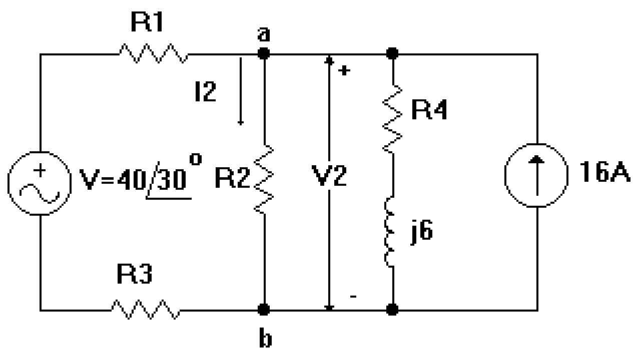
BLM104 Elektrik Devre Temelleri ve Uygulamaları Dersi Çözümlü Örnekler 3

Prob.2-1 Şek.P2-1 deki devrede R_2'nin uçlarındaki V_2 gerilimini ve içinden akan I_2 akımını bulunuz. R_1=Ye,Ma,Al,Al; R_2=Gr,Sa,Ye,Ka; R_3=Tu,Be,Si,Gü; R_4=Ka,Gr,Si,Gü



Şek. P2-1

Çöz.2-1:

$R_1 = 5{,}6\Omega$, $R_2 = 8450\Omega$, $R_3 = 39\Omega$, $R_4 = 18\Omega$

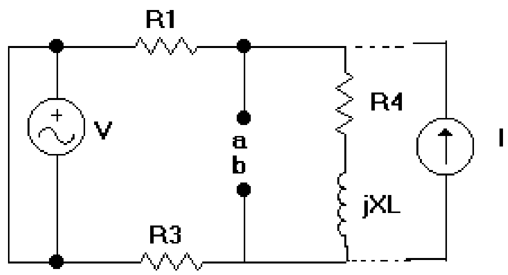
R_2'nin devreye bağlandığı uçlardan yani , ab uçlarından görünen thevenin eşdeğerinin elde edilmesi gerekir. Bu nedenle İlk önce Z_{ab}'yi bulalım . Empedans bulunurken bağımsız kaynaklar devre dışı edilir.

Bu durumda Z_{ab} aşağıdaki gibi olur.

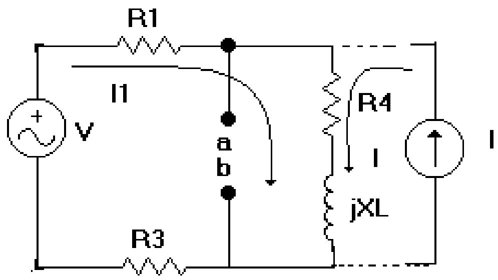
$$Z_{ab} = (R_1 + R_3)//(R_4 + jX_L) = \frac{(5{,}6+39)(18+j6)}{5{,}6+39+18+j6}$$

$$Z_{ab} = \frac{(44,6)x6(3+j)}{62,6+j6} = \frac{(276,6)(3+j)}{62,8869\angle 5,47848°} = \frac{874,686\angle 18,4349°}{62,8869\angle 5,4784} = 13,90887\angle 12,9565°$$

$$Z_{ab} = 13,90887\angle 12,9565°\ \Omega$$



Şekil 2-1a



Şekil 2-1b

Şekil 2-1 ab uçlarından görünen Thevenin eşdeğerinin elde edilmesi

a) Z_{ab} empedansının bulunması b) V_{ab} geriliminin bulunması

Şekil 2-1b' den faydalanarak ab uçlarındaki açık devre gerilimini bulalım.

$$(R_1 + R_3 + R_4 + jX_L)I_1 + (R_4 + jX_L)I = V$$

$$I = \frac{V - (R_4 + jX_L)I}{R_1 + R_3 + R_4 + jX_L} = \frac{40\angle 30° - (18 + j6)16}{5{,}6 + 39 + 18 + j6} = \frac{40\angle 30° - 288 - j96}{62{,}6 + j6}$$

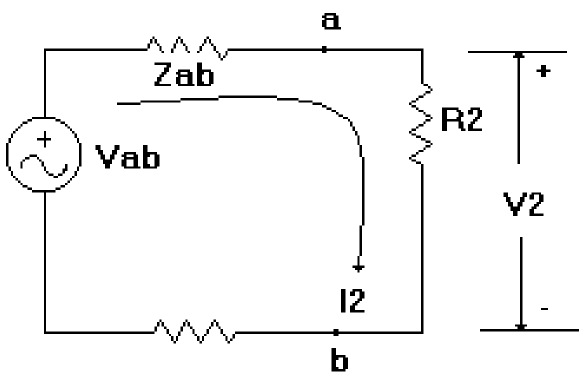
$$= \frac{34{,}641 + j20 - 288 - j96}{62{,}6 + j6} = \frac{-253{,}359 - j76}{62{,}6 + j6} = \frac{264{,}5123492\angle -163{,}302}{62{,}8868\angle 5{,}4784}$$

$$= 4{,}206161\angle -168{,}7772$$

$$V_{ab} = -R_1I_1 + V - R_3I_1 = V - (R_1 + R_3)I_1 = (40\angle 30° - (5{,}6 + 39))(4{,}206\angle -168{,}777)$$

$$= 34{,}641 + j20 - 44{,}6.4{,}206\angle -168{,}777 = 218{,}64835 + j56{,}5105764 = 225{,}833\angle 14{,}4912$$

R_2 'den görünen eşdeğer devre şekil 2-1c verilmiştir. Bu devreden faydalanarak I_2 ve V_2 'yi bulalım.



