Q For Ge diode, the reverse saturation current is 2 μA at a reverse voltage of 0.26V. Calculate forward & reverse dynamic resistance values if forward biased voltage is also 0.26 V at room temp.

$\eta = 1$

$I_0 = 2\,\mu A$ $\quad V_T = 26\,mV$ at room temp.

$V = 0.26\,V$ for forward biased

$= -0.26\,V$ for reverse biased.

Forward dynamic resistance $= r_f = \dfrac{\eta V_T}{I_0 e^{V/\eta V_T}} = 0.59101\,\Omega$

Reverse dynamic resistance $= r_r = \dfrac{\eta V_T}{I_0 e^{V/\eta V_T}} = 286.34\,M\Omega$

Q The reverse saturation current of a Ge diode is 100 μA at room temp. of 27°C. Calculate the current in forward biased condition if forward bias voltage is 0.2 V at room temp. If temp. is increased by 20°C, calculate the reverse saturation current & forward current, for same forward voltage, at new temp.

At $T_1 = 27°C = 300°K$, $V_T = 26\,mV$

$(I_0)_1 = 100\,\mu A$, $V = 0.2\,V$

$I = I_0 (e^{V/\eta V_T} - 1) = 100 \times 10^{-6} [e^{0.2/1 \times 0.026} - 1]$

$= 219.04\,mA$

$(I_0)_2 = 2^{\frac{T_2 - T_1}{10}} \times (I_0)_1$

$= 2^{20/10} \times (I_0)_1 = 4 \times 100 = 400\,\mu A$

At $T_2 = 27 + 20 = 47°C = 320°K$, $(I_0)_2 = 400\,\mu A$, $V = 0.2\,V$

$V_T = T/11600 \times 320 = 27.584\,mV$

$I = I_0 (e^{V/\eta V_T} - 1) = 400 \times 10^{-6} [e^{0.2/1 \times 27.584 \times 10^{-3}} - 1]$

$= 563.198\,mA$

Q, A Ge diode has a contact potential of 0.2 V, while the concentration of acceptor impurity atoms is $3 \times 10^{20}/m^3$, calculate for a reverse bias of 0.1 V, the width of depletion region. If the reverse bias is increased to 10 V, calculate the new width of depletion region. Assuming cross-sectional area of junction as 1 mm² calculate the transition capacitance values for both the cases. Assume ϵ_r as 16 for Ge.

$N_A = 3 \times 10^{20}/m^3$ $\quad A = 1\,mm^2 = 10^{-6}\,m^2$ $\quad \epsilon_r = 16$ for Ge

$V_0 = 0.2\,V$

i) $V = -0.1\,V$ $\quad V_B = V_0 - V = 0.2 - (-0.1) = 0.3\,V$

$V_B = \frac{1}{2} \frac{e N_A W^2}{\epsilon}$

$\epsilon = \epsilon_0 \epsilon_r = 8.854 \times 10^{-12} \times 16$

Q The Hall effect experiment is used for a silicon bar known to be p-type. The resistivity of the bar is 220×10^3 Ω-cm. The width of the bar is 2 mm & distance b/w the 2 surfaces of the bar is 2.2 mm. The magnetic field used has an intensity of 0.1 Wb/m². If measured values of current & Hall voltage are 5 μA & 28 mV respectively. Calculate the mobility of holes.

$\rho = 220\times10^3$ Ω-cm $= 2200$ Ω-m

$w = 2\,mm = 2\times10^{-3}\,m$

$B = 0.1\,Wb/m^2$

$I = 5\,\mu A$

$V_H = 28\,mV$

$\mu = \sigma R_H$ where $R_H = \frac{V_H w}{BI}$

$= \frac{1}{\rho}\frac{V_H w}{BI} = \frac{1}{2200}\times\frac{28\times10^{-3}\times2\times10^{-3}}{0.1\times5\times10^{-6}}$

$= 0.05091\,m^2/V\text{-}s = 509.1\,cm^2/V\text{-}s$

Q A silicon diode has a reverse saturation current of 7.12 nA at room temp. of 27°C. Calculate its forward current if it is forward biased with a voltage of 0.7V

