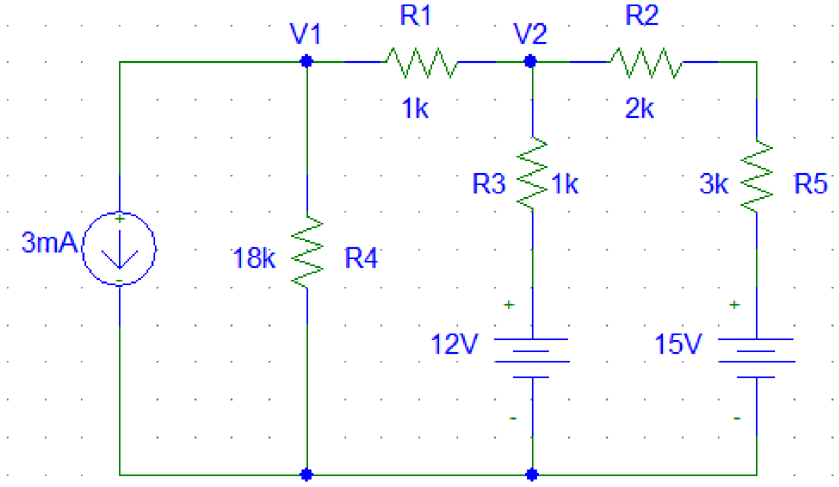
Düğüm Metodu ile çözüm



$$0{,}003+\frac{V_1}{18000}+\frac{V_1-V_2}{1000}=0$$

$$\frac{V_2-V_1}{1000}+\frac{V_2-12}{1000}+\frac{V_2-15}{2000+3000}=0$$

$$V_1\left[\frac{1}{18000}+\frac{1}{1000}\right]-\frac{V_2}{1000}=-\frac{3}{1000}$$

$$-V_1\left[\frac{1}{1000}\right]+V_2\left[\frac{1}{1000}+\frac{1}{1000}+\frac{1}{5000}\right]=\frac{12}{1000}+\frac{15}{5000}$$

$$V_1\left[\frac{\frac{1}{18000}}{1}+\frac{\frac{1}{1000}}{18}\right]-\frac{\frac{V_2}{1000}}{18}=-\frac{\frac{3}{1000}}{18}$$

$$-V_1\left[\frac{\frac{1}{1000}}{18}\right]+V_2\left[\frac{\frac{1}{1000}}{18}+\frac{\frac{1}{1000}}{18}+\frac{\frac{1}{5000}}{3{,}6}\right]=\frac{\frac{12}{1000}}{18}+\frac{\frac{15}{5000}}{3{,}6}$$

$$(1+18).V_1-18.V_2=-54$$

$$-18.V_1+(18+18+3{,}6).V_2=216+54$$

$$19.V_1-18.V_2=-54$$

$$-18.V_1+39{,}6.V_2=270$$

$$V_1 = \frac{\begin{vmatrix} -54 & -18 \\ 270 & 39,6 \end{vmatrix}}{\begin{vmatrix} 19 & -18 \\ -18 & 39,6 \end{vmatrix}} = \frac{(-54x39,6)-(270X(-18)}{19x39,6-(-18).(-18)} = \frac{2138,4+4860}{752,4-324} = \frac{6998,4}{428.4} = 16,33613445\text{V}$$

$$V_2 = \frac{\begin{vmatrix} 19 & -54 \\ -18 & 270 \end{vmatrix}}{\begin{vmatrix} 19 & -18 \\ -18 & 39,6 \end{vmatrix}} = \frac{19X270-(-18)X(-54)}{19x39,6-(-18).(-18)} = \frac{5130+972}{752,4-324} = \frac{6102}{428.4} = 14,24369748\text{V}$$

$$I_{\text{R1}} = \frac{V_1 - V2}{1000} = \frac{16,33613445 - 14,24369748 - 54}{1000} = 2,09243745mA$$

$$I_{\text{R4}} = -\left(\frac{V_1}{18}\right) = -\left(\frac{16,33613445}{18}\right) = -0,907563025mA \text{ yada}$$

