SOLUTIONS

Solution-1:

$$I_D = I_S\left(e^{\frac{V_D}{nV_T}} - 1\right) \qquad \text{with} \qquad V_T = \frac{kT}{q}$$

$k = (1.38\times10^{-23})$ J/K (Boltzmann's constant), $q = 1.6\times10^{-19}$ C (electronic charge)

At 25^0 C, $T = 273+25 = 298\,\text{K}$ and $V_T = 25.70$ mV

$$\frac{I_D}{I_s} = \frac{10\times10^{-3}}{0.01\times10^{-6}} = 10^6$$

Therefore, $V_D = nV_T \ln\left(\frac{I_D}{I_S}+1\right)$ = 0.71 V

For Temperature =30⁰ C

We know, $I_{S2} = I_{S1}\times 2^{\left(\frac{T_2-T_1}{10}\right)}$

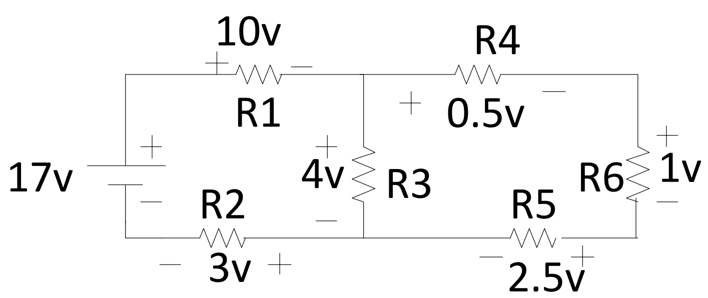
Here, $T_1 = 298\text{K}$ and $T_2 = 273+30 = 303\,\text{K}$ for $I_{S1} = I_S|_{T=298K}$ and $I_{S2} = I_S|_{T=303K}$

At 30^0 C (303 K), $I_{s2} = \left(0.01\times10^{-6}\right)\times\sqrt{2} = 1.414\times10^{-8}\ A = I_S|_{T=303K}$ and $V_T = 26.134$ mV

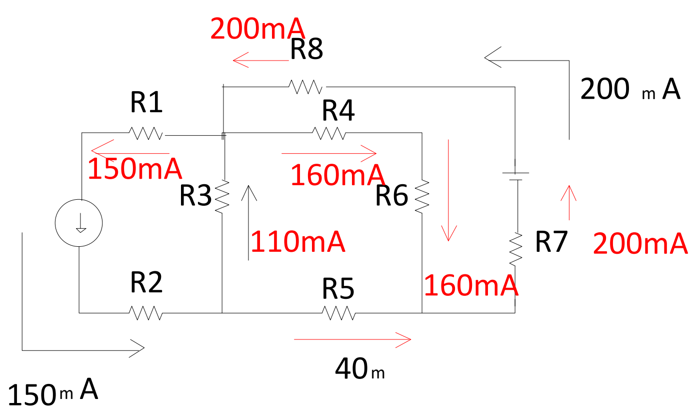
Using the new values for I_S and V_T, the required V_D for $I_D = 10\,\text{mA}$ is - $V_D = 0.704\text{V}$

Therefore, Percentage decrease in V_D required is $\frac{0.710-0.704}{0.710}\times100 = 0.85\%$.

Solution-2 (a): Voltage across R_4 is 0.5 V.



Solution-2 (b): Currents are indicated in RED colour.



Solution-3:

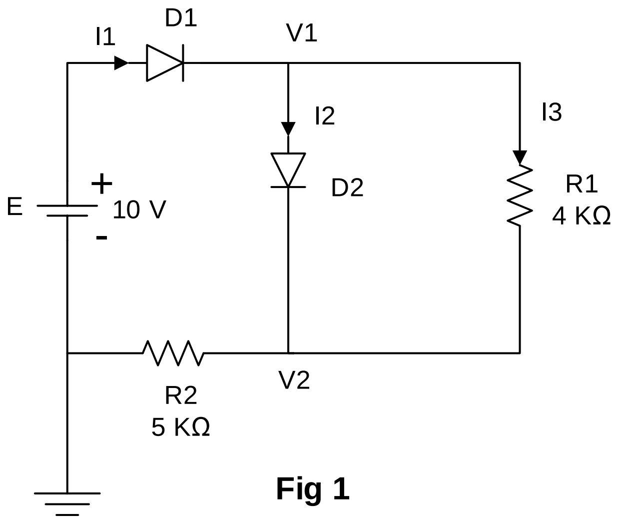


Fig 1

$V1=10-0.7=9.3$ V, $V2=9.3-0.7=8.6$ V, $I_{R2}=\frac{8.6}{5}=1.72$ mA

$I3=\frac{0.7}{4}=0.175$ mA, $I2=1.72-0.175=1.545$ mA

$I1=I2+I3=I_{R2}=1.72$ mA

Solution-4 (a):