Şekil 2-1c

$$I_2 = \frac{V_{ab}}{Z_{ab}+R_2} = \frac{V_{ab}}{13,4563\angle 12,96 + 845°} = \frac{V_{ab}}{13,113526 + j3,017855 + 845°}$$

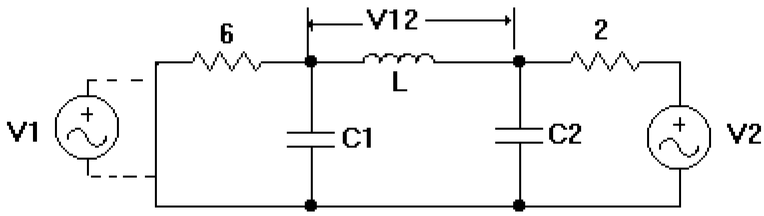
$$I_2 = \frac{225,833\angle 14,4912}{8463,114\angle 0,02043} = 0,0266844\angle 14,471 = 0,025838 + j6,668.10^{-3}\,A$$

$$V_2 = R_2 I_2 = (8450)0.0266844\angle 14,471 = 225,483\angle 14,447 = 218,33 + j56,345 \text{ V}$$

Prob.2-2

a) Şek.P2-2 devrede $V_{12} = 49,5268\angle -49,6355°$ mV dir . V_2 gerilimini bulunuz.

b) Şekildeki devrede ab uçları açık devre edilip , (a) ucu (+) olmak üzere değeri $V_1 = 100\angle 0° mV$ olan bir gerilim kaynağı bağlandığında V_{12} gerilimini bulunuz. L_1=0,6366197 mH , C_1=39,7888736 μF , C_2= 79,577472 μF , f=1000Hz.



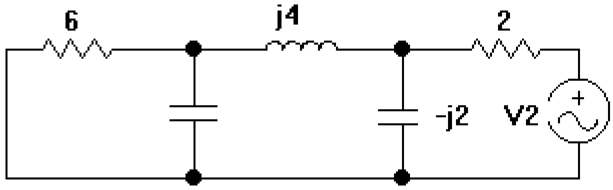
Şekil P2-2

Çöz.2-2:

a) $X_{C1} = \frac{1}{2\pi f C_1} = \frac{1}{2\pi .10^3.39,788736} = 4\Omega \quad X_L = 2\pi f L = 2\pi .10^3.0,63661977 \cong 4\Omega$,

$$X_{C2} = \frac{1}{2\pi f} = \frac{1}{2\pi .10^3.79,577472} = 2\Omega$$

Devrede V_1 gerilimi yokken düğüm gerilimlerini kullanarak devre denklemlerini yazalım



Şek.2-2

$$\begin{vmatrix} \frac{1}{6}+\frac{1}{-J4}+\frac{1}{J4} & \frac{-1}{J4} \\ \frac{-1}{J4} & \frac{1}{J4}+\frac{1}{J2}+\frac{1}{2} \end{vmatrix} \begin{vmatrix} V_{d1} \\ V_{d2} \end{vmatrix} = \begin{vmatrix} 0 \\ \frac{V_2}{2} \end{vmatrix} \quad , \quad \begin{vmatrix} \frac{1}{6} & -J0,25 \\ -J0,25 & 0,5+J0,25 \end{vmatrix} .. \begin{vmatrix} V_{d1} \\ V_{d2} \end{vmatrix} = \begin{vmatrix} 0 \\ \frac{V_2}{2} \end{vmatrix}$$

$$V_{d1}-V_{d2}=(V_{12})_2=\frac{\begin{vmatrix} 0 & J0,25 \\ \frac{V_2}{2} & 0,5+J0,25 \end{vmatrix} - \begin{vmatrix} \frac{1}{6} & 0 \\ -J0,25 & \frac{V_2}{2} \end{vmatrix}}{\begin{vmatrix} \frac{1}{6} & -J0,25 \\ -J0,25 & 0,5+J0,25 \end{vmatrix}} = \frac{-(\frac{V_2}{2})(j0.25)-(\frac{V_2}{2})-\frac{1}{6}}{\frac{1}{6}(0,5+j0,25)-(j0,25)(j0,25)}$$

$$(V_{12})_2=\frac{-(\frac{V_2}{2})(j0,25.6+1)}{0,5+j0,25+6.(0,25)^2}=\frac{-\frac{V_2}{2}*(j1,5+1)}{0,875+j0,25}$$

$$\Rightarrow V_2=\frac{-2(0,875+j0,25)(V_{12})}{1+j1,,5}=\frac{(-2.0,91\angle 15,945).(49,5268\angle -49,6355)}{1,8028\angle 56,3099}$$

$V_2=-49,99999\angle -90° = -50\angle -90° = 50\angle(180°-90°) = 50\angle 90°$ =j50 mV

b) Devreye ab uçlarından $V_1 = 100\angle 0°$ mV gerilim kaynağı bağlandığında V_{12} gerilimini bulalım.