$$I_{\text{R1}} = 3 + I_{\text{R4}}$$

$$I_{\text{R4}} = -3 + I_{\text{R1}} = -3 + 2,09243745 = -0,90756255mA$$

$$I_{\text{R2}} = I_{\text{R5}} = -\left(\frac{V_1 - 15}{5}\right) = \frac{-14,24369748 + 15}{5} = 0,151260504mA$$

$$I_{\text{R3}} = -\left(\frac{V_1 - 12}{1}\right) = \frac{-14,24369748 + 12}{1} = -2,24369748mA$$

$$V_{\text{R1}} = R_1 x I_{\text{R1}} = 1000x0,00209243745 = 2,09243745$$

$$V_{\text{R5}} = R_5 x I_{\text{R5}} = R_5 x I_{\text{R5}} = 3000x0,000151260504 = 0,453781512V$$

$$P_{\text{R1}} = R_1 x {I_{\text{R1}}}^2 = 1000x(2,09243745x10^{-3})^2 = 0,004378294482W$$

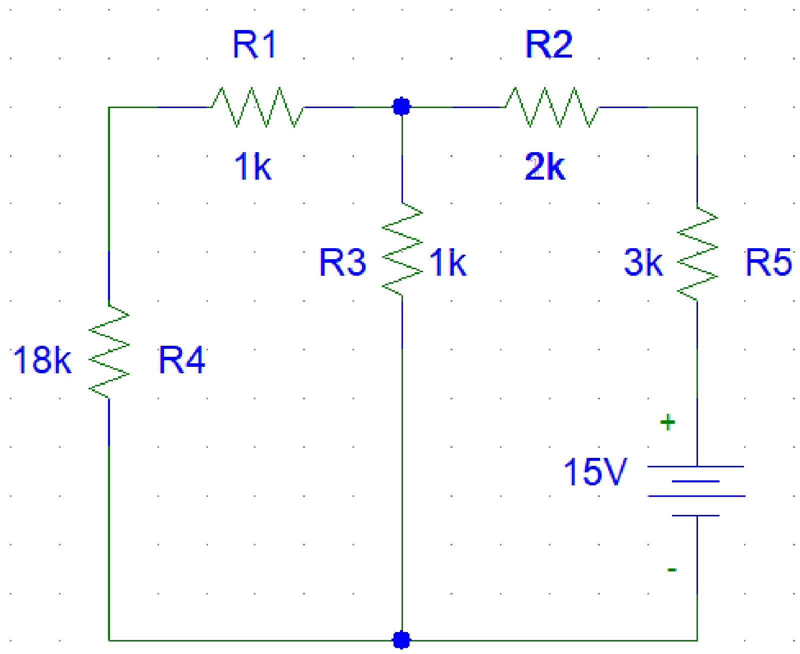
$$P_{\text{R2}} = R_2 x {I_{\text{R2}}}^2 = 2000x(0,1512060504x10^{-3})^2 = 0,000004572653936W$$

$$P_{\text{R3}} = R_3 x {I_{\text{R3}}}^2 = 1000x(-2,24369748x10^{-3})^2 = 0,005034178382W$$

$$P_{\text{R4}} = R_4 x {I_{\text{R4}}}^2 = 18000x(-0,90756255x10^{-3})^2 = 0,014826056W$$

$$P_{\text{R5}} = R_5 x {I_{\text{R5}}}^2 = 2000x(0,1512060504x10^{-3})^2 = 0,000004572653936W$$

