## Solved Questions

Q1. A half-wave rectifier circuit is connected to a 230-V, 50-Hz voltage source through a transformer having turn ratio 10:1. The rectifier circuit is to supply power to a 500Ω, 1W resistor. The diode forward resistance is 100Ω, then calculate the following:

a. Maximum, Average, and Root Mean Square (RMS) value of current and voltage

b. Efficiency of rectification

c. Percentage regulation

(Assume that the value of $R_s = 0\Omega$)

**Solution**: The solution to the preceding problem is as follows:

a. Maximum, Average, and RMS value of current and voltage are as follows:

$$V_{RMS}(sec) = \frac{230\ V}{10} = 23\ V$$

$$V_M = V_{RMS(sec)} \times \sqrt{2}$$

$$\therefore V_M = 23 \times \sqrt{2} = 32.52\ V$$

Now,

$$I_M = \frac{V_M}{R_f + R_L} = \frac{32.52}{100 + 500} = 54.2\ mA$$

$$I_{DC} = \frac{I_M}{\pi} = \frac{54.2 \times 10^{-3}}{\pi} = 17.25\ mA$$

$$I_{RMS} = \frac{I_M}{2} = \frac{54.2 \times 10^{-3}}{2} = 27.1\ mA$$

b. Efficiency of rectification:

$$P_{DC} = \left(\frac{I_M}{\pi}\right)^2 \times R_L = \left(\frac{54.2 \times 10^{-3}}{\pi}\right)^2 \times 500 = 148.82\ mW$$

$$P_{AC} = I_{RMS}^2 (R_f + R_L) = (27.1 \times 10^{-3})^2 (100 + 500) = 440.64 \text{ mW}$$

$$\therefore \%\eta = \frac{P_{DC}}{P_{AC}} \times 100 = \frac{148.82 \times 10^{-3}}{440.64 \times 10^{-3}} \times 100 = 33.77\%$$

c. Percentage Regulation:

$$V_{DC} \text{ (Full load)} = I_{DC} \times R_L$$
$$= 17.25 \times 10^{-3} \times 500$$
$$= 8.62 \text{ V}$$

$$V_{DC} \text{ (No load)} = \frac{V_M}{\pi}$$
$$= \frac{32.52}{\pi} = 10.35 \text{ V}$$

$$\therefore \% \text{ Regulation} = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100$$
$$= \frac{10.35 - 8.62}{10.35} \times 100$$
$$R = 16.71\%$$

**Q2.** **A half-wave rectifier is connected to a 1-kΩ resistive load. The mains supply used is 220 V (RMS). Draw the circuit diagram and waveforms for the input and output voltages. Also, calculate the following:**

