CLASS TEST

Sl. 01 SK_EE_ABCD_030722 [G]

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ANALOG ELECTRONICS

ELECTRICAL ENGINEERING

Date of Test : 03/07/2022

ANSWER KEY

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

DETAILED EXPLANATIONS

1. **(a)**

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

2. **(a)**

The PIV rating of full-wave rectifier with centre tap is $2\,V_m = 2 \times 100 = 200$ V

3. **(d)**

For amplifier to have a valid

$$V_{out} = A(V_1 - V_2)$$

$$V_1 - V_2 = \frac{V_{out}}{A}$$

now, for virtual ground $A \to \infty$.

But if $A \neq \infty$, then

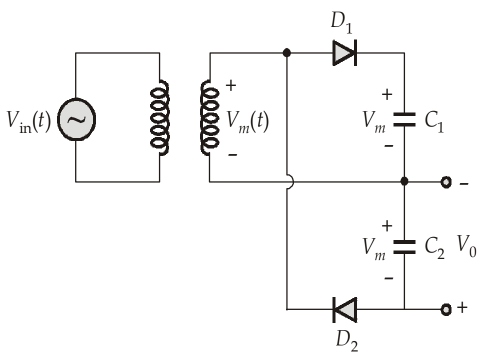
$$V_t = \frac{\pm V_{out}}{A} = \frac{\pm 10}{1000} = \pm 10\text{ mV}$$

4. **(d)**

Maximum current is drawn in saturation while minimum current is drawn in cut-off.

5. **(d)**

The circuit can be redrawn as,

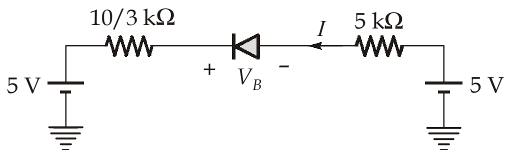


The circuit represents a voltage doubler circuit, if the voltage was taken by adding voltages of both the capacitors, but to calculate V_0 we have to find the voltage stored on a single capacitor. Thus, comparing from the above figure,

$$V_0 = -V_m$$

6. **(a)**

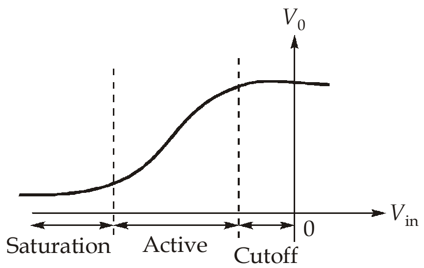
Drawing the Thevenin equivalent circuit, we get



Applying KVL we get $V_D = 0$ V, thus no current will flow through the diode D_1.

Hence, $I = 0$ A

7. (b)



8. (d)

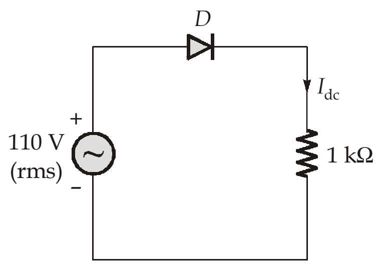
∵ It is a voltage doubler circuit.

9. (d)

BJTs can supply more current than MOSFETs because the channel formed in the MOS is smaller than the channel in BJTs.

10. (b)

The diode will work as a half wave rectifier



thus, $$I_{dc} = \frac{I_m}{\pi}$$

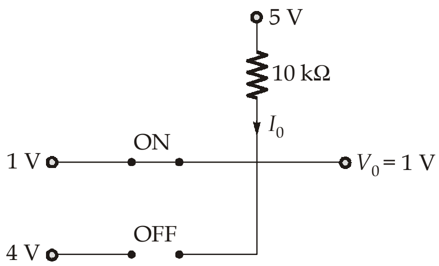
$$R = 1000 + 40 = 1040\ \Omega$$

Now, $$I_m = \frac{V_m}{R} = \frac{110 \times \sqrt{2}}{1040} = 149.58\ \text{mA}$$

∴ $$I_{dc} = \frac{149.58}{\pi} = 47.61\ \text{mA}$$

11. (c)

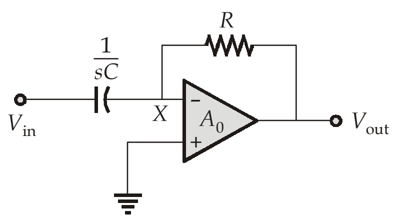
From the circuit, we can conclude that diode D_1 will conduct and diode D_2 will be switched off.



$$I_0 = \frac{5\text{V} - V_0}{10\ \text{k}\Omega} = \frac{5\text{V} - 1\text{V}}{10\ \text{k}\Omega} = 0.4\ \text{mA}$$

Thus, $V_0 = 1$ V and $I_0 = 0.4$ mA.

