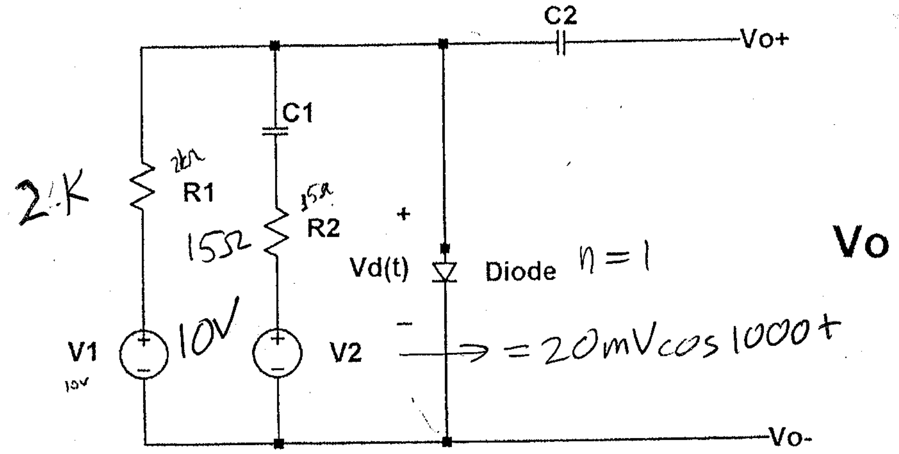


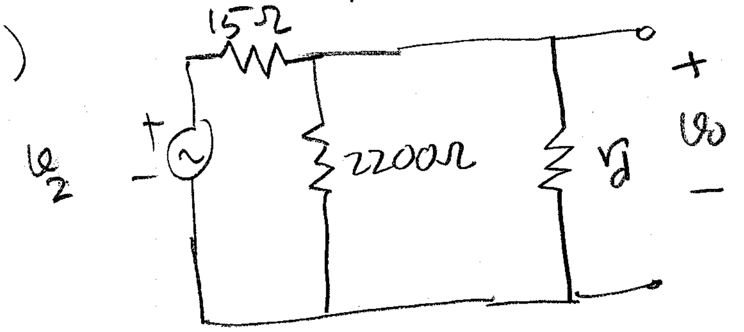
1. (25 points) At the circuit given above, the diode $V\gamma = 0.6$Volts. The value of the resistor R_2 is 15Ω. $V_1 = 10$Volts, $R_1 = 2k\Omega$, C_1 and C_2 are very large. $V_2(t)$ is equal to 0.02cos(1000t) Volts. The diode is at room temperature and the ideality factor n=1. Answer the following:

a. (6 points) Find the DC current, I_{DQ}, through the diode,
b. (6 points) Draw the AC equivalent circuit,
c. (7 points) Calculate and plot $v_o(t)$, carefully label the time axis and zero-crossing points.
d. (6 points) Do we expect to see an undistorted or distorted sinusoidal wave over the diode? Please state the reason behind your answer.

solutions :

(a) $I_{DC} = \dfrac{V_{DC} - V_\gamma}{R_1} = \dfrac{10V - 0.6V}{2000\Omega} = \dfrac{9.4V}{2000\Omega} = 4.7\times10^{-3}A$

(b)



$r_d = \dfrac{V_T}{I_{DC}} = \dfrac{26.6mV}{4.7mA}$

$r_d = 5.659\Omega$

$r_d // 2000 = \dfrac{5.659\times2000}{5.659+2000}$

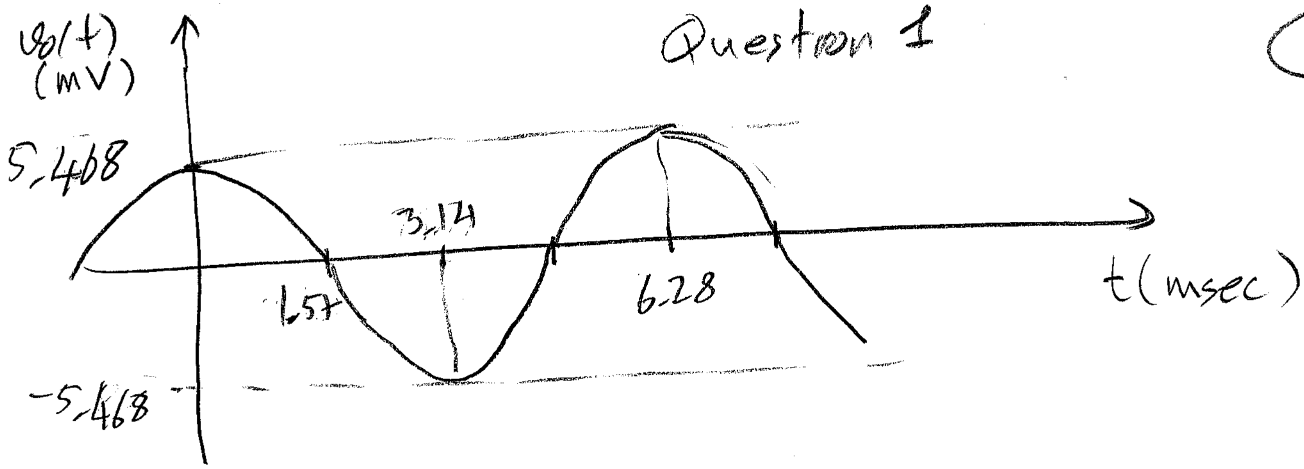
(c) $v_o(t) = v_2(t)\cdot\dfrac{r_d // 2000}{r_d // 2000 + 15}$ $= 2000 // r_d = 5.643\Omega$