a. $V_{LDC}$

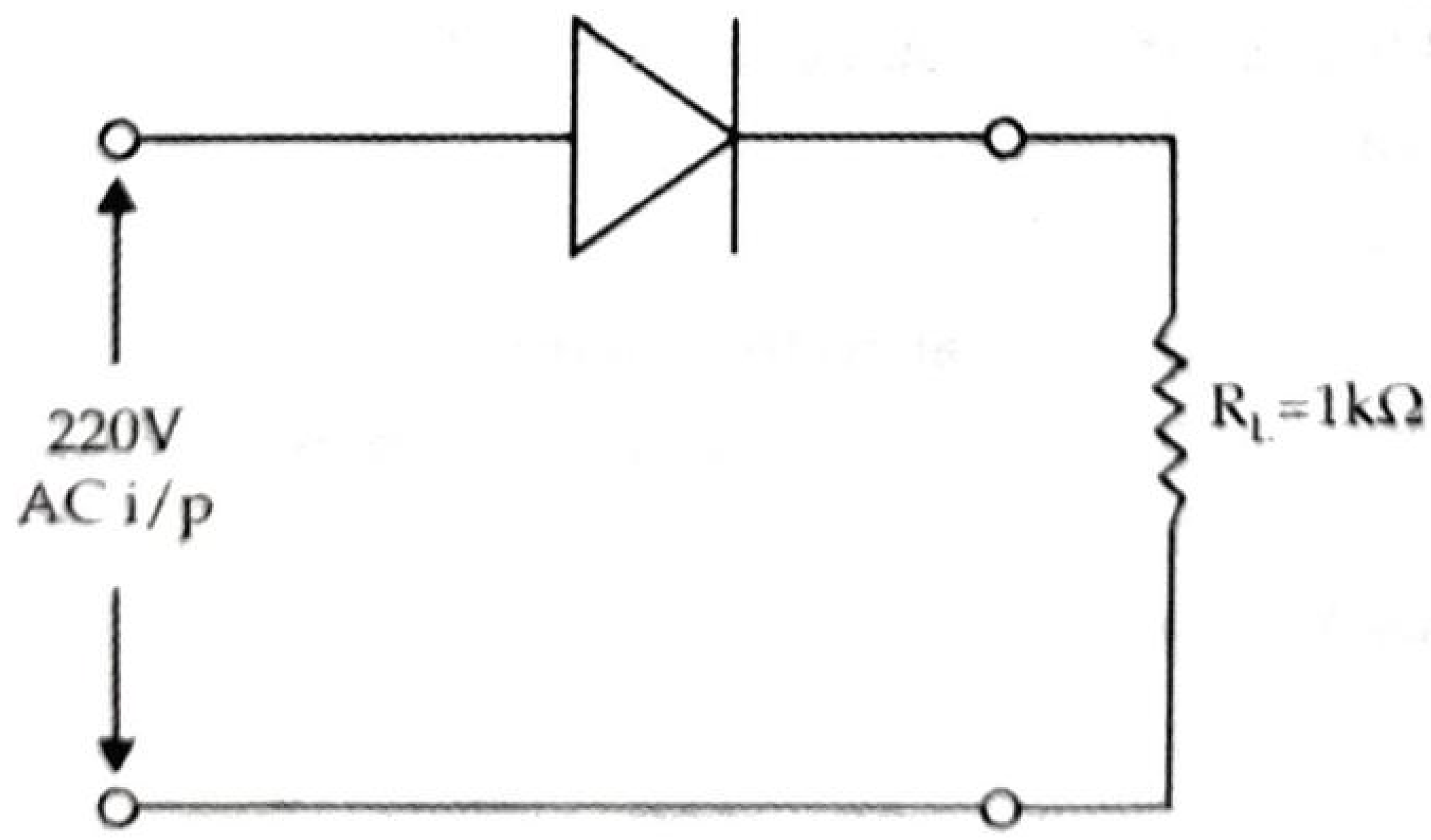
b. $I_{LRMS}$

c. $I_{Lpeak}$

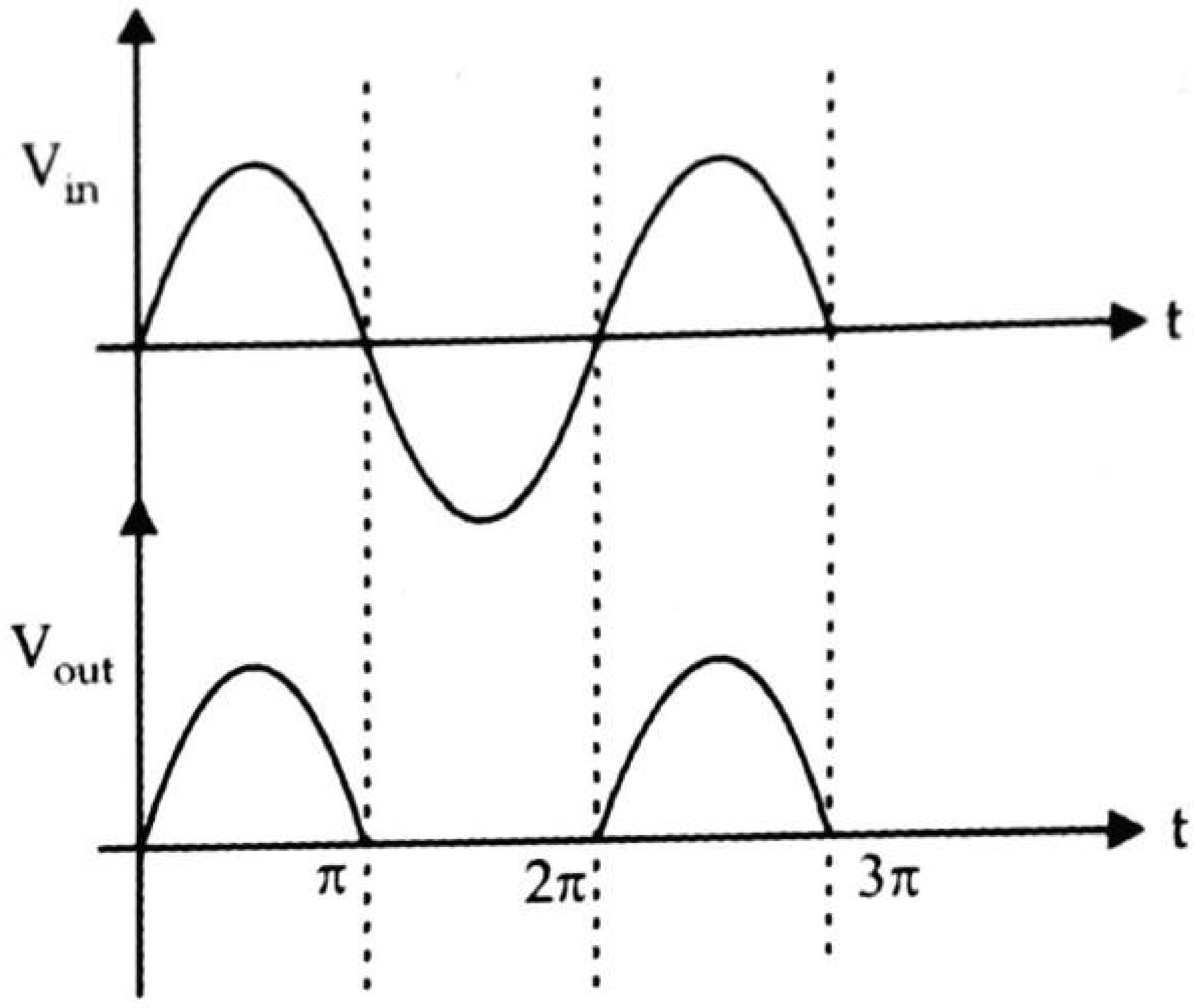
d. Total input power to the circuit.

**Solution**: The solution to the preceding problem is as follows:

Circuit diagram is drawn as follows:




Waveforms for the input and output voltages are drawn as follows:




We have,

$$V_M = V_{RMS} \times \sqrt{2}$$
$$= 220 \times \sqrt{2}$$
$$= 308\ V$$

a. $V_{LDC} = \dfrac{V_M}{\pi} = \dfrac{308}{\pi} = 98\ V$

b. $I_{Lpeak} = \dfrac{V_M}{R_L} = \dfrac{308}{1\ k\Omega} = 308\ mA$

c. $I_{LRMS} = \dfrac{I_{Lpeak}}{2} = \dfrac{308}{2} = 154\ mA$

d. $P_{in} = V_{RMS} \times I_{LRMS}$

$$= 220 \times 154 \times 10^{-3}$$
$$= 33.88\ \ W$$

**Q3. A diode whose internal resistance is 20 Ω is to supply power to a 1 kΩ load from a 110 $V_{RMS}$ source of supply, then calculate the following:**

**a. DC load current**

**b. DC load voltage**

**c. Total input power to the circuit**

**Solution**: The solution to the preceding problem is as follows:

a. DC load current:

we know that,

$$I_M = \frac{V_M}{R_f + R_L} = \frac{110 \times \sqrt{2}}{20 + 1000} = 152.5 \times 10^{-3}\ A$$

$$\therefore I_{DC} = \frac{I_M}{\pi} = \frac{152.5 \times 10^{-3}}{\pi} = 48.5\ mA$$

b. DC load voltage:

$$V_{DC} = \frac{I_M}{\pi} \times R_L = \frac{152.5 \times 10^{-3}}{\pi} \times 1000 = 48.5 \text{ V}$$

$$\text{Or } V_{DC} = I_{DC} \times R_L = 48.5 \times 10^{-3} \times 1000 = 48.5 \text{ V}$$

c. Total input power to the circuit:

$$P_{in} = I_{RMS}^2 (R_F + R_L) \quad \text{(Assuming that } R_s = 0\ \Omega)$$

$$I_{RMS} = \frac{I_M}{2} = \frac{152.5 \times 10^{-3}}{2} = 76.25 \times 10^{-3} \text{ A}$$

$$\therefore P_{in} = \left(76.25 \times 10^{-3}\right)^2 (20 + 1000)$$

$$P_{in} = 5.92 \text{ W}$$

**Q4.** **A step-down transformer having a coil ratio of 10:1 taking an input of 230 V and 50 Hz is used in a half-wave rectifier. The diode forward resistance is 15 Ω and the resistance of secondary winding is 10Ω. For a load resistance of 4 kΩ, calculate the following:**

a. **Average and RMS values of load current and voltage**

b. **Rectification energy**

c. **Ripple factor**

**Solution:** The solution to the preceding problem is as follows:

Given that:

$$R_L = 4\text{ k}\Omega = 4000\ \Omega$$

$$R_F = 15\ \Omega$$

$$R_S = 10\ \Omega$$

$$\frac{N_1}{N_2} = \frac{10}{1}$$

a. Average and RMS value of the load current and voltage:

we know that,

$$\frac{V_S(\text{sec})}{V_P(\text{pri})} = \frac{N_2}{N_1}$$

$$\therefore V_S(\text{sec}) = 230 \times \frac{1}{10} = 23 \text{ V}$$

So, RMS value of secondary voltage $V_{S(RMS)} = 23$ V

$$\therefore V_M = \sqrt{2} \times V_{S(RMS)}$$

$$= \sqrt{2} \times 23$$

$$= 32.53 \text{ V}$$

Now,

$$I_M = \frac{V_M}{R_S + R_f + R_L}$$

$$= \frac{32.53}{10 + 15 + 4000}$$

$$= 8.082\,mA$$

$$\therefore I_{avg} = I_{dc} = \frac{I_M}{\pi} = \frac{8.082 \times 10^{-3}}{\pi} = 2.576\ mA$$

$$I_{RMS} = \frac{I_M}{2} \quad \text{for HWR}$$

$$= \frac{8.082\ mA}{2}$$

$$= 4.041\,mA$$

$$V_{L(DC)} = I_{DC} \times R_L$$

$$= 2.576 \times 10^{-3} \times 4000$$

$$= 10.304\,V$$

b. Rectification energy:

