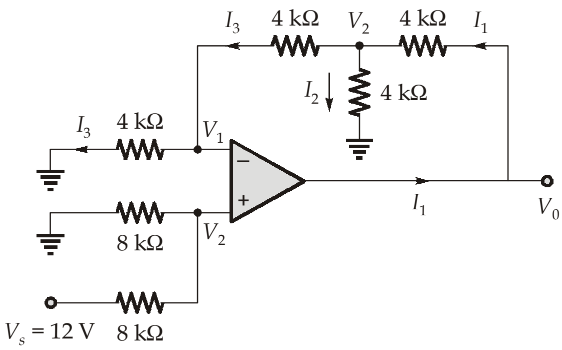
18. (c)

It is CB amplifier,

$$A_v = g_m R_C$$
$$= g_m \times 7.5 \text{ k}\Omega$$
$$g_m = \frac{1}{r_e} = \frac{I_C}{V_T}$$
$$I_C \approx I_E = 0.5 \text{ mA}$$
$$g_m = \frac{0.5\,\text{mA}}{25\,\text{mV}} = 20 \text{ mA/V}$$
$$A_v = 20 \text{ mA/V} \times 7.5 \text{ k}\Omega$$
$$= 150$$

19. (d)

Given circuit can be redrawn

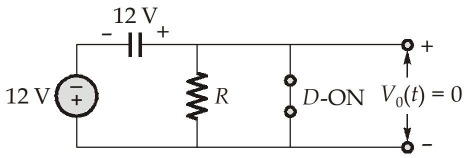


$$V_2 = V^+$$
$$V^+ = \frac{V_S \times 8\text{k}}{(8+8)\text{k}} = \frac{V_s}{2} = 6 \text{ V}$$
$$V_1 = V^+ \quad \text{(by virtual short)}$$
$$V_1 = \frac{V_s}{2} = \frac{12}{2} = 6 \text{ V}$$
$$I_3 = \frac{V_1}{4\text{ k}\Omega} = \frac{6}{4\text{ k}\Omega} = 1.5 \text{ mA}$$
$$V_2 - V_1 = I_3 R = 1.5 \text{ mA} \times 4 \text{ k}\Omega = 6 \text{ V}$$
$$V_2 = 6 \text{ V} + 6 \text{ V} = 12 \text{ V}$$
$$I_2 = \frac{V_2}{4\text{ k}\Omega} = \frac{12}{4\text{ k}\Omega} = 3 \text{ mA}$$

$$I_1 = I_2 + I_3 = 1.5 \text{ mA} + 3 \text{ mA} = 4.5 \text{ mA}$$
$$V_0 - V_2 = I_1 \text{ (4 k}\Omega)$$
$$= 4.5 \text{ mA} \times (4 \text{ k}\Omega) = 18 \text{ V}$$
$$\therefore \quad V_0 = 18 + V_2 = 18 + 12 = 30 \text{ V}$$

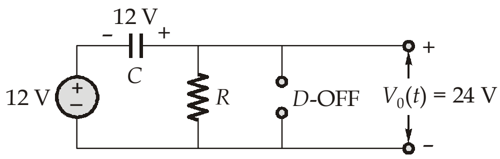
20. (c)

For given figure, when V_{in} is negative



Output is zero

When $V_i(t)$ is positive



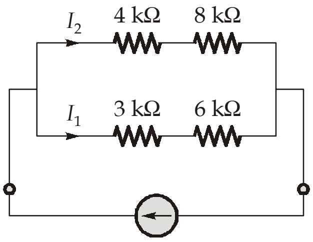
At t = 15 msec

The capacitor voltage and source voltage together will appear at the output :

$$12 \text{ V} + 12 \text{ V} = 24 \text{ V}$$

21. (a)

As given bridge is balanced, the diode will not conduct

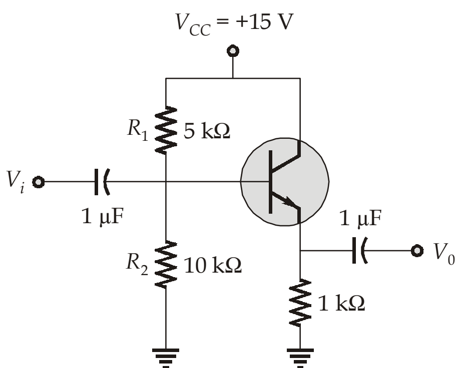


By current division rule, current in 6 kΩ resistor

$$I_1 = \frac{12}{12+9} \times 2 \text{ mA} = 1.14 \text{ mA}$$

22. (a)