$v_o(t) = \left(20\times\dfrac{5.643}{5.643+15}mV\right)\cos 1000t = 20\times0.2734\ mV\cos 1000t$

$= 5.468\ mV)\cos 1000t$ $\quad f = \dfrac{1000}{2\pi} = 159.15\ msec$

$T = 6.2831$

Question 1

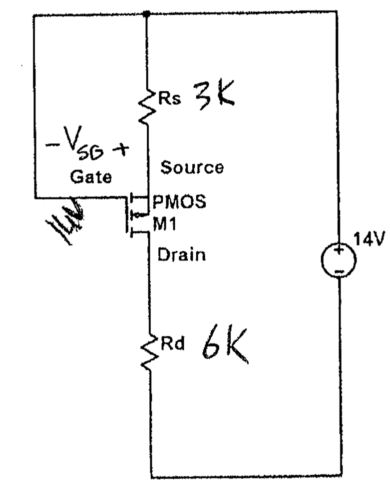


$T/4 =$

(d) We expect to see an undistorted waveform because

$|v_o(t)|_{peak} \ll V_T = 26.6\,mV$

Question 2



2. (20 points) At the depletion-mode p-channel MOSFET circuit given above, $V_{TP}=$ 3 Volts and $K_P = 5\times10^{-3}A/V^2$. $R_d = 6k\Omega$ and $R_S = 3k\Omega$

a. (15 points) Find the bias of the transistor,

b. (5 points) Verify the solution.

Solutions:(a)

(a) assuming saturation and writing the gate-source loop:

$$0 = I_D R_S + V_{SG} = R_S K_n (V_{SG} + (V_{TP}))^2 + V_{SG}$$

$$3\times10^3 \cdot 5\times10^{-3}\left[V_{SG}^2 + 2V_{SG}\times3 + 9\right] + V_{SG} = 0$$

$$15V_{SG}^2 + 90V_{SG} + 135 \quad + V_{SG} = 0 \Rightarrow$$

$$\underbrace{15}_{a}V_{SG}^2 + \underbrace{91}_{b}V_{SG} + \underbrace{135}_{c} = 0$$

$$V_{SG_{1,2}} = \frac{-b \pm \sqrt{b^2-4ac}}{2a} = \frac{-91 \pm \sqrt{91^2 - 4\times15\times135}}{30}$$

$$= \frac{-91 \pm \sqrt{181}}{30} = -3.033 \pm 0.448 = -2.585, \cancel{-3.482}$$

means cut-off

$$\Rightarrow \boxed{V_{SG} = -2.58488\ V}$$

Validation

$$\boxed{I_D = K_n(V_{SG}+3)^2 = 5\times10^{-3}(-2.58488+3)^2 = 8.6162\times10^{-4}A}$$

$$V_{SG} = -I_D R_S = -8.6162\times10^{-4}\times3\times10^3 = -2.58488\ V \checkmark$$

2

Question 2

$$\boxed{V_{SD} = V_{DC} - (R_D + R_S) I_D = 14 - 8\times10^{3} \times 8.6162\times10^{-4}}$$

$$= 14 - 6.89 = 7.107\,V > V_{SG} + V_{TP} =$$

$$-2.58488 + 3 = 0.415\,V$$

$\Rightarrow$ SAT assumption is correct

b-) Verifying

$$V_{SG} = -I_D R_S = -5\times10^{-3}\left[-2.58488+3\right]^2 \times 3\times10^{-3}$$

$$= -2.58488\,V \checkmark$$