$$\begin{vmatrix} \frac{1}{6} & j0,25 \\ j0,25 & 0,5+j0,25 \end{vmatrix} .. \begin{vmatrix} V_{d1} \\ V_{d2} \end{vmatrix} = \begin{vmatrix} \frac{100}{6} \\ \frac{-j50}{2} \end{vmatrix} \quad , \quad V_{12}=V_{d1}-V_{d2}=\frac{\begin{vmatrix} \frac{100}{6} & j0,25 \\ j25 & 0,5+j0,25 \end{vmatrix} - \begin{vmatrix} \frac{1}{6} & \frac{100}{6} \\ j0,25 & j25 \end{vmatrix}}{\begin{vmatrix} \frac{1}{6} & j0,25 \\ j0,25 & 0,5+j0,25 \end{vmatrix}}$$

$$V_{12}=\frac{\frac{100}{6}(0,5+j0,25)+0,25(25)+j0,25\frac{100}{6}-\frac{1}{6}(j25)}{\frac{1}{6}(0,5+j0,25)-(j0,25)(j0,25)}=\frac{50+j25+6(6,25)+j25-j25}{0,875+j0,25}$$

$$V_{12}=\frac{87,5+j25}{0,875+j0,25}=\frac{100(0,875+j0,25}{0,875+j0,25}=100=100\angle 0°$$

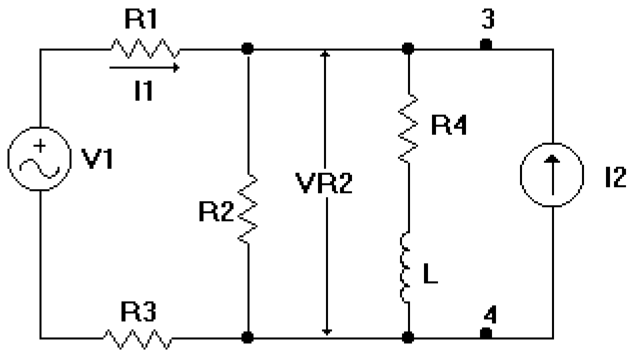
Prob.2-3

a) Şek.P2-3 deki devrede 3-4 uçları kısa devre edildiğinde (I_2 akım kaynağı devre dışı) $I_1 = 10\angle 30° mA' dir.$ V_1 gerilimini bulunuz.

b) V_1 ve I_2 kaynakları devrede iken $V_{R2} = 2{,}50875\angle 14{,}471° V' dur.$ $I_2' yi$ bulunuz.

R_1 =Ye,Ma,Al,Gü R_2 =Gr,Sa,Ye,Ka,Gü R_3 =Tu,Be,Si,Al

R_4 =Ka,Gr,Si,Al L=0,95492966 mH f=1KHz

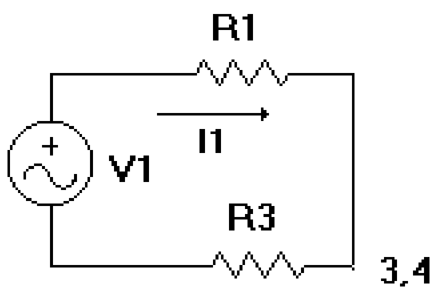


Şek.P2-3

Çöz.2-3:

a) Renk kodları ile verilen dirençlerin değerleri R_1= 5,6 Ω; R_2= 8450 Ω= 8,4 KΩ R_3=R_4= 18 Ω

Verilen devrenin 3-4 uçlarını kısa devre ettiğimizde şekil 2-3a daki devre elde edilir.



Şek.2-3a

$$I_1 = \frac{V_1}{R_1 + R_3} \Rightarrow V_1 = (R_1 + R_2)I_1$$

$$V_1 = (5{,}6 + 39)(10^{<30^\circ}.10^{-3}) = 0{,}446^{<30^\circ} V$$

b) $X_L = 2\pi f L = 2\pi .10^3.0{,}95492966.10^{-3} = 6\Omega$

$$I_{R2} = \frac{Vab}{Zab + R_2} = \frac{Vab}{13{,}4563^{\langle 12{,}96} + 845°} = \frac{Vab}{8463{,}1141^{\langle 0{,}02043}}$$

$$V_{R2} = R_2 . I_{R2} = 845° \frac{Vab}{8463{,}1141^{\langle 0{,}02043}} = 2{,}50875^{\langle 14{,}471}$$

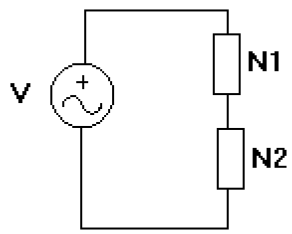
$$Vab = \frac{8463{,}1141^{\langle 0{,}02043} . 2{,}50875^{\langle 14{,}471}}{8450} = 2{,}5126^{\langle 14{,}49143}$$

$$I_{R2} \cong 1{,}6A$$

Prob.2-4 Şek.P2-4 deki devrede $V = 100\cos(2\pi 10^3 t + 80°)mV$, $i = 2{,}1\cos(2\pi 10^3 t + 25°)mA$, N_1 ve N_2 tek bir devre elemanı temsil etmektedir.

a) Akımın fazı gerilimin fazından ne kadar ileride veya geridedir. N_1 ve N_2 devre elemanlarının türünü bulunuz.

b) N_1 ve N_2 elemanlarının değerlerini bulunuz.