The output DC power is given by:

$$P_{DC} = V_{LDC} \times I_{LDC}$$

$$= 10.304 \times 2.576 \times 10^{-3}$$

$$= 26.543\ mW$$

The AC input power is given by:

$$P_{AC} = I_{RMS}^2 (R_S + R_F + R_L)$$

$$= (4.041 \times 10^{-3})^2 [10 + 15 + 4000]$$

$$= 65.727\ mW$$

The rectification efficiency is given by:

$$\therefore \eta = \frac{P_{DC}}{P_{AC}} \times 100$$

$$= \frac{26.543 \times 10^{-3}}{65.727 \times 10^{-3}} \times 100$$

$$= 40.384$$

c. Ripple factor $= \dfrac{I_{AC}}{I_{DC}} = \sqrt{\left[\dfrac{I_{RMS}}{I_{DC}}\right]^2 - 1}$

$$= 1.21$$

**Q5.** A half-wave rectifier uses a diode with a forward resistance of 100Ω. If the input applied is 220 V (RMS) and load resistance is of 2 kΩ, calculate the following:

a. $I_{max}$, $I_{DC}$, $I_{RMS}$

b. PIV

c. Load output voltage

d. Rectifier efficiency

e. Ripple factor

**Solution**: The solution to the preceding problem is as follows:

RMS value of supply voltage $V_{S(RMS)} = 220$ V

∴ Maximum value of supply voltage $V_{S\,(max)} = 220 \times \sqrt{2}$

a. $I_{max}$, $I_{DC}$, $I_{RMS}$:

we know that:

$$I_{max} = \frac{V_M}{R_L + R_F} = \frac{220 \times \sqrt{2}}{(2000 + 100)} = 148.156 \text{ mA}$$

Avg. value of the output current $I_{DC} = \frac{I_M}{\pi} = \frac{148.156}{\pi} = 47.16 \text{ mA}$

RMS value of the output current $I_{RMS} = \frac{I_{max}}{2} = \frac{148.156}{2} = 74.078 \text{ mA}$

b. PIV:

$$PIV = V_{S\,max} = 220 \times \sqrt{2} = 311.127 \text{ V}$$

c. Load output voltage

Load output voltage $V_{DC} = I_{DC} \times R_L$

$$= 47.16 \times 10^{-3} \times 2000$$
$$= 94.32 \text{ V}$$

d. Rectifier efficiency

$$P_{DC} = I_{DC}^2 \times R_L = (47.16 \times 10^{-3})^2 \times 2 \times 10^3$$
$$= 4.448 \text{ W}$$

$$P_{AC} = \frac{I_M^2}{4}(R_F + R_L) = \frac{(148.156 \times 10^{-3})^2}{4}(100 + 2000)$$
$$= 11.524 \text{ W}$$

$$\therefore \eta = \frac{P_{DC}}{P_{AC}} = \frac{4.448}{11.524} = 38.6\ \%$$

e. Ripple factor:

Ripple factor $\gamma = \frac{I_{AC}}{I_{DC}}$

$$= \sqrt{\left[\frac{I_{RMS}}{I_{DC}}\right]^2 - 1}$$
$$= 1.21$$

Q6. If the forward resistance of a Full wave Rectifier diode is 2Ω, $V_{RMS}$ of a center tapped secondary transformer having resistance of 6Ω in each half is 24V, then find the following:

a. Output voltage at zero load current and at 100 mA load current

b. Load regulation

**Solution**: The solution to the preceding problem is as follows:

a. Output voltage at zero load current and at 100 mA load current:

From the given transformer voltage we take as:

Half secondary voltage = 24/2 = 12 $V_{RMS}$

$$\therefore V_M = \sqrt{2} \times V_{RMS}$$

$$= \sqrt{2} \times 12$$

$$= 16.97 \text{ V}$$

$$V_{DC} = \frac{2V_M}{\pi}$$

$$= \frac{2 \times 16.97}{\pi}$$

$$= 10.80 \text{ V}$$

$\therefore$ No load voltage = $V_{DC}$ = 10.8 V

$$V_{DC(FL)} = \frac{2V_M}{\pi} - I_{DC}(R_S + R_F)$$

$$= \frac{2 \times 16.97}{\pi} - 100 \times 10^{-3}(6 + 2)$$

$$= 10 \text{ V}$$

$$V_{FL} = 10 \text{ V}$$

b. Load regulation:

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

$$= \frac{10.8 - 10}{10} \times 100$$

$$= 8\%$$

Q7. If the forward resistance of a Full wave Rectifier diode is 1Ω, $V_{RMS}$ of a center tapped secondary transformer having resistance of 5Ω in each half is 10V, then find the following:

a. No load DC voltage

b. DC output voltage at 100 mA

c. Percentage regulation at 100 mA

**Solution**: The solution to the preceding problem is as follows:

a. No load DC voltage:

DC voltage can be calculated as:

$$V_{DC(NL)} = \frac{2V_M}{\pi}$$

$$V_M = \sqrt{2} \times V_{RMS} = \sqrt{2} \times 10$$

$$\therefore V_{DC(NL)} = \frac{2 \times 10\sqrt{2}}{\pi} = 9.0 \text{ V}$$

b. DC output voltage at 100 mA:

$$V_{DC(FL)} = V_{DC(NL)} - I_{DC}(R_F + R_S)$$

$$= 9 - 100 \times 10^{-3}(1 + 5)$$

$$= 8.4 \text{ V}$$

c. Percentage regulation at 100 mA:

$$\therefore \% \text{Reg} = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$

$$= \frac{9.0 - 8.4}{8.4} \times 100 = 6.62\,\%$$

**Q8.** **In a center-tapped FWR, the RMS half secondary voltage is 10 V. Assuming ideal diodes and load resistance of $R_L = 2k\Omega$, find the following:**

a. Peak current

b. DC voltage

c. Ripple factor

d. Efficiency of rectification

**Solution**: The solution to the preceding problem is as follows:

Given that: $R_F = 0\ \Omega$, $R_L = 2\ k\Omega = 2000\ \Omega$, $V_{RMS} = 10$ V

a. Peak current

We know that:

$$I_M = \frac{V_M}{R_F + R_L}$$

$$= \frac{10 \times \sqrt{2}}{2 \times 10^3}$$

$$= 7.07 \times 10^{-3}$$

$$= 7.07 \text{ mA}$$

b. DC voltage:

To find $V_{DC}$, let's first calculate $I_{DC}$

$$I_{DC} = \frac{I_M}{\pi} = \frac{7.07 \times 10^{-3}}{\pi} = 2.25 \times 10^{-3}$$

$$\therefore V_{DC} = I_{DC} \times R_L$$

$$= 2.25 \times 10^{-3} \times 2 \times 10^3 = 4.5 \text{ V}$$

c. Ripple factor:

$$\text{Ripple factor} = \sqrt{\left(\frac{I_{RMS}}{I_{DC}}\right)^2 - 1}$$

For center tapped FWR, $I_{RMS} = \frac{I_M}{\sqrt{2}}$

$$I_{DC} = \frac{2\,I_M}{\pi}$$

$$\therefore r = \sqrt{\frac{\pi^2}{8} - 1}$$

$$\therefore \gamma = 0.33$$

d. Efficiency of rectification:

$$\text{Efficiency of rectification} = \eta = \frac{P_{DC}}{P_{AC}}$$

$$\eta = \frac{8R_L}{\pi^2(R_F + R_L)}$$

$$= \frac{8R_L}{\pi^2 R_L}$$

$$= \frac{8}{\pi^2}$$

$$= 0.81$$

$$\eta = 81\,\%\ ]$$

**Q9. The load resistance of a center-tapped FWR is 500 Ω and the end-to-end voltage is 60 sin (100πt). Calculate the following:**

**a. Peak, average and RMS values of current**

**b. Ripple factor**

**c. Efficiency of rectifier**

**Assume that the forward resistance of diode = 50 Ω.**

**Solution**: The solution to the preceding problem is as follows:

Maximum value of supply voltage $V_{s(max)} = 60$ V $R_F$ 50 Ω, $R_L = 500$ Ω.

a. Peak current:

$$I_M = \frac{V_{SM}}{R_L + R_F} = \frac{60}{500 + 50} = 109.09 \text{ mA}$$

$$\text{Average current } I_{DC} = \frac{2\,I_M}{\pi} = \frac{2 \times 109.09}{\pi} = 69.5 \text{ mA}$$

RMS value of current $I_{RMS} = \frac{I_{max}}{\sqrt{2}} = \frac{109.09}{\sqrt{2}} = 77.14$ mA

b. Ripple factor:

$$r = \sqrt{\left(\frac{I_{RMS}}{I_{DC}}\right)^2 - 1} = \sqrt{\left(\frac{0.077}{0.0695}\right)^2 - 1}$$

$= 0.485$

c. Efficiency:

$$\eta = \frac{0.812}{1 + \frac{R_F}{R_L}} \times 100$$

$$= \frac{0.812}{1 + \frac{50}{500}} \times 100$$

$= 73.82\ \%$

**Q10. A bridge rectifier has 10 $V_{RMS}$ voltage across secondary winding of transformer. Find PIV of each diode.**

**Solution**: The solution to the preceding problem is as follows:

Given that: $V_{RMS(sec)} = 10$ V

In bridge rectifier, PIV of each diode is $V_m$.

$$\therefore V_M = V_{RMS(Sec)} \times \sqrt{2}$$

$$= 10 \times \sqrt{2}$$

$$= 14.2\ \text{V}$$

$\therefore$ PIV of each diode $= 14.2$ V

**Q11. If the required DC output voltage is 9 V, assuming ideal diodes are used then calculate the value of AC RMS input voltage required in the following cases:**

**a. HWR**

**b. Center-tapped FWR**

**Solution**: The solutions to the preceding problem are as follows:

a. For HWR:

$$V_{DC} = \frac{V_M}{\pi}$$

$$V_M = \pi \times V_{DC}$$

$$= 9\ \text{V} \times \pi$$

$$= 28.27\ \text{V}$$

$$\therefore V_{RMS} = \frac{V_M}{\sqrt{2}} = 19.99\,V$$

b. For FWR:

$$\therefore V_M = V_{DC} \times \frac{\pi}{2}$$

$$= \frac{9 \times \pi}{2}$$

$$= 14.14\,V$$

$$\therefore V_{RMS} = \frac{V_M}{\sqrt{2}} = \frac{14.14}{\sqrt{2}}$$

$$= 10\,V$$

**Q12. For a full-wave rectifier circuit, if the ripple factor of 0.01 supplies a load of 2 kΩ and the supply frequency is 50 Hz, calculate the value of capacitor filter.**

**Solution:** The solution to the preceding problem is as follows:

$$\gamma = \frac{1}{4\sqrt{3}\,fCR_L}$$

$$\therefore 0.01 = \frac{1}{4\sqrt{3} \times 50 \times C \times 2 \times 10^3}$$

$$\therefore 0.01 = \frac{1}{4\sqrt{3} \times 50 \times C \times 2 \times 10^3}$$

$$= 1.4433 \text{ x } 10^{-4}\text{ F.}$$

$$= 144.33\text{ MF}$$

**Q13. A zener diode with a breakdown voltage $V_Z$ = 5 V at room temperature has a temperature coefficient of +2.5 mV/°C. It is to be temperature compensated by connecting it in series with two forward-biased diodes with a forward drop of 0.65 V at 25°C and temperature coefficient of –2m V/°C.**

a. Calculate the temperature stability of the uncompensated zener diode

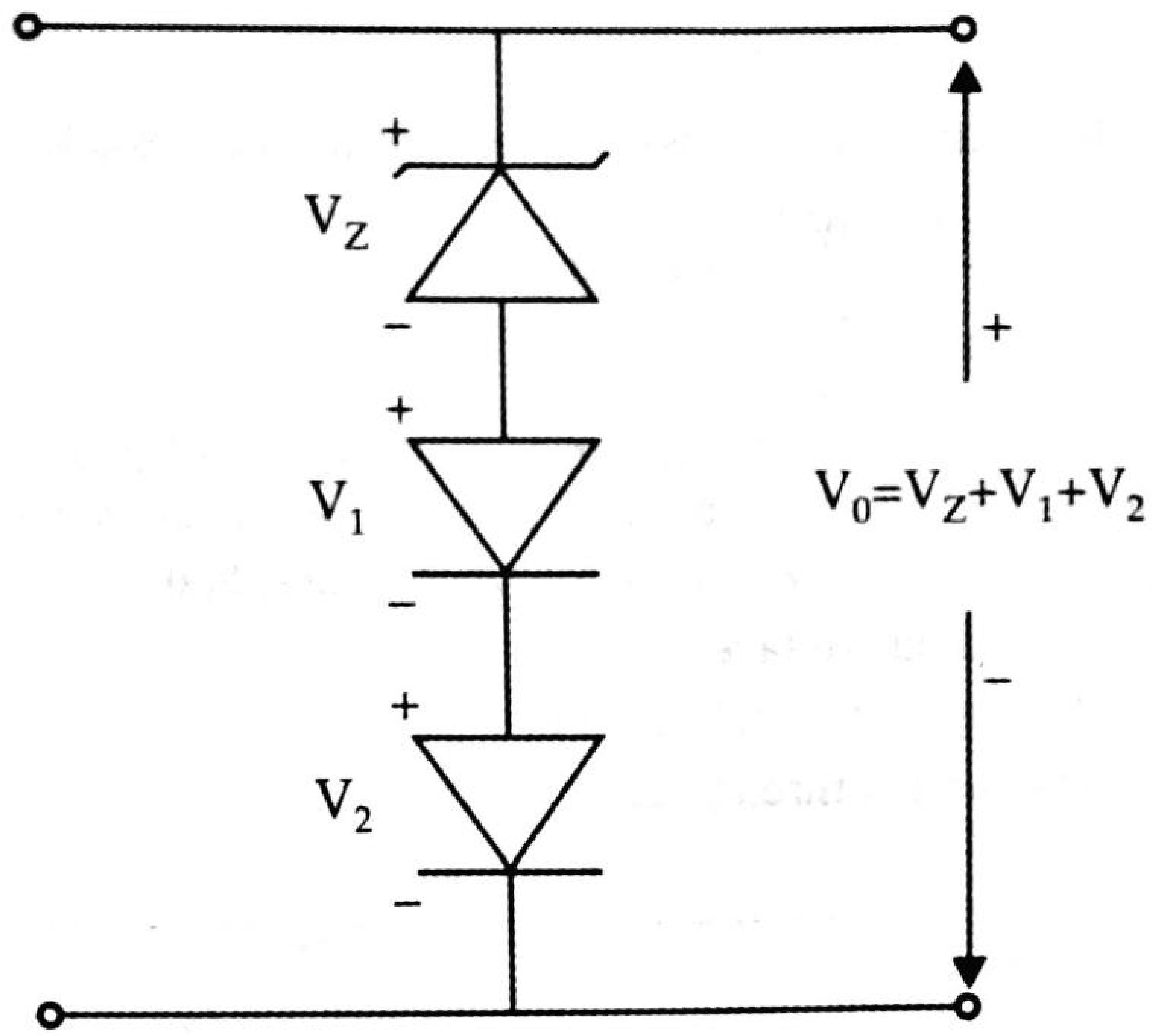
b. At temperature $T_2$ = 100°C, calculate the breakdown voltage of the uncompensated zener diode