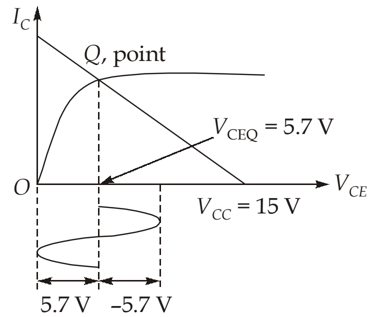
For given circuit DC analysis:



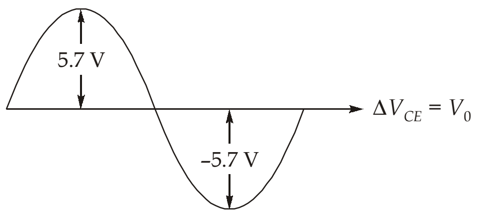
$$(V_B)_q = \frac{V_{CC} \times R_2}{R_1 + R_2} = \frac{15 \times 10\,\text{k}\Omega}{(10+5)\,\text{k}\Omega} = 10\text{ V}$$

$$(V_E)_q = V_B - 0.7 = 10 - 0.7 = 9.3\text{ V}$$

$$(V_{CE})_q = (V_C)_Q - (V_E)_Q = 15 - 9.3 = 5.7\text{ V}$$



∴ Let maximum undistorted peak to peak output voltage, $V_{0(p-p)}$



$$V_{0(p-p)} = 2 \times 5.7 = 11.4\text{ V}$$

23. (b)

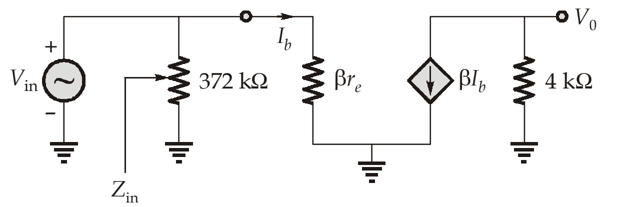
By DC analysis

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{10 - 0.7}{372\,\text{k}} = 25\ \mu\text{A}$$

$$I_C = \beta I_B = 100 \times 25\ \mu\text{A} = 2.5\text{ mA}$$

$$r_e = \frac{V_T}{I_C} = \frac{25\,\text{mV}}{2.5\,\text{mA}} = 10\ \Omega$$

By equivalent r_e - model of the amplifier



Input impedance, $Z_i = R_B \,||\, \beta r_e$

$= (372\text{ k}) \,||\, (100 \times 10)$

$= 997.32\ \Omega$

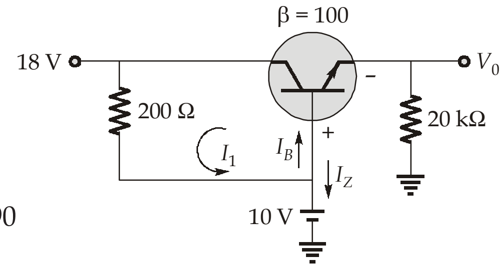
$V_0 = -4\text{ k} \times \beta I_b$, $\qquad V_i = I_b \times \beta r_e$

Voltage gain, $A_v = \dfrac{-4\text{k} \cdot \beta I_b}{r_e \cdot \beta I_b} = \dfrac{-4\text{k}}{10\Omega} = -400$

24. (c)

Given, $V_i = 18$ V, $V_Z = 10$ V

Assuming BJT in forward active mode and zener diode is in breakdown mode



So, $V_0 = 10 - 0.7\text{ V} = 9.3\text{ V}$

$$I_E = \frac{9.3}{20\,\text{k}\Omega} = 0.465\text{ mA}$$

$$I_B = I_E(1 - \alpha)$$

Where, $$\alpha = \frac{\beta}{\beta+1} = \frac{100}{100+1} = 0.990$$

$$I_B = 0.465 \times 10^{-3}(1 - 0.990) = 4.65\ \mu\text{A}$$

$$I_1 = \frac{18-10}{200} = 0.4 \approx 40\text{ mA}$$

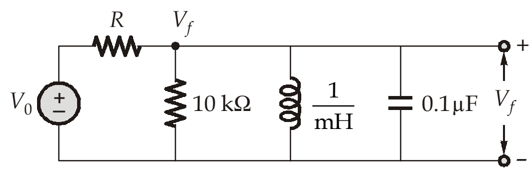
Since $I_1 > I_B$ so, I_Z will be positive

Zener breakdown occurs and our assumption forward active mode is correct.