Şek.P2-4

Çöz.2-4:

a)

$$V = 100\cos\left(2\pi .10^3 t + 80°\right)mV \qquad i = 2{,}1\cos\left(2\pi 10^3 t + 25°\right)mA$$

$$\varphi_V - \varphi_i = 80 - 25 = 55°$$
$$\left(\varphi_i - \varphi_V = -55°\right)$$

akım gerilimden 55° geridedir. O halde bu elemanlar bir direnç ve endüktanstan ibarettir.

b) $$\frac{V_m}{I_m} = |Z| = \sqrt{R^2 + (\omega L)^2} \qquad (1)$$

$$\varphi = \tan^{-1}\left(\tfrac{\omega L}{R}\right) \qquad \tan\varphi = \frac{\omega L}{R} \qquad (2)$$

$$\omega L = R \ \tan\varphi = R.\tan(55) = 1{,}428\,R$$

$$\frac{V_m}{I_m} = \sqrt{R^2 + (\omega L)^2} = \sqrt{R^2 + (1{,}428R)^2} = \sqrt{3{,}0396R^2} = 1{,}743446R$$

$$\frac{V_m}{I_m} = \frac{100}{2{,}1} = 1{,}743446R$$

$$R = \frac{V_m}{I_m}\cdot\frac{1}{1{,}743446} = \frac{100}{21}\frac{1}{1{,}743446} = 27{,}313\Omega$$

$$(3) \Rightarrow L = \frac{1{,}428}{\omega}R = \frac{1{,}428.27{,}13}{2\pi.10^3} = 6{,}208.10^{-3}H = 6{,}208mH$$

$$Z = |Z|e^{j\varphi} = \frac{100}{21}e^{j55} = 27{,}313 + j39{,}0072\Omega$$

$$R = 27{,}313\Omega \qquad\qquad X_L = \omega L$$

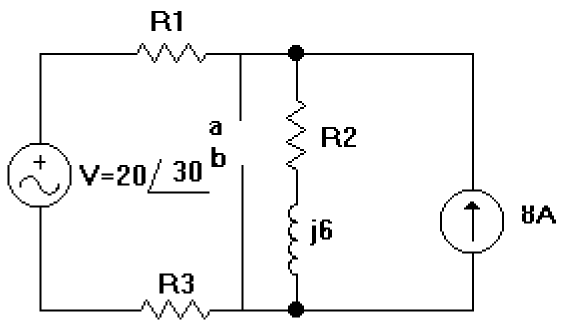
$$L = \frac{X_L}{\omega} = \frac{39{,}0072}{2\pi.10^{-3}} = 6{,}208.10^{-3}H = 6{,}208mH$$

Prob.2-5

a)Şek.P2-5 deki devrede ab uçlarından görülen thevenin eşdeğer devresini bulunuz.

R_1=Ye,Ma,Al,Al R_2=Ka,Gr,Si,Gü R_3=Tu,Be,Si,Gü

b)ab uçlarına R_4=Gr,Sa,Ye,KA,Al olan bir direnç bağlandığında bu direncin uçlarındaki gerilim ve akımı bulunuz.

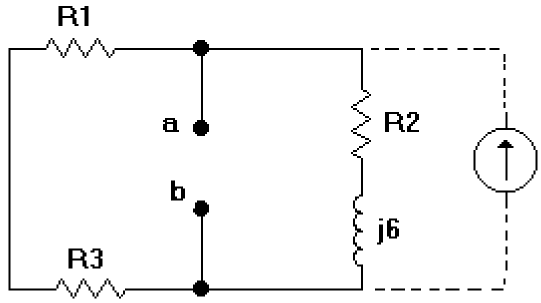


Şek.P2-5

Çöz.2-5

a) R_1=5,6 Ω R_2=18Ω R_3= 39Ω R_4= 8450Ω =8,45 K

ab uçlarından görünen Z_{ab} empedansını bulalım. Bağımsız kaynakları devre dışı edersek Şek.2-5a daki şekli elde ederiz.



Şek.2-5a

Şek.2-5a'dan

$$Z_{ab} = \left(R_1 + R_3\right)//\left(R_2 + j6\right) = \left(5{,}6 + 39\right)//\left(18 + j6\right)$$

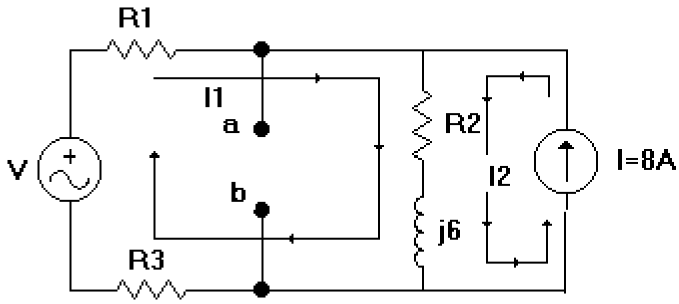
$$Z_{ab} = \frac{44{,}6\left(18 + j6\right)}{44{,}6 + 18 + j6} = \frac{44{,}6\left(18{,}9736^{\angle 18^\circ{,}4349}\right)}{62{,}6 + j6} = \frac{18{,}9736^{\angle 18^\circ{,}4349}}{62{,}8868\angle 5^\circ{,}4748}$$