Toplamsallık (Superpozisyon) Teoremi

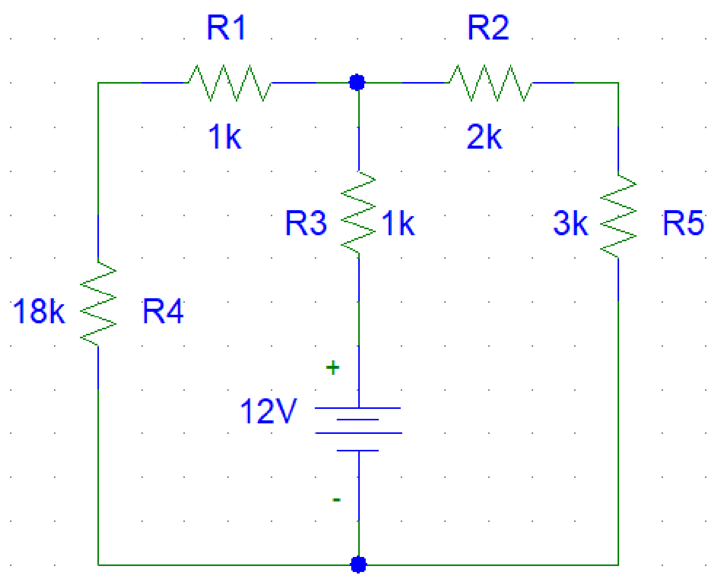


15 V'luk gerilim kaynak devrede Diğer gerilim kaynakları kısa devre

$$I_{\mathrm{R2}} = I_{\mathrm{R5}} = \frac{15}{\frac{(1+18).1}{(1+18)+1} + .(2+3)} = \frac{15}{\frac{19}{20}+5} = \frac{15X20}{19+100} = \frac{300}{119} = 2{,}521008403mA$$

$$I_{\mathrm{R3}} = -0{,}002521008403x\frac{1+18}{1+18+1} = -2{,}394957983mA$$

$$I_{\mathrm{R1}} = -0{,}002521008403x\frac{1}{1+18+1} = -0{,}12605042mA$$

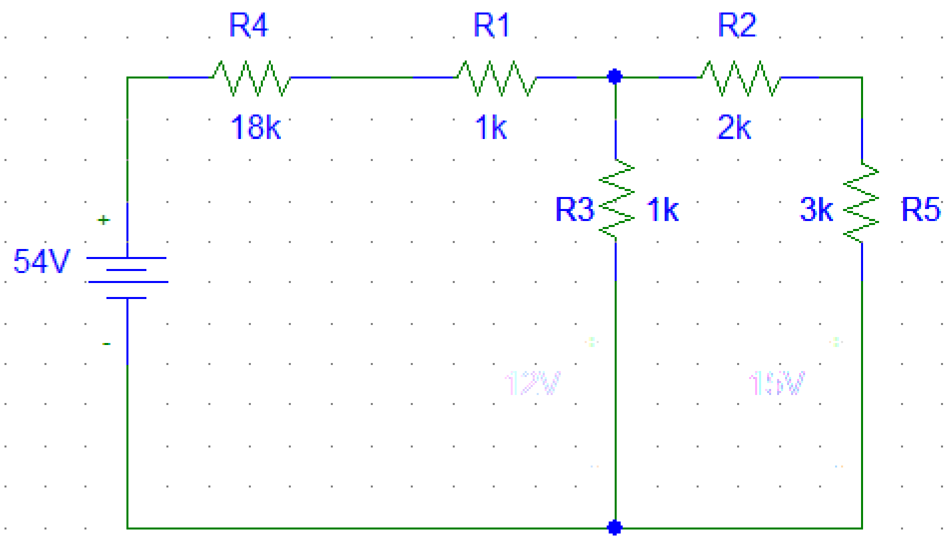


12 V'luk gerilim kaynak devrede Diğer gerilim kaynakları kısa devre

$$I_{\mathrm{R3}} = \frac{12}{\frac{(1+18).(2+3)}{(1+18)+(2+3)}+1} = \frac{12}{\frac{95}{24}+1} = \frac{12X24}{95+24} = \frac{288}{119} = 2{,}420168067mA$$

$$I_{\mathrm{R2}} = I_{\mathrm{R5}} = -0{,}002420168067x\,\frac{1+18}{1+18+2+3} = -1{,}915966387mA$$

$$I_{\mathrm{R1}} = -0{,}002420168067x\,\frac{2+3}{1+18+2+3} = -0{,}50420168mA$$



15 V'luk gerilim kaynak devrede Diğer gerilim kaynakları kısa devre (not: 3 mA'lik akım kaynağı gerilim kaynağına çevrildi 18KOhmx3mA=54V seri direnç 18KOhm)

$$I_{\mathrm{R1}} = \frac{54}{18+1+\frac{(2+3)x1}{(2+3)+1}} = \frac{54}{18+1+0{,}8333} = 2{,}722689121mA$$

$$I_{\mathrm{R3}} = -0{,}002722689121x\,\frac{2+3}{1+2+3} = -2{,}268907601mA$$

$$I_{\mathrm{R2}} = I_{\mathrm{R5}} = -0{,}002722689121x\,\frac{1}{1+2+3} = -0{,}45378152mA$$