25. (a)

We know, $$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{1\times10^{-3}\times0.1\times10^{-6}}}$$

$$= \frac{1}{1\times10^{-5}} = 10^5\text{ rad/sec}$$



Apply nodal analysis

$$\frac{V_f - V_0}{R} + \frac{V_f}{10\text{k}} + \frac{V_f}{j\omega L} + V_f j\omega C = 0$$

$$V_f\left[\frac{1}{R} + \frac{1}{10\text{k}}\right] + V_f\left[j\left(\omega C - \frac{1}{\omega L}\right)\right] = \frac{V_0}{R}$$

For oscillation, $$\omega C - \frac{1}{\omega L} = 0$$

$$V_f\left[\frac{1}{R} + \frac{1}{10\text{k}}\right] = \frac{V_0}{R}$$

$$\beta = \frac{V_f}{V_0} = \frac{\frac{1}{R}}{\frac{1}{R} + \frac{1}{1\text{k}}}$$

$$A = 1 + \frac{R_f}{R_1} = 1 + \frac{100\text{k}}{5\text{k}} = 21$$

$$\beta = \frac{1}{A} = \frac{1}{21} = \frac{\frac{1}{R}}{\frac{1}{R} + \frac{1}{10\text{k}}}$$

[$\because A\beta = 1$ for sustained oscillations, $\therefore \beta = 1/A$]

$$\frac{1}{21} = \frac{\frac{1}{R}}{\frac{10\text{k}+R}{10\text{k}\,R}} = \frac{1}{R}\times\frac{10\text{k}\,R}{10\text{k}+R}$$

$$10\text{ k} + R = 210\text{ k}$$

$$R = 200\text{ k}\Omega$$

26. (c)

$$S_v = \left.\frac{\partial I_C}{\partial V_{BE}}\right|_{\beta,\, I_{CO}\text{ are constant}}$$

$$= \frac{-\beta}{R_B + R_E(1+\beta)} = \frac{-\frac{\beta}{R_E}}{1+\beta+\frac{R_B}{R_E}}$$

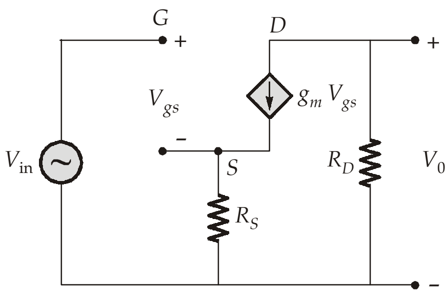
$$S_v \approx -\frac{1}{R_E} \qquad \because \frac{R_B}{R_E} << 1+\beta \text{ and } 1+\beta \cong \beta$$

27. (d)

If the bypass capacitor is removed, then the mid band voltage gain will decrease and the input resistance will increase. This happens because of the negative feedback introduced by R_E.

28. (c)

For common source amplifier the ac small signal circuit is,



$$V_0 = -g_m V_{gs} R_D$$

KVL in gate source loop,

$$-V_i + V_{gs} + g_m V_{gs} R_s = 0$$

$$V_i = V_{gs}(1 + g_m R_s)$$

$$A_V = \frac{-g_m R_D}{1+g_m R_s}$$

$$|A_V| = 1 = \frac{g_m R_D}{1+g_m R_s}$$

If $g_m R_s >> 1$

$$1 = \frac{g_m R_D}{g_m R_s}$$

$$R_D = R_s$$

29. (c)

Dynamic resistance of diode,

$$r_d = \frac{\eta V_T}{I_0\, e^{v/\eta V_T}} \quad Þ \quad \frac{r_{d_2}}{r_{d_1}} = \frac{e^{v_1/\eta V_T}}{e^{v_2/\eta V_T}}$$

$$\therefore \quad 1000 = e^{|v_1 - v_2|/\eta V_T}$$

$$\therefore \quad \ln 10^3 = |v_1 - v_2| / \eta V_T$$

$$\Rightarrow \text{for } \eta = 1, \quad |v_1 - v_2| = V_T\,(\ln 10^3)$$

30. (b)

The nominal value of the current in the diode,

$$I = \frac{10 - 2.1}{1} = 7.9 \text{ mA}$$

Thus each diode will have an incremental resistance,

$$r_d = \frac{\eta V_T}{I_{DC}} = \frac{2 \times 25}{7.9} = 6.3\ \Omega$$

The three diode in series will have a total incremental resistance,

$$r = 3r_d = 18.9\ \Omega$$

$$\Delta V_0 = 2 \times \frac{r}{r + R} = 2 \times \frac{0.0189}{0.0189 + 1} = 37.1 \text{ mV}$$

($\because$ It is multiplied by two because the change will be both side)

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