$$Z_{ab} = 13{,}45678\angle 12{,}96^\circ = 13{,}1139 + j3{,}017977$$

Şek.2-5-2b'den V_{ab} açık devre gerilimini bulalım

$$\left(R_1 + R_2 + R_3 + jX_L\right)I_1 + \left(R_2 + jX_L\right)I = V \qquad (1)$$

$$\left(R_2 + jX_L\right)I_1 + \left(R_2 + jX_2\right)I = V_I \qquad (2)$$



Şek.2-5-2b

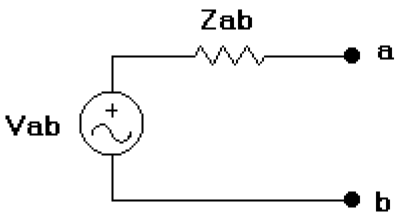
$$(1) \Rightarrow I_1 = \frac{V - \left(R_2 + jX_L\right)I}{R_1 + R_2 + R_3 + jX_L} = \frac{20^{\angle 30^\circ} - \left(18 + j6\right)8}{5{,}6 + 18 + 39 + j6} = \frac{-126{,}6795 - j38}{62{,}6 + j6}$$

$$I_1 = \frac{132{,}256^{\angle -163^\circ{,}303}}{62{,}887^{\angle 5^\circ{,}4749}} = 2{,}103^{\angle -168^\circ{,}7769}$$

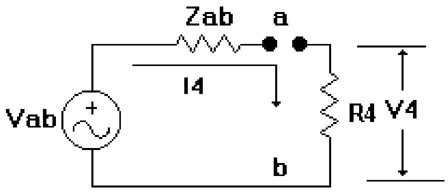
$$V_{ab} = -R_1 I_1 + V - R_3 I_1 = V - (R_1 + R_3)I_1 = 20\angle 30^\circ - (5{,}6 + 39)(2{,}103\angle -1668{,}7769)$$

$$V_{ab} = 20\angle 30° - 93{,}797\angle -168{,}77699 = 17{,}32 + j10 - (-92 - j18{,}25569)$$

$$V_{ab} = 109{,}323 + j28{,}2557 = 112{,}916^{\angle 14{,}4j}$$
$$V_{ab} = 112{,}916^{\angle 14{,}4j} V$$



Şek.5-2c



Şek.5-2d

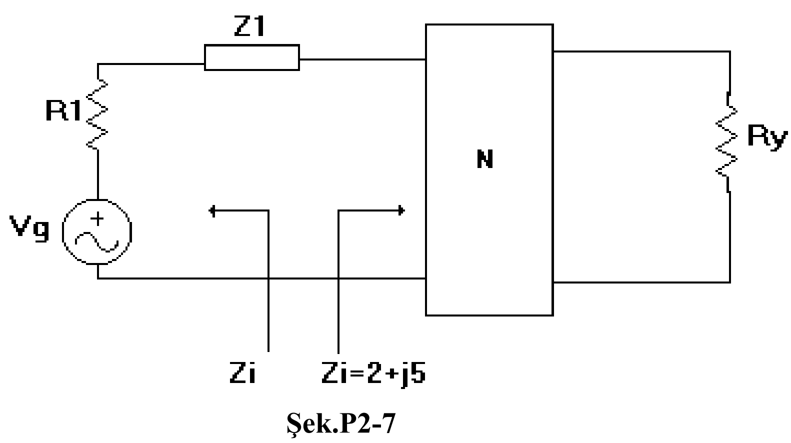
b) R_4=8,45 KΩ

$$I_4 = \frac{V_{ab}}{Z_{ab} + R_4} = \frac{112{,}916^{\angle 14{,}49°}}{13{,}1139 + j3{,}0179 + 8450} = \frac{112{,}916^{\angle 14{,}49}}{8463{,}1145^{\angle 0{,}0204°}}$$

$$I_4 = 0{,}01334^{\angle 14{,}469} = 0{,}01292 + j3{,}3337.10^{-3} mA$$

$$V_4 = R_4 I_4 = 8450.\left(0{,}01334\right)^{\angle 14{,}469} = 112{,}74^{\angle 14{,}469} V = 109{,}16 + j28{,}17V$$

Prob.2-7 Şek.P2-7 deki Vg kaynağının gücünün devrenin girişine maksimum olarak aktarılması için Z_1 elemanın değerini bulunuz. Maksimum güç konumunda Vg ’nin gücünü ve devrenin girişindeki gücü bulunuz.



Şek.P2-7

Çöz.2-7:

Maksimum güç aktarılması için

$$Z_i' = Z_i^* \qquad (1)$$

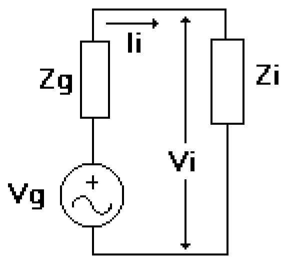
$$Z_i' = R_1 + Z_1$$

$$Z_i = R_i + jX_i \qquad (2)$$

$$Z_i^* = R_1 - jX_i$$

$$Z_1 = R_i - jX_i - R_1 = 2 - j5 - R_1 = (2 - R_1) - j5$$

Kaynağın verdiği gücü bulalım;