12. (d)



Applying KCL at node 'X', we get,

$$\frac{V_{in} - V_x}{1/sC} = \frac{V_x - V_{out}}{R_1}$$

now, $$\frac{-V_{out}}{A_0} = V_x$$

∴ $$\frac{-V_{out}}{V_{in}} = \frac{-RCs}{1 + \frac{1}{A_0} + \frac{sRC}{A_0}}$$

$$\frac{s_p RC}{A_0} + \frac{1}{A_0} + 1 = 0$$

$$\frac{s_p RC}{A_0} = -1 - \frac{1}{A_0}$$

$$\text{Pole, } s_p = \frac{-(1 + A_0)}{RC}$$

Hence option (d) is correct.

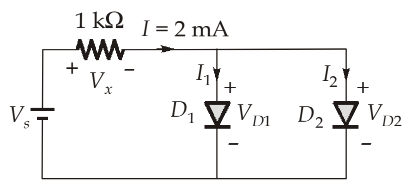
13. (b)

$$A_{CL} = \frac{A_{OL}}{1 + A_{OL}\beta} = \frac{\frac{A_0}{(1 + j\omega/\omega_0)}}{1 + \frac{A_0}{\left(1 + \frac{j\omega}{\omega_0}\right)} \cdot \beta} = \frac{A_0}{1 + j\frac{\omega}{\omega_0} + A_0\beta}$$

$$= \frac{\frac{A_0}{1 + A_0\beta}}{1 + j\frac{\omega}{\omega_0(1 + A_0\beta)}} = \frac{A'_{CL}}{1 + j\frac{\omega}{\omega'_0}}$$

∴ $$\omega'_0 = \omega_0(1 + A_0\beta)$$

14. (c)



$$V_s = V_x + V_{D1} \qquad (\because V_{D1} = V_{D2})$$

and $$I = I_1 + I_2$$

thus $$2 \times 10^{-3} = 10^{-12}\left[e^{\frac{V_{D1}}{26 \times 10^{-3}}} - 1\right] + 10^{-10}\left[e^{\frac{V_{D1}}{26 \times 10^{-3}}} - 1\right]$$

$$2 \times 10^{-3} \approx 10^{-10}(1.01) \cdot e^{\frac{V_{D1}}{26 \times 10^{-3}}}$$

$$\frac{V_{D1}}{26 \times 10^{-3}} = \ln(1.9801 \times 10^7) = 16.801$$

$\therefore$ $V_{D1} = 0.437$ V

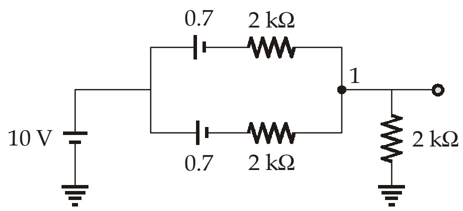
Now, $V_x = 2 \times 10^{-3} \times 1 \times 10^3 = 2$ V

$V_s = V_x + V_{D1} = 2 + 0.437$

$= 2.437$ V

15. (b)

The above circuit can be represented as,



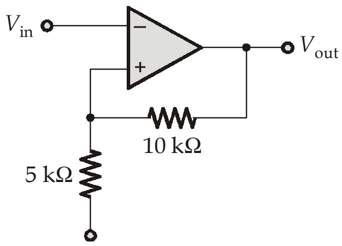
Applying KCL at node 1,

$$\frac{V_0}{2k} + \frac{V_0 - 10 + 0.7}{2k} + \frac{V_0 - 10 + 0.7}{2k} = 0$$

$$V_0\left[\frac{3}{2k}\right] = \frac{9.3}{1k}$$

$$V_{out} = \frac{9.3}{3} \times 2 = 6.2 \text{ V}$$

16. (b)