$I_0 = 7.12\,nA = 7.12\times10^{-9}\,A$

$V = 0.7V$

$T = 27°C = 27+273 = 300°K$, $V_T = 26\,mV$

$\eta = 2$ for Si

$I = I_0(e^{V/\eta V_T}-1) = 7.12\times10^{-9}[e^{0.7/2\times0.026}-1]$

$= 4.99\times10^{-3} = 5\,mA$

Q A Ge diode has a reverse saturation current of 3 μA. Calculate the forward bias voltage at the room temp. of 27°C & 1% of rated current is flowing through the forward biased diode. The diode forward rated current is 1 A

$I_0 = 3\,\mu A$ $\quad I_{rated} = 1\,A$

$T = 27°C = 300°K$ $\quad I = 1\%$ of I_{rated}

$\eta = 1$ $\quad = 0.01\,A$

$V_T = 26\,mV$

$I = I_0(e^{V/\eta V_T}-1)$

$\Rightarrow 0.01 = 3\times10^{-6}[e^{V/1\times0.026}-1]$

$\Rightarrow e^{V/0.026} = 3334.3333$

$\Rightarrow \frac{V}{0.026} = \ln[3334.3333] = 8.112$

$\Rightarrow V = 0.2109\,V$

Q) A certain zener diode exhibits a 50mV change in V_Z for a 2.5mA change in I_Z. What is zener resistance

$$r_Z = \frac{\Delta V_Z}{\Delta I_Z} = \frac{50m}{2.5m} = 20\Omega$$

Q) A diode whose internal resistance is 20Ω is to supply power to a 1kΩ load from a 110V (rms) source of supply. Calculate (a) peak load current (b) dc load current (c) ac load current (d) dc diode voltage (e) total i/p power to the ckt (f) peak inverse voltage (g) percentage regulation from no load to full load

$V_m = \sqrt{2} \times 110\ V = 155.56\ V$

(a) $I_m = \frac{V_m}{R_f + R_L} = \frac{155.56}{1020} = 152.5\ mA$

(b) $I_{dc} = \frac{I_m}{\pi} = 48.54\ mA$

(c) $I_{rms} = \frac{I_m}{2} = 76.25\ mA$

(d) $V_{dc} = -\frac{I_m}{\pi} R_L = -I_{dc} R_L = -48.54V$

(e) $P_i = I_{rms}^2 (R_f + R_L) = 5.33\ W$

(f) $PIV = V_m = 155.56V$

(g) $V_{no\ load} = \frac{V_m}{\pi} = 49.51\ V$

$V_{full\ load} = \frac{V_m}{\pi} - I_{dc} R_f = 48.54\ V$

$\%\ regulation = \frac{V_{no\ load} - V_{full\ load}}{V_{full\ load}} \times 100 = 1.94\%$

Rectifier Efficiency

$$\eta = \frac{dc\ o/p\ power}{ac\ i/p\ power} = \frac{P_{dc}}{P_{ac}}$$

$$\eta = \frac{I_{dc} V_{dc}}{I_{rms}^2 (R_f + R_L)} = \frac{I_{dc}^2 R_L}{I_{rms}^2 (R_f + R_L)}$$

$$= \frac{I_m^2/\pi^2 R_L}{\frac{I_m^2}{4}(R_f + R_L)}$$

$$= \frac{4/\pi^2}{1 + \frac{R_f}{R_L}}$$

$$= \frac{0.406}{1 + R_f/R_L}$$

Since $R_f << R_L$, $\eta = 0.406$

$\therefore \%\eta = 40.6$ for half wave rectifier

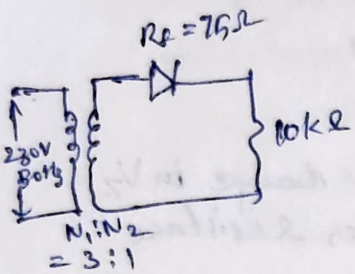
Q) A half wave rectifier ckt is supplied from a 230V, 50Hz supply with a step down ratio of 3:1 to a resistive load of 10kΩ. The diode forward resistance is 75Ω while transformer secondary resistance is 10Ω. Calculate max, average, rms values of current, DC o/p voltage, efficiency of rectification & ripple factor.