Şek.2-7

$$Z_i = Z_y^* \} \; R_i + jX_i = R_g + jX_g \Rightarrow \begin{cases} R_i = R_y \\ X_i = -X_g \end{cases}$$

$$Z_i = R_i + jX_i \;, \qquad Z_g = R_g + jX_g = R_i - jX_i$$

Bu koşullarda devreden akan akım;

$$v_g = v_{gm} Sin\omega t \qquad , \qquad v_g = \frac{v_{gm}}{\sqrt{2}}$$

$$I_1 = \frac{V_g}{Z_g + Z_i} = \frac{V_g}{R_i + jX_i + R_i - jX_i} = \frac{V_g}{2R_i} = \frac{V_t}{2R_g}$$

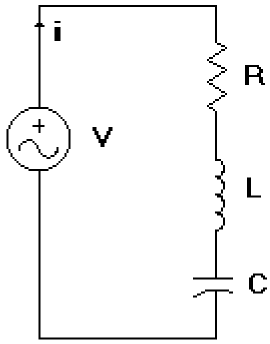
Kaynağın gücü; $P_g = V_g.I_i = V_g \cdot \dfrac{V_g}{2R_g} = \dfrac{V_g^2}{2R_g}$

Devrenin girişindeki güç; $P_i = V_i.R_i$

$$V_i = \frac{V_g R_i}{Z_g Z_i} = \frac{V_g R_i}{R_i + jX_i + R_i - jX_i} = \frac{V_g}{2R_i} \cdot R_i = \frac{V_g}{2}$$

$$P_i = V_i I_i = \frac{V_g}{2}\frac{V_g}{2R_g} = \frac{V_g^2}{4R_g} = \frac{V_g^2}{4R_i} = \frac{P_g}{2}$$

Prob.2-8 Şek.P2-8 deki devrede $V = 270\cos(2\pi 10^3 t - 15°) mV$, $i = 5\cos(2\pi 10^3 t - 75°)$ mA ve C=33µF'dúr. R ve L' yi bulunuz. Direnç değerlerini renk kodları ile veriniz.



Şek.P2-8

Çöz.2-8:

$\varphi = \varphi_v - \varphi_i = -15 - (-75) = 60°$ akım gerilimden 60º geridedir. Bu, devrede indüktif reaktansın kapasitif reaktanstan daha büyük olduğunu göstermektedir. $\left(\omega L > \frac{1}{\omega L}\right)$

$$\varphi = \tan^{-1}\left(\frac{\omega L - \frac{1}{\omega C}}{R}\right) = 60° \Rightarrow \left(\frac{\omega L - \frac{1}{\omega C}}{R}\right) = \tan 60° = \sqrt{3}$$

$$\varphi = \sqrt{3} \Rightarrow \omega L - \frac{1}{\omega C} = \sqrt{3}R \qquad (1)$$

$$\frac{V_m}{I_m} = |Z| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} = \sqrt{R^2 + \left(\sqrt{3}R\right)^2} = \sqrt{R^2 + 3R^2} = \sqrt{4R^2} = 2R \qquad (2)$$

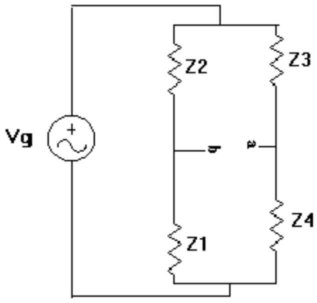
$$2R = \frac{V_m}{I_m} = \frac{270.10^{-3}}{5.10^{-3}} = 54\Omega$$

$R = \frac{54}{2} = 27\Omega$ R=Kı, Mo, Si, Al

$$(1) \Rightarrow \omega L = \sqrt{3}R + \frac{1}{\omega C} \Rightarrow L = \frac{\sqrt{3}R + \frac{1}{\omega C}}{\omega} = \frac{\sqrt{3}2,7 + \frac{1}{2\pi 10^3.33.10^{-6}}}{2\pi 10^3} = \frac{46,765 + 4,8229}{2\pi 10^3}$$

L= 8,21 mH

Prob.2-9



Şek.P2-9

a)Şek.P2-9 devrede ab uçlarından görülen Thevenin eşdeğer devresini bulunuz.

b)Aynı devrede Z_1, Z_2, Z_3 olarak R_1, R_2, R_3 dirençleri Z_4 olarak ta NTC kullanılmıştır. 15˚C ve 35˚C'de Vab geriliminin değerlerini bulunuz. R_1=Ka,Kı,Tu,Al - R_2=Tu,Kı,Sa,Kı,Al - R_3=Kı,Mo,Tu,Al- Z_4=NTC

NTC ' nin direncinin sıcaklıkla değişimi

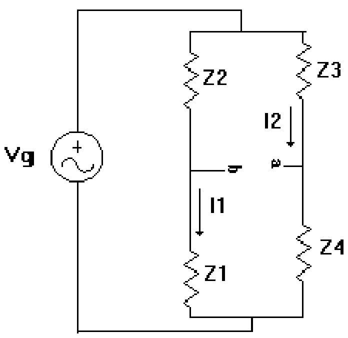
T(ºC)	NTC(KΩ)
15	15,69
25	10
35	6,536

Çöz.2-9

a) Şek.P2-9 da Vg kaynağını kısa devre edersek ab uçlarından görünen empedans

$$Z_{ab} = (Z_1 // Z_2) + (Z_3 // Z_4); Z_{ab} = \frac{Z_1 Z_2}{Z_1 + Z_2} + \frac{Z_3 Z_4}{Z_3 + Z_4}$$