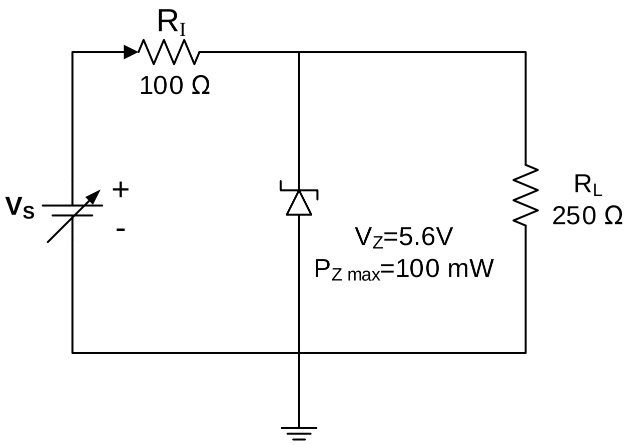


Fig 2

Since $P_Z=V_ZI_Z$ where I_Z is the current through the Zener diode, we have $I_{Z,\,MAX}=100/5.6=17.86$ mA

Since $I_{RL}=5.6/0.250=22.4$ mA, we have $I_{RI\,MAX}=I_{Z\,MAX}+I_{RL}=17.86+22.4=40.26$ mA

Therefore, $V_{S\,MAX}=I_{RI\,MAX}R_I+V_Z=40.26*0.1+5.6=9.63$ V

Solution-4 (b):

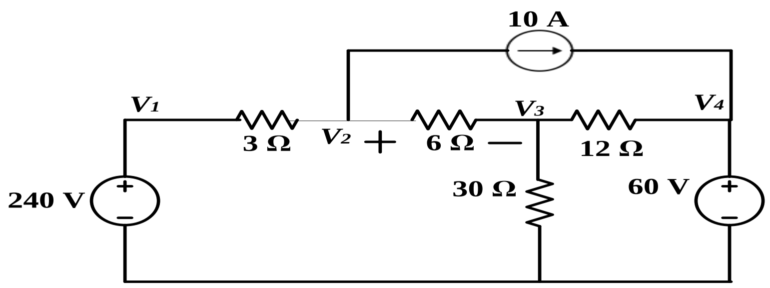
If the Zener diode is such that a minimum current of 1 mA is required for the Zener action to take place, what is the minimum source voltage V_S that can be used?

When the Zener diode is drawing minimum current, we have $I_{RI\ MIN}$=1+I_{RL}=23.4 mA

Therefore, $V_{S\ MIN}$=$I_{RI\ MIN}R_I$ + V_Z = 23.4*0.1+5.6= 7.94 V

Solution-5:

The circuit has 4 nodes namely V_1, V_2,V_3 and V_4 apart from the reference node connected to negative terminal of the independent voltage sources.



Using Kirchoff's current law (KCL) at the node V_2:

$\frac{V_2-240}{3}+\frac{V_2-V_3}{6}$ +10 = 0 or $2(V_2-240)+V_2-V_3+60=0$ giving

$3v_2$ - v_3 -420=0 ……………….……………..(1)

Using KCL at the node V_3:

$\frac{V_3-V_2}{6}+\frac{V_3}{30}+\frac{V_3-60}{12}$ = 0 or 10(V_3- V_2) + 2V_3+ 5(V_3-60) = 0 giving

$17V_3$ - $10V_2$ -300 = 0 ………………………..…. .(2)

Now, (1) x10 becomes

$30V_2$ - $10V_3$ - 4200=0 …………… .(3)

and, (2) x3 gives

$-30V_2$ + $51V_3$ -900=0 …………… .(4)

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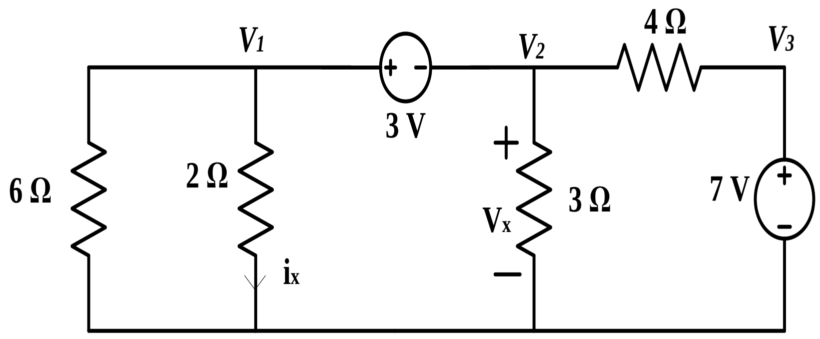
(3)+(4) becomes $41V_3$-5100=0 => V_3=124.39 V

Substitution of V_3 in (2) gives V_2=181.46 **V**

Voltage across the 6**Ω** resistor is V_2-V_3= 181.46-124.39 = 57.07 V (Ans)

Solution-6:
V_1, V_2, V_3 are the three nodes apart from the reference node. As a source is connected in between V_1 and V_2 , it forms **a super node.**



Due to the super node *V1*-*V2*: V_1=3+ V_2 ………………………………….(1)

Applying KCL due to super node *V1* - *V2*:

$\frac{V_2-7}{4} + \frac{V_2}{3} + \frac{V_1}{2} + \frac{V_1}{6} = 0$

OR

3(V_2 -7)+ 4V_2+6V_1+2V_1= 0 resulting in

8V_1+7V_2=21 …………………………………….(2)

Substitution of (1) in (2) gives

24+8V_2+7V_2= 21

=> V_2= - 0.2

Now, (1) gives $V_1 = 2.8$

Therefore, i_x = V_1/2 = (3+V_2) / 2 = **1.4 A** (Ans)

Lastly, **V_x = V_2 = - 0.2 V (Ans)**