Her kaynaktaki dirençlerin akımlarını toplarsak

$$I_{\text{R2}} = I_{\text{R5}} = \frac{15}{\frac{(1+18).1}{(1+18)+1} + .(2+3)} = \frac{15}{\frac{19}{20}+5} = \frac{15X20}{19+100} = \frac{300}{119} = 2{,}521008403mA$$

$$I_{\text{R2}} = I_{\text{R5}} = -0{,}002420168067x\,\frac{1+18}{1+18+2+3} = -1{,}915966387mA$$

$$I_{\text{R2}} = I_{\text{R5}} = -0{,}002722689121x\,\frac{1}{1+2+3} = -0{,}45378152mA$$

$$I_{\text{R2}} = I_{\text{R5}} = 2{,}521008403 - 1{,}915966387 - 0{,}45378152$$

$$I_{\text{R2}} = I_{\text{R5}} = 0{,}151260496$$

$$I_{\text{R1}} = -0{,}002521008403x\,\frac{1}{1+18+1} = -0{,}12605042mA$$

$$I_{\text{R1}} = -0{,}002420168067x\,\frac{2+3}{1+18+2+3} = -0{,}50420168mA$$

$$I_{\text{R1}} = \frac{54}{18+1+\frac{(2+3)x1}{(2+3)+1}} = \frac{54}{18+1+0{,}8333} = 2{,}722689121mA$$

$$I_{\text{R1}} = -0{,}12605042 - 0{,}50420168 + 2{,}722689121$$

$$I_{\text{R1}} = 2{,}092437021mA$$

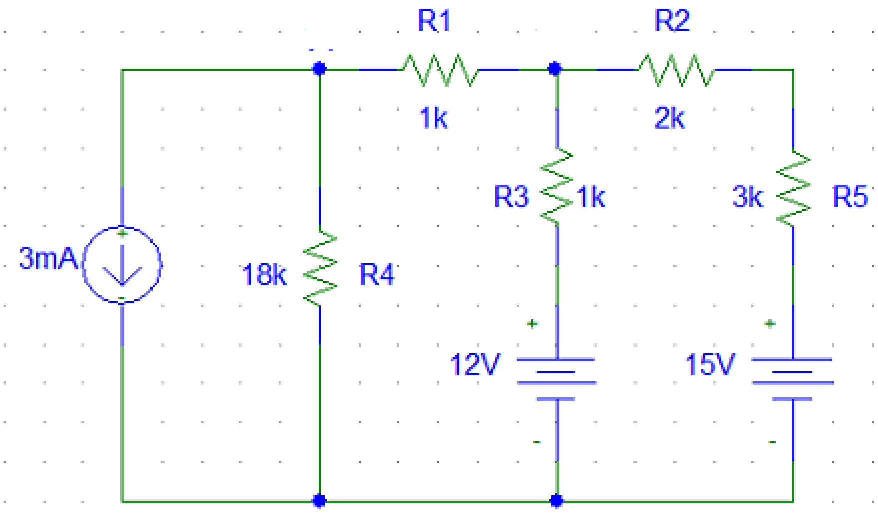
$$I_{\text{R3}} = -0{,}002521008403x\,\frac{1+18}{1+18+1} = -2{,}394957983mA$$

$$I_{\text{R3}} = \frac{12}{\frac{(1+18).(2+3)}{(1+18)+(2+3)}+1} = \frac{12}{\frac{95}{24}+1} = \frac{12X24}{95+24} = \frac{288}{119} = 2{,}420168067mA$$

$$I_{\text{R3}} = -0{,}002722689121x\,\frac{2+3}{1+2+3} = -2{,}268907601mA$$

$$I_{\text{R3}} = -2{,}394957983 + 2{,}420168067 - 2{,}268907601$$

$$I_{\text{R3}} = -2{,}243697517$$



$I_{\mathrm{R1}} = 3 + I_{\mathrm{R4}}$

$I_{\mathrm{R4}} = -3 + I_{\mathrm{R1}} = -3 = 2{,}09243745 = -0{,}90756255mA$

$V_{\mathrm{R1}} = R_1 x I_{\mathrm{R1}} = 1000x0{,}00209243745 = 2{,}09243745$

$V_{\mathrm{R5}} = R_5 x I_{\mathrm{R5}} = R_5 x I_{\mathrm{R5}} = 3000x0{,}000151260504 = 0{,}453781512V$