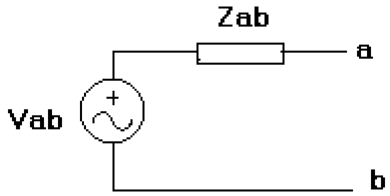
açık devre gerilimi Vab'yi bulalım



Şek.P2-9

$$I_1 = \frac{V_g}{Z_1 + Z_2} \quad , \quad I_2 = \frac{V_g}{Z_3 + Z_4}$$

$$V_{ab} = Z_1 I_1 - Z_4 I_2 = \frac{Z_1}{Z_1 + Z_2} V_g - \frac{Z_4}{Z_3 + Z_4} V_g = V_g \left| \frac{Z_1 Z_3 - Z_2 Z_4}{(Z_1 + Z_2)(Z_3 + Z_4)} \right|$$



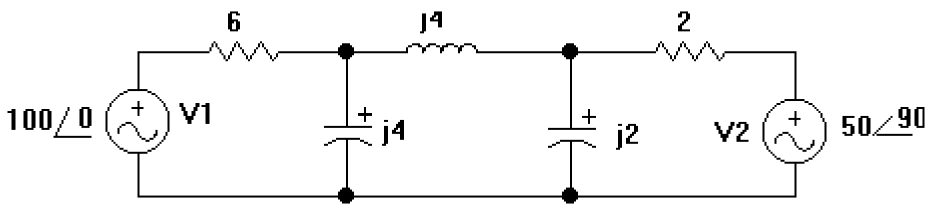
Şek.2-9.2 Thevenin eşdeğer devresi

b) $R_1 = 15K$, $R_2 = 32400\Omega = 32{,}4K$, $R_3 = 27K$

$T_1 = 15C°$ $\quad V_{ab15} = 10 \dfrac{(12.27 - 32{,}4.15{,}69)}{(12 + 27)(32{,}4 + +15{,}69)} = -0{,}97263V$

$T_2 = 35C°$ $\quad V_{ab35} = 10 \dfrac{(12.27 - 32{,}4.6{,}536)}{(12 + 27)(32{,}4 + 6{,}536)} = 10 \dfrac{112{,}2336}{1518{,}504} = 0{,}75395V$

Prob2-10 Şek.P2-10 deki devrede her bir gerilim kaynağının 1-2 uçlarında meydana getirdiği gerilimi bulunuz.



Şek.P2-10

Çöz.2-10

Düğüm gerilimleri yöntemiyle çözelim.

Yalnız V_1 varken ve yalnız V_2 varken düğüm gerilimleri denklemlerini yazalım.

$$\begin{vmatrix} \frac{1}{6}+\frac{1}{-j4}+\frac{1}{j4} & -\frac{1}{j4} \\ -\frac{1}{j4} & \frac{1}{j4}+\frac{1}{-j2}+\frac{1}{2} \end{vmatrix} \cdot \begin{vmatrix} V_{d1} \\ V_{d2} \end{vmatrix} = \begin{vmatrix} \frac{100}{6} \\ 0 \end{vmatrix},$$

Yalnız V_1 kaynağı varken devrenin Düğüm denklemleri

$$\begin{vmatrix} \frac{1}{6}+\frac{1}{-j4}+\frac{1}{j4} & -\frac{1}{j4} \\ -\frac{1}{j4} & \frac{1}{j4}+\frac{1}{-j2}+\frac{1}{2} \end{vmatrix} \cdot \begin{vmatrix} V_{d1} \\ V_{d2} \end{vmatrix}_2 = \begin{vmatrix} 0 \\ j25 \end{vmatrix}$$

Yalnız V_2 kaynağı varken devrenin Düğüm denklemleri

$$\begin{vmatrix} \frac{1}{6} & j0,25 \\ +j0,25 & 0,5+j0,25 \end{vmatrix} \cdot \begin{vmatrix} V_{d1} \\ V_{d2} \end{vmatrix} = \begin{vmatrix} \frac{100}{6} \\ 0 \end{vmatrix}, V_{11} = \frac{\begin{vmatrix} \frac{100}{6} & j0,25 \\ 0 & 0,5+j0,25 \end{vmatrix}}{\underbrace{\begin{vmatrix} \frac{1}{6} & j0,25 \\ j0,25 & 0,5+j0,25 \end{vmatrix}}_{17}},\ V_{21} = \frac{\begin{vmatrix} \frac{1}{6} & \frac{100}{6} \\ j0,25 & 0 \end{vmatrix}}{[A]}$$

$$V_{d1}-V_{d2} = (V_{12})_1 = \frac{\frac{100}{6}\cdot(0,5+j0,25)-\left(-\frac{100}{6}\cdot j0,25\right)}{\frac{1}{6}\cdot(0,5+j0,25)-(j0,25)(j0,25)}$$

$$= \frac{50+j25+j25j}{0,5+j0,25+6(0,25)^2} = \frac{50(1+j)}{0,875+j0,25}$$

$$(V_{12})_1 = \frac{50\sqrt{2}\angle 45°}{0,91\angle 15°,945} = 77,7029\angle 29°,0546$$

$$V_{d1}-V_{d2} = (V_{12})_2 = \frac{\begin{vmatrix} 0 & j0,25 \\ j25 & 0,5+j0,25 \end{vmatrix} - \begin{vmatrix} \frac{1}{6} & 0 \\ j25 & j25 \end{vmatrix}}{[A]}$$

$$= \frac{-(j25)(j0,25)-\frac{1}{6}(j25)}{[A]} = \frac{6\cdot 6,25-j25}{0,875+j0,25}$$

$$(V_{12})_2 = \frac{37,5-j25}{0,875+j0,25} = \frac{45,06939\angle -33°,69}{0,91\angle 15°,945} = 49,5268\angle -49°,6355 = 32,07593-j37,736$$