c. Calculate voltage across the compensated network at 25°C and 100°C

d. Calculate the temperature stability of the compensated network

**Solution:** The solution to the preceding problem is as follows:

The circuit diagram of the temperature compensation network is as follows:




a. $S = \dfrac{TC \times 100\%}{V_Z}$

$= \dfrac{2.5 \times 10^{-3} \times 100}{5\,V}$

$= 0.05\%$

b. Breakdown voltage of uncompensated zener diode is as calculated:

$V_Z = 5V + \Delta T(TC)$

$= 5V + (100 - 25)(2.5mV/^\circ C)$

$= 5\,V + 0.1875$

$= 5.1875$

c. Output voltage at uncompensated network:

$V_O = V_Z + V_1 + V_2$

$= 5V + 2(0.65)$

$= 5V + 1.3$

$= 6.3\,V$

At 100°C, the drop across each forward-biased diode is:

$V_D = (0.65V) + (100-25)(-2mV/^\circ C) = 0.5V$

$\therefore$ At 100°C

$V_O = (5.1875) + 2(0.5V)$

$= 6.1875\,V$

d. $TC = \left|(+2.5\ mV/^\circ C) + 2(-2\ mV/^\circ C)\right|$

$= -1.5 \text{ mV}/^\circ \text{C}$

The voltage drop across the network at 25°C is 6.3 V.

$$\therefore S = \frac{-1.5 \text{ mV}/^\circ \text{C}}{6.3} \times 100\%$$

$$= -0.002381\%$$

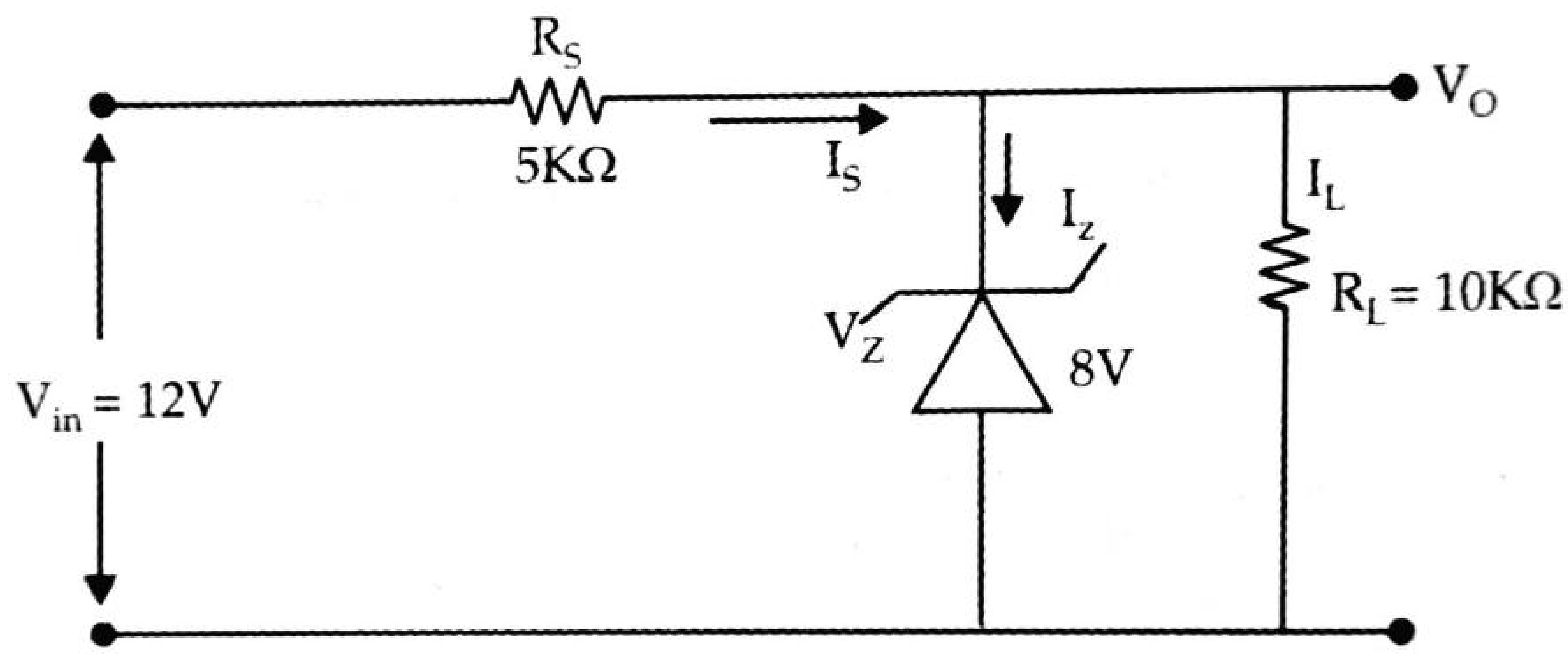
The value of S is charged from 0.05% to −0.002381%. This indicates that the stability increases by about 20 times by using compensating circuit.