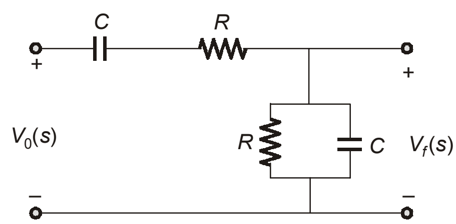
$$V_1 = \frac{3 \times 10 + V_0 \times 5}{15} = \frac{6 + V_0}{3}$$

$$V_{UT} = \frac{6 + 15}{3} = 7 \text{ V}$$

$$V_{LT} = \frac{6 - 15}{3} = -3 \text{ V}$$

17. (b)

This is a Wein bridge oscillator,



$$\beta = \frac{V_f(s)}{V_0(s)}$$

Loop gain, $$A\beta = L(s) = \left(1 + \frac{R_2}{R_1}\right)\frac{V_f(s)}{V_0(s)}$$

$$\beta = \frac{\left(R \parallel \frac{1}{sC}\right)}{\left(R + \frac{1}{sC}\right)\left(R \parallel \frac{1}{sC}\right)}$$

$$L(s) = \left(1+\frac{R_2}{R_1}\right)\left(\frac{1}{3-SRC+\frac{1}{SCR}}\right)$$

$$L(j\omega) = \left(1+\frac{R_2}{R_1}\right)\left(\frac{1}{3+j\omega RC+\frac{1}{j\omega RC}}\right)$$

to produce oscillations at $\omega = \omega_0$

$$L(j\omega_0) = 1$$

$$\omega_0 RC - \frac{1}{\omega_0 RC} = 0$$

$$\omega_0 = \frac{1}{RC}$$

So, $$1 = \left(1+\frac{R_2}{R_1}\right)\left(\frac{1}{3}\right)$$

$\Rightarrow$ $$\frac{R_2}{R_1} = 2$$

So, to sustain oscillations, we must have $\frac{R_2}{R_1} \geq 2$

18. (c)

$$I_C = \beta I_B + (1+\beta)I_{CO}$$

but $$\beta = \frac{\alpha}{1-\alpha}$$

$\therefore$ $$I_C = \beta I_B + \left(1+\frac{\alpha}{1-\alpha}\right)I_{CO} = \beta I_B + \frac{1-\alpha+\alpha}{1-\alpha}I_{CO}$$

$$I_C = \beta I_B + \frac{1}{1-\alpha}I_{CO}$$

19. (d)

Given,

Base current, $I_B = 25\ \mu A$

$I_{CBO} = 200\ nA$

$\alpha = 0.98$

where, $$\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = 49$$

Collector current, $I_C = \beta I_B + (1+\beta)I_{CBO}$

$\therefore$ $I_C = 49 \times 25 \times 10^{-6} + (50) \times 200 \times 10^{-9}$

$I_C = 1.235 \times 10^{-3}$ A

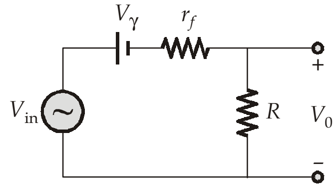
Emitter current, $I_E = I_C + I_B$

$= 1.235$ mA $+ 0.025$ mA

$\therefore$ $I_E = 1.26$ mA

20. (c)

The small signal equivalent model can be drawn as



∴ The output can be expressed as,

$$V_0 = \frac{R}{R+r_f}V_{in} - \frac{R}{R+r_f}V_\gamma \quad \text{...(i)}$$

Thus, the slope of line in the graph of the input output curve can be written

$$\text{Slope} = \frac{R}{R+r_f} = \frac{1.2}{2-0.7} = \frac{1.2}{1.3} \quad \text{...from equation (i)}$$

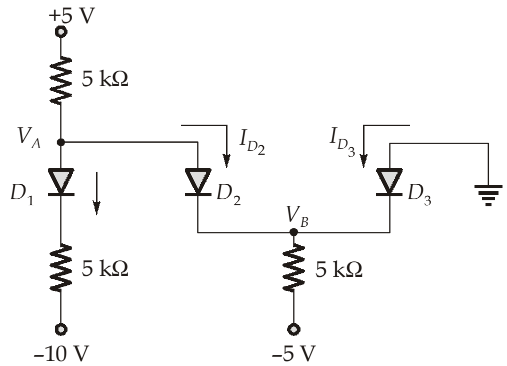
Thus, $r_f = 83.33\ \Omega$

21. (d)