$R_f = 75\Omega \quad R = 10k\Omega \quad R_s = 10\Omega$

$\frac{N_1}{N_2} = \frac{3}{1} \Rightarrow \frac{N_2}{N_1} = \frac{1}{3} = \frac{V_s (r.m.s)}{V_p (r.m.s)}$

$\Rightarrow \frac{1}{3} = \frac{V_i(rms)}{230} \Rightarrow V_i(rms) = 76.667V$

$V_m = \sqrt{2} V_i(rms) = 108.423V$



$I_m = \frac{V_m}{R_f + R_s + R_L} = 10.75 mA$

$I_{dc} = \frac{I_m}{\pi} = 3.422 mA$

$I_{rms} = \frac{I_m}{2} = 5.375 mA$

$V_{dc} = I_{dc} R_L = 34.22 V$

$P_{dc} = V_{dc} I_{dc} = 0.1171 W$

$P_{ac} = I_{rms}^2 (R_f + R_s + R_L) = 0.2913 W$

$\% \eta = \frac{P_{dc}}{P_{ac}} \times 100 = 40.19\%$

$\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} = 1.21$

Transformer Utilization Factor (TUF)

The factor which indicates how much is the utilization of transformer in the ckt

$TUF = \frac{\text{DC power delivered to load}}{\text{AC power rating of transformer}}$

$= \frac{V_{dc} I_{dc}}{V_{rms} I_{rms}}$

~~$= \frac{I_{dc}^2 R_L}{I_{rms}^2 R_L}$~~

~~$= \frac{(I_m/\pi)^2}{(I_m/2)}$~~

$= \frac{I_{dc}^2 R_L}{\frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{2}}$

$= \frac{(I_m/\pi)^2 R_L}{\frac{I_m^2}{2\sqrt{2}} (R_f + R_L)}$

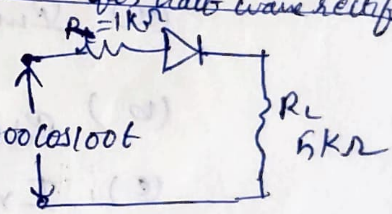
$= \frac{2\sqrt{2}}{\pi^2 \left(1 + \frac{R_f}{R_L}\right)}$

If $R_f << R_L$, then

$TUF = \frac{2\sqrt{2}}{\pi^2} = 0.287$

for half wave rectifier

Q. A half wave rectifier with $R_L = 5k\Omega$ is given with an i/p ~~as i/p of 10 V peak from stepdown transformer. Calculate DC voltage & load current for ideal & silicon diode~~ $V = 300 \cos 100t$. ~~Calculate~~ The rectifier may be represented by ideal diode in series with a resistance of 1kΩ. Calculate (i) I_m (ii) DC Power (iii) AC power (iv) Rectifier efficiency & (v) Ripple factor.



$V = V_m \sin\omega t$

$\therefore V_m = 300 \quad \omega = 100$

(i) $I_m = \frac{V_m}{R + R_L}$

$= \frac{300}{6k} = 50 mA$

(ii) $I_{dc} = \frac{I_m}{\pi} = 15.915 mA$

$P_{dc} = I_{dc}^2 R_L = 1.2665 W$

(iii) $P_{ac} = I_{rms}^2 (R + R_L)$

$= \frac{I_m^2}{4} (R + R_L)$

$= 3.75 W$

(iv) $\% \eta = \frac{P_{dc}}{P_{ac}} \times 100 = 33.77\%$

(v) $\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} = 1.21$

TUF for FW Rectifier

$= \frac{I_{dc}^2 R_L}{V_{rms} I_{rms}} = \frac{\left(\frac{2 I_m}{\pi}\right)^2 R_L}{\frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}}} = \frac{8}{\pi^2} = 0.812$

TUF of secondary $= \frac{\text{DC power to load}}{\text{AC power rating of secondary}}$

TUF of primary $= 2 \times$ TUF of HW Rectifier $= 2 \times 0.287 = 0.574$

Average TUF of FW rectifier $= \frac{\text{TUF of primary} + \text{TUF of secondary}}{2} = 0.693$

Q. A full-wave rectifier ckt is fed from a transformer having a center-tapped secondary winding. The rms voltage from either end of secondary to center tap is 30V. If the diode forward resistance is 2Ω & that of half secondary is 8Ω, for a load of 1kΩ. Calculate.