**Q14. For the circuit shown in the following figure, find:**

**a. The output voltage**

**b. Voltage across resistance $R_s$**

**c. The current through zener diode**




**Solution:** The solution to the preceding problem is as follows:

a. Output voltage:

$$V_0 = 8V$$

b. Voltage across $R_s$:

$$R_s = V_{in} - V_0$$
$$= 12 - 8$$
$$= 4V$$

c. Current through zener diode:

Load current, $I_L = \frac{V_o}{R_L}$

$$= \frac{8V}{10 \times 10^3 \ \Omega}$$
$$= 0.8 \text{ mA}$$

Current through $R_S$ is $I_S = \frac{V_{in} - V_0}{R_s}$

$$= \frac{12 - 8}{5 \times 10^3}$$

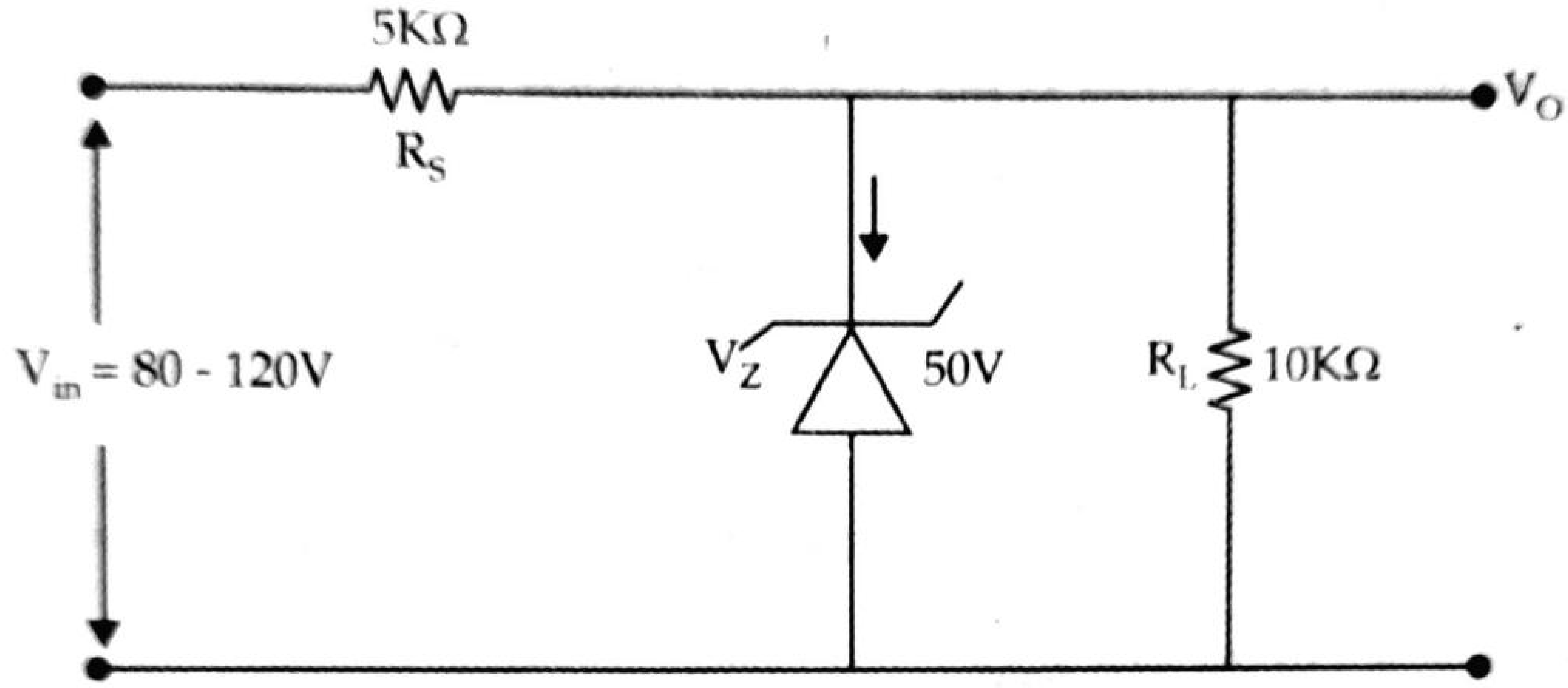
$$= 0.8mA$$

$$\therefore I_Z = I_L - I_S$$

$$= 0 mA$$

**Q15. Find the maximum and minimum values of the current through the zener diode for the following circuit:**

**Solution**: Circuit diagram of the problem is shown as:




$$V_O = V_Z = 50V$$

$$I_L = \frac{V_O}{R_L} = \frac{50}{10 \times 10^3} = 5 mA.$$

a. Zener current will be maximizes when the input maximum, i.e. 120 V

$$\therefore I_{s\,max} = \frac{V_{inmax} - V_O}{R_S}$$

$$= \frac{120 - 50}{5 \times 10^3}$$

$$= 14 mA$$

$$\therefore I_{z\,max} = I_s - I_L$$

$$= 14 mA - 5 mA$$

$$= 9 mA$$

b. Zener current will be minimizes when the input is minimum, i.e. 80 V

$$\therefore I_{s\,min} = \frac{V_{inmin} - V_O}{R_S}$$

$$= \frac{80 - 50}{5 \times 10^3}$$

$$= 6 mA$$

$$\therefore I_{z\,min} = I_{s\,min} - I_L$$
$$= 6 - 5$$
$$= 1\,mA$$

**Q16. In a shunt regulator circuit using zener diode, the series resistance used is $1.2\ K\Omega$. It provides $4.7V$ to the load resistance of $2.2K\Omega$. If $I_{z\,min}$ is $1\,mA$ and $I_{zmax} = 20mA$, find the range of input voltage for the constant output voltage.**

**Solution**: The solution to the preceding problem is as follows:

$$R_s = 1.2K\Omega,\ R_L = 2.2\ K\Omega,\ V_Z = 4.7\ V$$
$$I_{z\,min} = 1mA \quad I_{zmax} = 20mA$$
$$I_L = \frac{V_z}{R_L}$$
$$= \frac{4.7}{2.2 \times 10^3} = 2.136\ mA$$