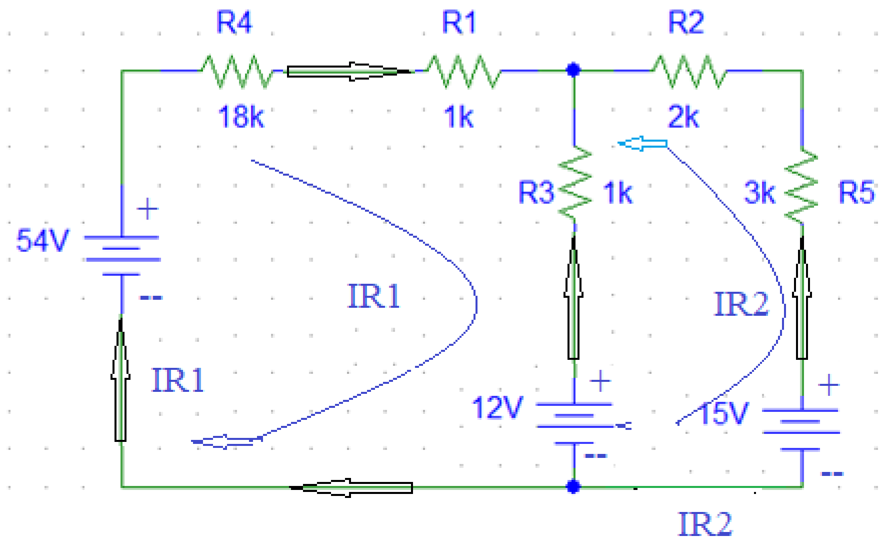
$P_{\mathrm{R1}} = R_1 x {I_{\mathrm{R1}}}^2 = 1000x(2{,}09243745x10^{-3})^2 = 0{,}004378294482W$

$P_{\mathrm{R2}} = R_2 x {I_{\mathrm{R2}}}^2 = 2000x(0{,}1512060504x10^{-3})^2 = 0{,}000004572653936W$

$P_{\mathrm{R3}} = R_3 x {I_{\mathrm{R3}}}^2 = 1000x(-2{,}24369748x10^{-3})^2 = 0{,}005034178382W$

$P_{\mathrm{R4}} = R_4 x {I_{\mathrm{R4}}}^2 = 18000x(-0{,}90756255x10^{-3})^2 = 0{,}014826056W$

$P_{\mathrm{R5}} = R_5 x {I_{\mathrm{R5}}}^2 = 2000x(0{,}1512060504x10^{-3})^2 = 0{,}000004572653936W$



$$\begin{vmatrix} 18+1+1 & +1 \\ +1 & 1+2+3 \end{vmatrix} \begin{vmatrix} IR1 \\ IR5 \end{vmatrix} = \begin{vmatrix} 54-12 \\ 15-12 \end{vmatrix}$$

$$\begin{vmatrix} 18+1+1 & +1 \\ +1 & 1+2+3 \end{vmatrix} \begin{vmatrix} IR1 \\ IR5 \end{vmatrix} = \begin{vmatrix} +42 \\ 3 \end{vmatrix}$$