Initially assume each diode is in its conducting state

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

and $V_A = 0.7 - 0.7 = 0\text{ V}$



Applying KCL at node A,

$$\frac{5-V_A}{5k} = I_{D2} + \frac{(V_A - 0.7)-(-10)}{5k}$$

Since, $V_A = 0$

$$I_{D2} = \frac{5-9.3}{5k}$$

$$I_{D2} = -0.86\text{ mA}$$

Which is in consistant with the assumption that all diodes are ON.

Now assume that D_1 and D_3 are ON and D_2 is OFF

Applying KVL in the loop,

$-5 + (I_{D1} \times 5k) + 0.7 + (I_{D1} \times 5k) - 10 = 0$

$$I_{D1} = \frac{15-0.7}{10k} = 1.43\text{ mA}$$

∴ $V_A = 0.7 + (I_{D1} \times 5k) - 10$

$= 0.7 + (1.43 \times 5) - 10$

$V_A = -2.15\text{ V}$

22. (c)

$$I = \frac{10-6}{50} = 80 \text{ mA}$$

$$I = I_Z + I_L = I_{Z\,min} + I_{L\,max}$$

$$I_{Z\,min} = 5 \text{ mA}$$

$$80 = 5 + I_{L\,max}$$

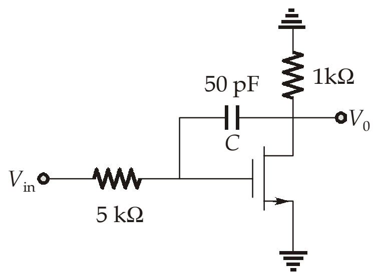
$$I_{L\,max} = 75 \text{ mA}$$

$$I_{L\,max} = \frac{V_L}{R_{min}}$$

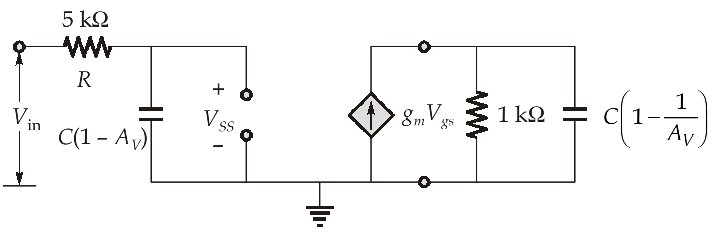
$$R_{min} = \frac{V_L}{I_{L\,max}} = \frac{6}{75\times10^{-3}} = 80\ \Omega$$

23. (a)

With respect to AC



Taking Miller's equivalent and assume $r_0 = \infty$



$$A_V = -g_m R_D = -0.01 \times 10^3$$
$$= -10$$

Small signal input pole frequency,

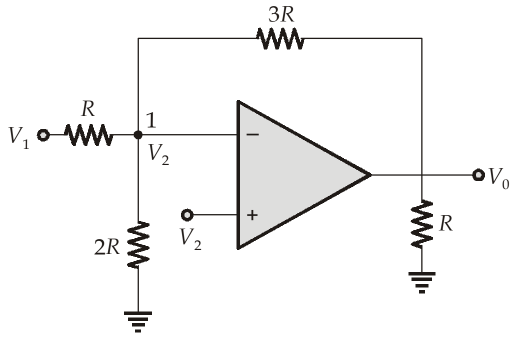
$$f = \frac{1}{2\pi RC}$$

$$= \frac{1}{2\pi \times 5\times10^3 \times 50\times10^{-12}(1+10)}$$

$$= 57.87 \text{ kHz}$$

24. (d)