a. To calculate $V_{in(min)}$

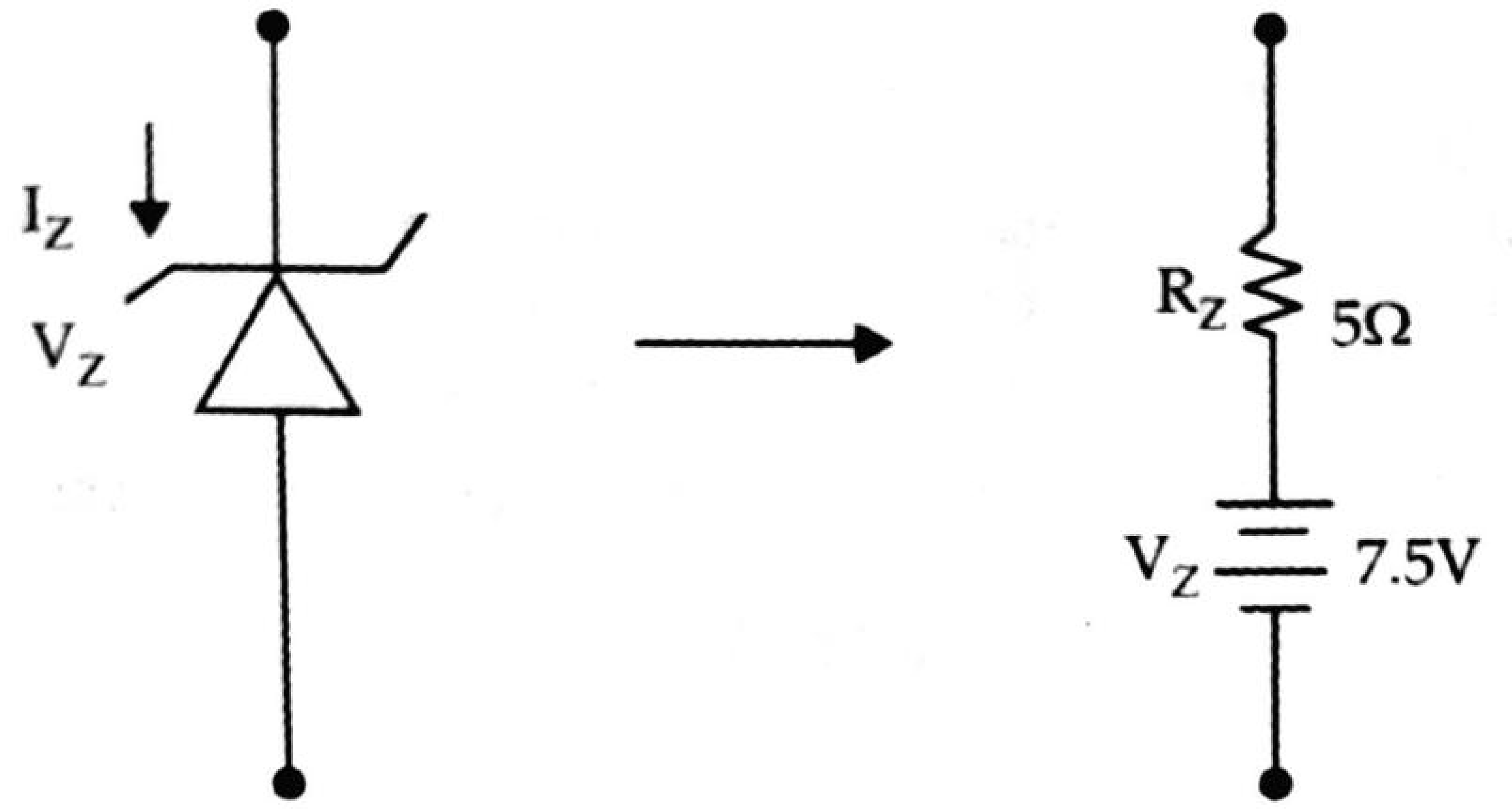
$$I_Z = I_{Z(min)} = 1mA$$
$$I_S = I_{Z_{(min)}} + I_L$$
$$= 1\,mA + 2.136\,mA$$
$$= 3.136\,mA$$
$$V_{in\,(min)} = V_Z + I_S R_S$$
$$= 4.7 + 3.136 \times 10^{-3} \times 1.2 \times 10^3$$
$$= 8.4632V$$

b. To calculate $V_{in(max)}$

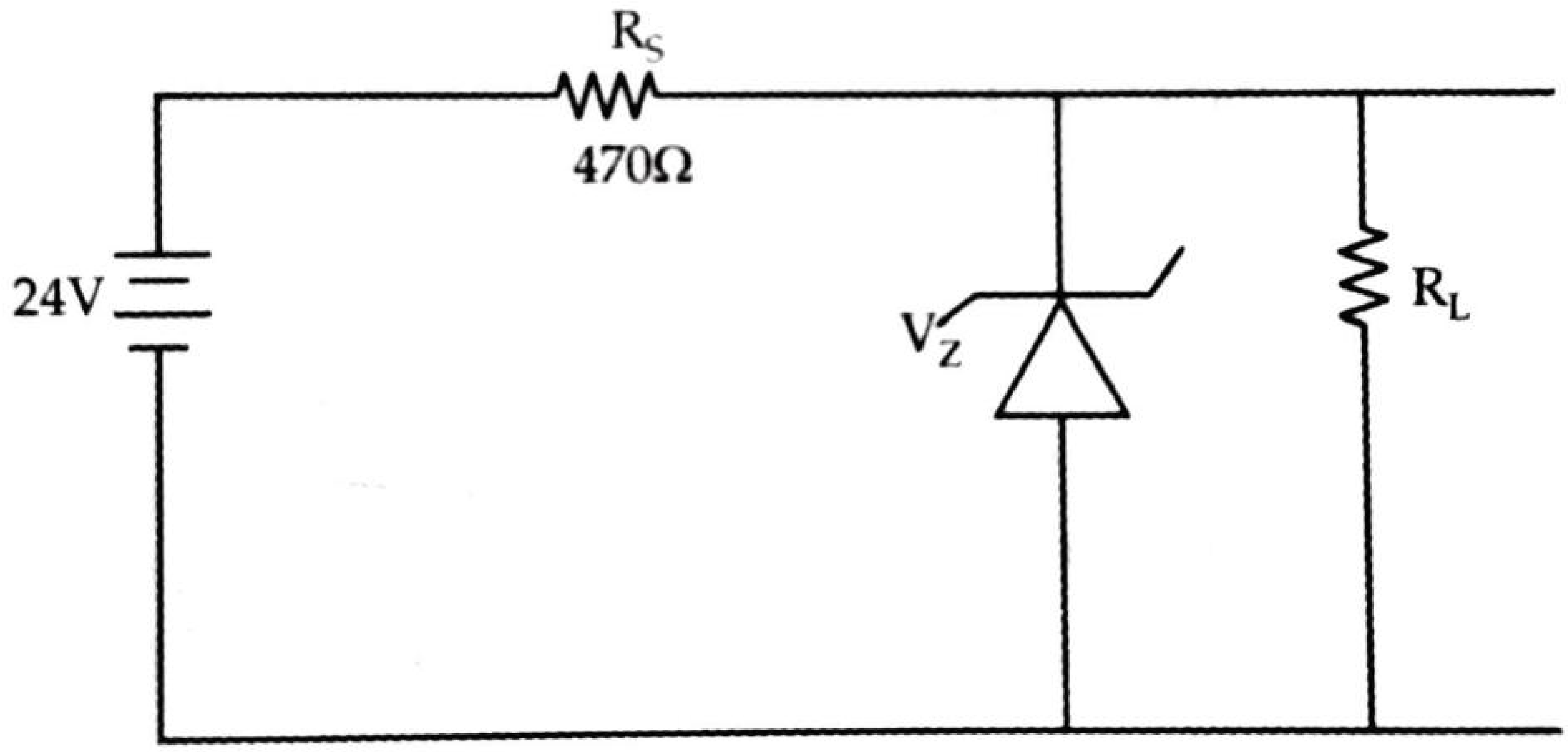
$$I_Z = I_{Z(max)} = 20mA$$
$$\therefore I_S = I_{Z(max)} + I_L$$
$$= 20 + 2.136\,mA$$
$$= 22.136mA$$
$$\therefore V_{in\,(max)} = V_Z + I_S R_S$$
$$= 4.7 + 22.136 \times 1.2 \times 10^3$$
$$= 31.2632\,V$$

**Q17.** **A zener diode has $V_z$ = 7.5 V and $V_z$ = 5 Ω at a certain current. Sketch the equivalent circuit.**

**Solution:** The following figure shows the equivalent circuit of the zener diode:




**Q18.** **Find the minimum and maximum load currents for which the following circuit will maintain regulation. Determine the minimum $R_L$ that should be used if $V_z$ = 3.3 V, $I_{Zmin}$=1 mA $I_{Zmax}$=150 mA. Assume that $R_z$ = 0Ω.**




**Solution:** The solution to the preceding problem is as follows:

When $I_L$ = 0, i.e., $R_L$ = infinite (00), the current through the zener diode will be maximum.

$$I_z = \frac{V_{in} - V_z}{R_s} = \frac{24 - 3.3}{470\Omega} = 44.04\,\text{mA}$$

Given that $I_z$ < 150 mA, the zener diode can handle all of the load current i.e. 44.04 mA.