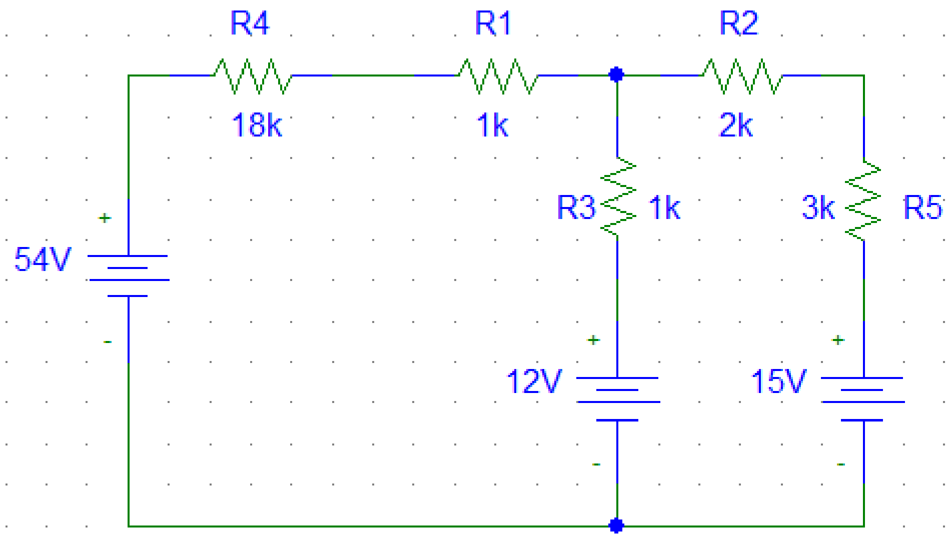
$$I_{\mathrm{R1}} = \frac{\begin{vmatrix} 42 & 1 \\ 3 & 6 \end{vmatrix}}{\begin{vmatrix} 20 & 1 \\ 1 & 6 \end{vmatrix}} = \frac{42x6 - 3X1}{20x6 - 1X1} = \frac{252-3}{120-1} = \frac{249}{119} = 2{,}092436975mA$$

$$I_{\mathrm{R5}} = I_{\mathrm{R2}} = \frac{\begin{vmatrix} 20 & 42 \\ 1 & 3 \end{vmatrix}}{\begin{vmatrix} 20 & 1 \\ 1 & 6 \end{vmatrix}} = \frac{20X3 - 1X42}{20x6 - 1X1} = \frac{60-42}{120-1} = \frac{18}{119} =$$

$$I_{\mathrm{R5}} = I_{\mathrm{R2}} = 0{,}151260504mA$$

$$I_{\mathrm{R1}} + I_{\mathrm{R3}} + I_{\mathrm{R2}} = 0$$

$$I_{\mathrm{R3}} = -I_{\mathrm{R1}} - I_{\mathrm{R2}} = -2{,}092436975 - 0{,}151260504 = -2{,}243697479mA$$



$$\frac{V_1-54}{19}+\frac{V_1-12}{1}+\frac{V_1-15}{5}=0$$

$$V_1\left[\frac{1}{\frac{19}{5}}+\frac{1}{\frac{1}{95}}+\frac{1}{\frac{5}{19}}\right]=\frac{54}{\frac{19}{5}}+\frac{12}{\frac{1}{95}}+\frac{15}{\frac{5}{19}}$$

$$V_1(5+95+19)=(54x5+12x95+15x19)$$

$$V_1(119)=(270+1140+285)$$

$$V_1=\frac{1695}{119}=14{,}24369748$$

$$I_{R3}=-\left(\frac{V_1-12}{1}\right)=\frac{-14{,}24369748+12}{1}=-2{,}24369748mA$$

$$I_{R2}=I_{R5}=-\left(\frac{V_1-15}{5}\right)=\frac{-14{,}24369748+15}{5}=0{,}151260504mA$$

$$I_{R1}=-\left(\frac{V_1-54}{19}\right)=-\left(\frac{14{,}24369748-54}{19}\right)=2{,}092436975mA$$

$$V_{R1}=R_1xI_{R1}=1000x0{,}00209243745=2{,}09243745$$

$$V_{R5}=R_5xI_{R5}=R_5xI_{R5}=3000x0{,}000151260504=0{,}453781512V$$

$$P_{R1}=R_1x{I_{R1}}^2=1000x(2{,}09243745x10^{-3})^2=0{,}004378294482W$$

$$P_{R2}=R_2x{I_{R2}}^2=2000x(0{,}1512060504x10^{-3})^2=0{,}00004572653936W$$

$$P_{R3}=R_3x{I_{R3}}^2=1000x(-2{,}24369748x10^{-3})^2=0{,}005034178382W$$

$$P_{R5}=R_5x{I_{R5}}^2=2000x(0{,}1512060504x10^{-3})^2=0{,}00004572653936W$$