By applying KCL at node 1 we get,



$$\frac{V_2 - V_1}{R} + \frac{V_2}{2R} + \frac{V_2 - V_0}{3R} = 0$$

$$\frac{6V_2 - 6V_1 + 3V_2 + 2V_2 - 2V_0}{6R} = 0$$

$$11\ V_2 - 6V_1 - 2V_0 = 0$$

$$2V_0 = -6V_1 + 11\ V_2$$

$$V_0 = -3V_1 + \frac{11}{2}V_2$$

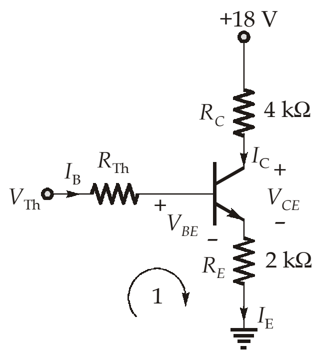
25. (d)

By taking the Thevenin's equivalent between base and ground nodes, the given circuit can be reduced as follows:

$$V_{\text{Th}} = \frac{16}{16+44} \times 18\text{V} = 4.8\text{ V};$$

$$R_{\text{Th}} = (44\ k \,||\, 16\ k)\ \Omega$$

Applying KVL in loop 1 we get,



$$I_E R_E = V_{\text{Th}} - V_{BE} - I_B R_{\text{Th}}$$

$$I_B = 0\text{ A}$$

Given, $\alpha = 1$

So, $I_E R_E = 4.8 - 0.8$

$$= 4\text{ V}$$

$$I_E = \frac{4}{2 \times 10^3} = 2\text{ mA}$$

$$I_C = I_E = 2\text{ mA}$$

$$V_{CE} = V_{CC} - I_C R_C - I_E R_E$$

$$= 18 - (2 \times 4) - (2 \times 2) = 6\text{ V}$$

26. (b)

Transistor will enter to saturation region for $V_{CE\,(sat)} = 0$ V

Applying KVL in collector emitter loop,

$$-20 + (I_C \times 10\text{ k}) + V_{CE\text{ sat}} = 0$$

$$I_C = \frac{20 - V_{CE(\text{sat})}}{10\text{k}} = 2\text{ mA}$$

$$I_B = \frac{I_C}{\beta} = \frac{2 \times 10^{-3}}{50} = 40\ \mu\text{A}$$

Applying KVL in base emitter loop

$$-10 + I_B R_B + 0.7 = 0$$

$$R_B = \frac{10 - 0.7}{40 \times 10^{-6}} = 232.5\text{ k}\Omega$$

∴ For all values of $R_B > 232.5$ kΩ the transistor will not operate in saturation region.

27. (a)

The output voltage of differential amplifier is given as,

$$V_0 = A_d V_d + A_c V_c$$

Where,
A_d = Differential gain
A_c = Common mode gain
V_d = Differential input voltage = $V_1 - V_2$

$$V_c = \text{Common mode input voltage} = \frac{V_1 + V_2}{2}$$

$$V_0 = A_d V_d \left[1 + \frac{A_c V_c}{A_d V_d}\right] = A_d V_d \left[1 + \frac{1}{\rho} \cdot \frac{V_c}{V_d}\right]$$

Where, $\rho = \frac{A_d}{A_c}$ = common mode rejection ratio

Set of signal 1,

$$V_d = 50\ \mu V - (-50\ \mu V) = 100\ \mu V$$

$$V_c = \frac{50\ \mu V - 50\ \mu V}{2} = 0$$

$$V_{01} = 100\mu V\ A_d[1 + 0] = 100\ A_d\ \mu V$$

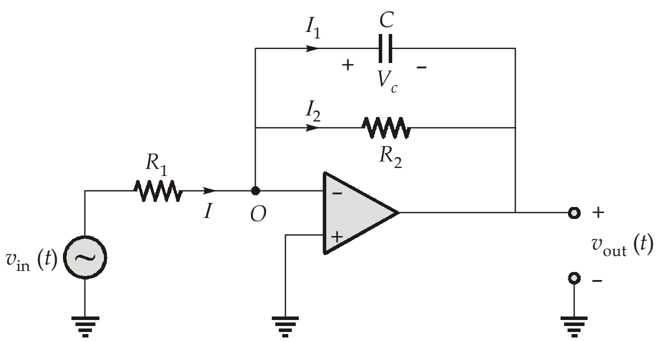
$$V_c = \frac{1050\ \mu V + 950\ \mu V}{2} = 1000\ \mu V$$

$$V_d = 1050\ \mu V - 950\ \mu V = 100\ \mu V$$

$$\therefore \quad V_{02} = A_d 100\ \mu V\left[1 + \frac{1}{100} \times \frac{1000\ \mu V}{100\ \mu V}\right] = 110\ A_d\ \mu V$$

$$\%\ \text{difference} = \frac{V_{02} - V_{01}}{V_{01}} \times 100 = \frac{110 - 100}{100} \times 100 = 10\%$$