(a) power delivered to load (b) % regulation at full load
(c) efficiency of rectification (d) TUF of secondary

$V_{rms} = 30\,V \quad R_f = 2\Omega \quad R_s = 8\Omega \quad R_L = 1k\Omega$

$V_m = 30\sqrt{2} = 42.426V$

$I_m = \frac{V_m}{R_f + R_s + R_L} = 42\,mA$

$I_{dc} = \frac{2I_m}{\pi} = 26.74\,mA$

a) Power delivered to load $= I_{dc}^2 R_L = 0.715\,W$

b) V_{dc} at no load $= V_{NL} = \frac{2V_m}{\pi} = 27V$

V_{dc} at full load $= V_{FL} = I_{dc}R_L = 26.74V$

% regulation $= \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100 = 0.97\%$

c) Efficiency of rectification $\%\,\eta = \frac{P_{dc}}{P_{ac}} \times 100$

$= \frac{8}{\pi^2\left(1 + \frac{R_f + R_s}{R_L}\right)}$

$= 80.2\%$

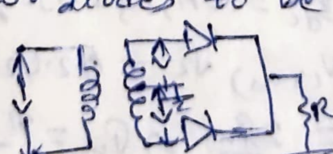
d) transformer secondary rating

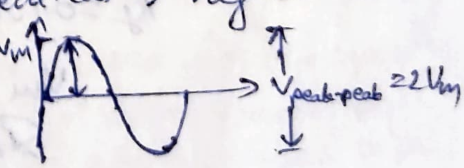
$= V_{rms} I_{rms} = 0.89W$

TUF $= \frac{P_{dc}}{\text{ac rating}} = 0.802$

Q. For a full wave rectifier shown below is a sinusoidal voltage. If the maximum allowable average d.c current in each diode is 1A, calculate the maximum allowable peak-to-peak value of V. Assume two diodes to be identical & neglect diode

$(I_{dc})_{max}$ thru diode $= 1A =$





$= \frac{I_m}{\pi} = \frac{V_m}{\pi R_L}$ as $R_f = 0$

$1 = \frac{V_m}{\pi R_L} \Rightarrow V_m = \pi R_L = \pi \times 100 = 314.16\,V$

$V_{peak\ to\ peak} = 2V_{max} = 628.32\,V$

Q. What is the necessary AC i/p power from the transformer secondary used in a half-wave rectifier to deliver 500W of DC power to the load? What would be the AC i/p power for the same load in a full wave rectifier?

$P_{dc} = 500W$, $\%\eta = 40.6\%$, for HWR

$40.6 = \frac{P_{dc}}{P_{ac}} \times 100 \Rightarrow P_{ac} = 1231.527W$

$P_{dc} = 500W$, $\%\eta = 81.2\%$, for FWR.

$81.2 = \frac{P_{dc}}{P_{ac}} \times 100 \Rightarrow P_{ac} = 615.76355W$

Q. A full wave rectifier uses a diode with forward resistance of 1Ω. The transformer secondary is centre tapped with $10-0-10V_{rms}$ & has resistance of 5Ω for each half section. Calculate (i) No-load dc voltage (ii) DC o/p voltage at 100mA (iii) % Regulation at 100mA

$R_f = 1\Omega$ $V_{rms} = 10V$ $R_s = 5\Omega$

$V_m = \sqrt{2} V_{rms} = 14.1421V$

(i) $V_{dc}(NL) = \frac{2V_m}{\pi} = 9.0031V$

(ii) $I_{dc} = 100mA = \frac{2I_m}{\pi}$

$I_m = \frac{\pi \times 100m}{2} = 157.079mA$

$I_m = 157.079 \times 10^{-3} = \frac{V_m}{R_f + R_s + R_L} = \frac{14.1421}{1+5+R_L}$

$\Rightarrow R_L = 84.0317\Omega$

$V_{dc}(FL) = I_{dc} R_L = 8.4031V$

(iii) % Regulation $= \frac{V_{dc}(NL) - V_{dc}(FL)}{V_{dc}(FL)} \times 100 = 7.14\%$.

Q. The 4 semiconductor diodes used in a bridge rectifier ckt each having a forward resistance of 0.1Ω & infinite reverse resistance feed a dc current of 10A to a resistive load from a sinusoidally varying alternating supply of 30V (rms). Determine the resistance of load & efficiency of ckt

$R_f = 0.1\Omega$, $I_{dc} = 10A$, $R_s = 0\Omega$, $V_{(rms)} = 30V$

$V_m = V_{(rms)}\sqrt{2} = 42.4264V$

$I_{dc} = \frac{2I_m}{\pi} \Rightarrow I_m = \frac{\pi I_{dc}}{2} = 15.7079A$

$I_m = \frac{V_m}{2R_f + R_s + R_L} \Rightarrow R_L = 2.5\Omega$

$P_{dc} = I_{dc}^2 R_L = 250W$

$P_{ac} = I_{rms}^2 (2R_f + R_s + R_L)$
$= \frac{I_m^2}{2}(2R_f + R_s + R_L)$
$= 333.0092W$

$\%\eta = \frac{P_{dc}}{P_{ac}} \times 100 = 75.05\%$.