This means $R_L$ can be removed from the circuit and regulation will be maintained.

$\therefore\ I_{L(min)} = 0$

The maximum value of $I_L$ occurs when $I_z$ is minimizes.

$I_{Lmax} = I_L - 1$ mA
$= 44.04 - 1$ mA
$= 43.04$ mA.

The minimum value of $R_L$ is given by:

$$R_{L(min)} = \frac{V_z}{I_{Lmax}} = \frac{3.3V}{43.04mA} = 76.67\Omega$$

∴ The regulation is maintained for any value of $R_L$ in the range of 76.67 Ω to ∞ (infinity).

**Q19.** In a shunt voltage regulator using zener diode, calculate the minimum and maximum values of the current limiting resistor $R_s$ for following specifications:

$V_Z = 8$ V, $V_{in} = 30$ V, $I_L = 50$ mA, $I_{z\,min} = 5$ mA, $P_{Z\,max} = 1$ W

**Solution:** The solution to the preceding problem is as follows:

$$I_{z\,max} = \frac{P_{z\,max}}{V_z} = \frac{1\,W}{8\,V} = 0.125\,A$$

$$= 125\text{ mA}$$

$$R_{s\,max} = \frac{V_{in} - V_z}{I_L + I_{z\,min}}$$

$$= \frac{30-8}{(50+5)\times 10^{-3}}$$

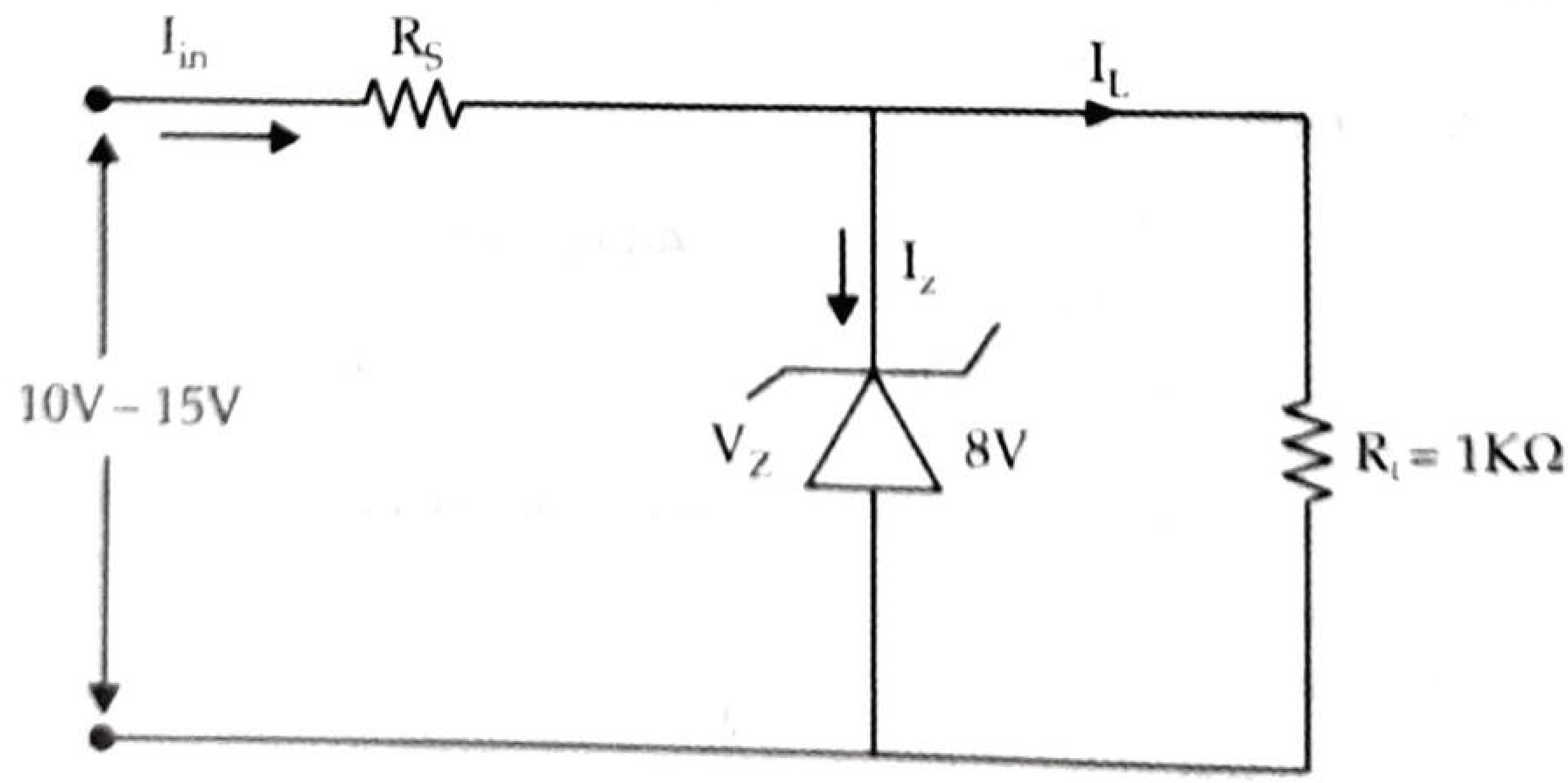
$$= 400\ \Omega$$

$$R_{s\,min} = \frac{V_{in} - V_z}{I_L + I_{z\,max}}$$

$$= \frac{30-8}{(50+125)\times 10^{-3}}$$

$$= 125.71\Omega$$

**Q20.** Find the value of $R_s$ for the following circuit:




Given $I_{Z\,min} = 2mA$

$I_{Z\,max} = 27mA$

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Solution: The solution to the preceding problem is as follows:

$$R_s = \frac{V_{in} - V_z}{I_L + I_z}$$

$$I_L = \frac{8\,V}{7\times 10^3} = 8.0\ mA$$

$$\therefore R_s = \frac{15-8}{(8+27)\times 10^{-3}} = \frac{7}{30\times 10^{-3}}$$

$$= 233.33\ \Omega$$

$$R_s = \frac{15-8}{(8+2)\times 10^{-3}}$$

$$= \frac{7}{10\times 10^{-3}}$$

$$= 700\Omega$$

## True or False

1. A diode is an active device.
2. Hole is a massless particle generated, when electron leaving a vacancy.
3. All semiconductors are conducting at room temperature.
4. Valence Band having the electrons, which are free to conduct electricity.
5. The semiconductor materials having the band gap energy of 1.12 eV.
6. Intrinsic semiconductors are pure form of semiconductors using for industrial purpose.
7. Depletion region contains no charge carriers.
8. Doping is the process, in which impurity atoms are added to make the semiconducting materials a good insulator.
9. Drift current is a natural current flow through p-n junction, when no applied electric field.
10. Current due to concentration gradient is called as diffusion current.
11. n-type semiconductors having the negative charge on it.
12. Increasing in temperature of p-n junction would increase forward current.
13. Ideal diode is working as an ON/OFF switch.
14. Center-trap and Bridge type full wave rectifier having the same efficiency.
15. Zener diode is always operated in forward bias as a voltage regulator.
16. LED changes color when, current intensity changes.