28. (d)



From KCL,

$$I = I_1 + I_2$$

$$\frac{V_i(t) - 0}{R_1} = \frac{C\,dV_c(t)}{dt} + \frac{0 - V_0(t)}{R_2}$$

Taking in S-domain,

$$\frac{V_i(s)}{R_1} = C[sV_c(s) - V_c(0)] - \frac{V_0(s)}{R_2}$$

$$\frac{V_i(s)}{R_1} = CV_c(s)\left[s + \frac{1}{R_2C}\right] \qquad [\because V_0(s) = -V_c(s)]$$

$$V_c(s) = \frac{V_i(s)}{R_1C\left[s + \frac{1}{R_2C}\right]}$$

$$V_c(s) = \frac{2}{(20\times10^3\times10\times10^{-6})\left(s + \frac{1}{40\times10^3\times10\times10^{-6}}\right)(s+2)}$$

$$\left[\because V_i(s) = \frac{2}{(s+2)}\right]$$

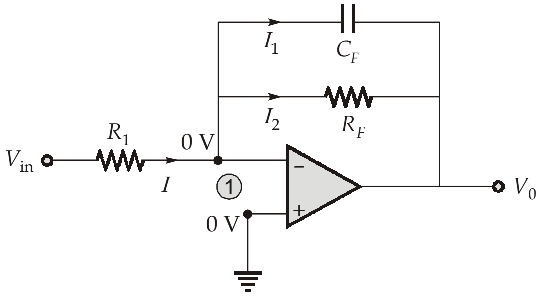
$$V_c(s) = \frac{10}{(s+2.5)(s+2)} = \frac{-20}{(s+2.5)} + \frac{20}{(s+2)}$$

$$V_0(s) = \frac{20}{(s+2.5)} - \frac{20}{(s+2)}$$

By taking inverse Laplace,

$$V_0(t) = 20\, e^{-2.5t}\, u(t) - 20\, e^{-2t}\, u(t)$$

29. (b)



By KCL at node-1

$$I = I_1 + I_2$$

$$\frac{V_i}{R_1} = \frac{-CdV_0}{dt} - \frac{V_0}{R_F}$$

Taking Laplace transform,

$$\frac{V_i(s)}{R_1} = V_0(s)\left[-sC - \frac{1}{R_F}\right]$$

$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{-\frac{R_F}{R_1}}{1 + sR_FC_F}$$

$$\left|\frac{V_0(s)}{V_{in}(s)}\right| = \left|\frac{\frac{-R_F}{R_1}}{1+j\omega R_F C_F}\right|$$

If $\quad f = 0,$

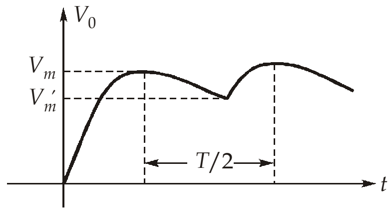
then $\quad |A| = \frac{R_F}{R_1} = \frac{1.2\times10^6}{120\times10^3} = 10$

$$\text{dc gain} = 20\log_{10}|A| = 20 \text{ dB}$$

30. (d)

$$V_{max} = \sqrt{2}\times 220 = 311.12 \text{ V}$$

Since output is a rectified wave we have,



$$V_m' = V_m\left(1-\frac{T}{2RC}\right)$$

$$V_m - V_m' = \frac{V_m T}{2RC}$$

$$\text{ripple} = V_m - V_m' = \frac{V_m T}{2RC}$$

Peak to peak ripple voltage,

$$= 0.01 \times V_{max}$$
$$= 0.01 \times 311.12$$
$$\text{ripple} = 3.11$$

$$3.11 = \frac{311.12}{2\times50\times10\times10^3\times C}$$

$$C = 100\ \mu\text{F}$$

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