$V_m = 162\,V$, $L = 1000\,mH$, $R = 100\,\Omega$, $C = 50\,\mu F$, $R_L = 1\,k\Omega$

$V_{dc(in)}$ = O/p dc voltage to filter

$= \frac{2V_m}{\pi} = 103.132\,V$

$V_{dc(out)} = \frac{V_{dc(in)}}{1+\frac{R}{R_L}} = 93.7567\,V = \frac{2V_m}{\pi} - I_{dc}R$

$\gamma = \frac{\sqrt{2}}{3}\frac{1}{2\omega C}\frac{1}{2\omega L} = \frac{1}{6\sqrt{2}\omega^2 LC}\left(1+\frac{R}{R_L}\right)$

$= 0.02626 = 2.6\%$

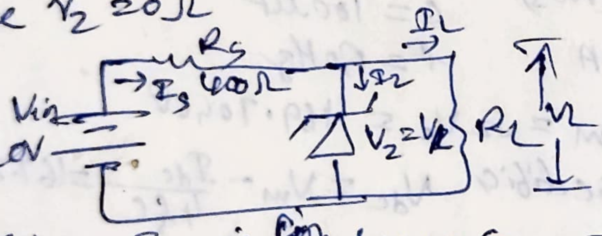
Q. Calculate the ripple factor for a π-type filter employing 10H choke & two equal capacitors 16 μF each & fed from a full wave rectifier & 50Hz mains. The load resistance

$C_1 = C_2 = 16\,\mu F$ $L = 10\,H$ $R_L = 4\,k\Omega$ $f = 50\,Hz$

$\frac{\sqrt{2}X_{C_1}X_{C_2}}{X_L R_L} = \gamma = \frac{\sqrt{2}}{8\omega^3 LC_1C_2R_L} = 5.56\times10^{-4}$

Q. Determine minimum & maxi load currents for which the zener diode will maintain regulation. What is the min. R_L that can be used? $V_Z = 10\,V$ $I_{Zmin} = 5\,mA$ & $I_{Zmax} = 50\,mA$

Assume $r_Z = 0\,\Omega$



When $I_L = 0$, I_Z is maxi & equal to I_S

$I_Z = \frac{V_{in} - V_Z}{R_S} = I_S$

$= 25\,mA$

Since I_Z is in range ($I_{Zmin} - I_{Zmax}$) $I_L \geq 0\,A$

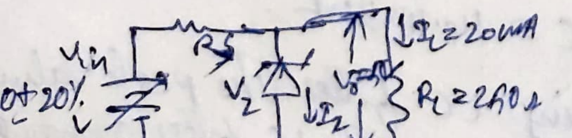
$\therefore I_{Lmin} = 0\,A$

$I_{Lmax} = I_S - I_{Zmin} = 25m - 5m = 20\,mA$

$R_{Lmin} = \frac{V_Z}{I_{Lmax}} = 500\,\Omega$

Q. In a zener regulator, the i/p dc is 10V ± 20%. The o/p requirements are 5V, 20 mA. Assuming I_{Zmin} & I_{Zmax} as 5 mA & 80 mA. Design the zener regulator.

$V_0 = 5\,V$ $I_L = 20\,mA$ $R_L = \frac{V_0}{I_L} = 250\,\Omega$ $I_{Zmin} = 5\,mA$, $I_{Zmax} = 80\,mA$



$I_{Lmax} = I_{Lmin} = 20\,mA$

$R_{Smax} = \frac{V_{in\,min} - V_0}{I_{Lmax} + I_{Zmin}} = 120\,\Omega$

$V_{in\,min} = 10 - 0.2\times10 = 8\,V$

$V_{in\,max} = 10 + 0.2\times10 = 12\,V$

$R_{Smin} = \frac{V_{in\,max} - V_0}{I_L + I_{Zmax}} = 70\,\Omega$