Prob.2-12 In a series R=5 ohms and L=0,06H the voltage across the inductance $V_L = 15Sin200t$ volts. Find the total voltage , the current , the angle which i lags V_T and the magnitude of the impedance.

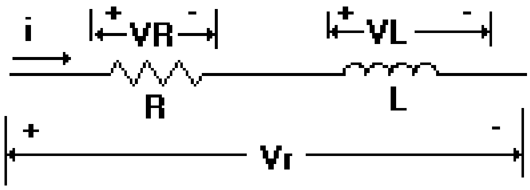


Figure P2-12

Solution 2-12

$$V_L = L\frac{di}{dt} = VmSinwt$$

$$\Rightarrow i = i_L \Rightarrow i = i_L = \frac{1}{L}\int V_L dt = \frac{1}{L}\int VmSinwt = \frac{Vm}{wL}(-Coswt)$$

$$i = \frac{Vm}{\omega L}Sin(\omega t - 90°) = I_m Sin(\omega t - 90°) = 1{,}25Sin(2\omega t - 90°)$$

$$i = \frac{Vm}{wL} = \frac{15}{200.0{,}06} = 1{,}25A$$

$$\begin{aligned} V_r &= V_R + V_L = R.L + V_L = R.\mathrm{Im}\,Sin(wt - 90°) + VmSinwt = \\ &= -R\,\mathrm{Im}\,Coswt + VmSinwt \end{aligned} \qquad (1)$$

Any number of sine and cosine terms of the same frequency can be combined into single sine with amplitude A and phasey ; thus we may write

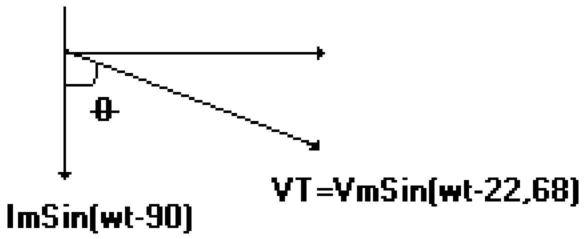
$$V_r = A(Sinwt + \varphi) = ASinwt.Cos\varphi + A.Coswt.Sin\varphi \qquad (2)$$

in (1) and (2) equale coefficients of Sinwt and then Coswt to obtain

$$ACos\varphi = Vm$$
$$ASin\varphi = -R\,\mathrm{Im}$$

$$\tan\varphi = \frac{-R.\mathrm{Im}}{Vm} = \frac{-5.1{,}25}{15} = 0{,}416 \quad \varphi = \tan^{-1}(-0{,}416) = -22{,}62°$$

$$A = \frac{Vm}{Cos\varphi} = \frac{15}{Cos(-22{,}62)} = 16{,}25V$$



$v_T = 16{,}25.Sin(200t - 22{,}62)$ V

The angle by which i lags V_T is $\theta = 90° - 22{,}62° = 67{,}38°$

$$|Z| = \sqrt{R^2 + (WL)^2} = \frac{V_T}{\text{Im}} = \frac{10{,}25}{1{,}25}\Omega = 8{,}2\Omega$$

Pro.2-14 In Fig.P2-14 .Obtain the Norton and Thevenin equivalent circuit with respect to terminals a and b for the network .

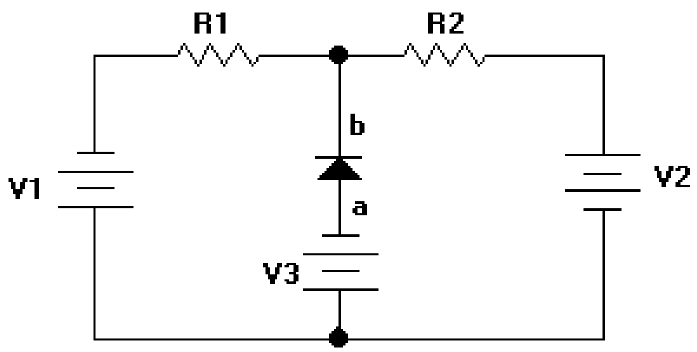


Fig.2-14

Solution 2-14

R_1 =Red,Red,Black,Gold

R_2 =Orange,Orange,Brown,Gold $V_1 = 60$ V, $V_2 = 80$ V , $V_3 = 20$ V

The current I_1 shown in the open circuit

$$(R_1 + R_2)I_1 + V_2 + V_1 = 0, \quad I_1 = \frac{-(V_2 + V_1)}{R_1 + R_2} = -\frac{(80 + 60)}{22 + 330}$$

The open curcit voltage is the drop the across ab

$$V_{ab} = -R_1 I_1 - V_1 + V_3 = -22\left(\frac{-140}{22 + 330}\right) - 60 + 20 = -31{,}25V$$

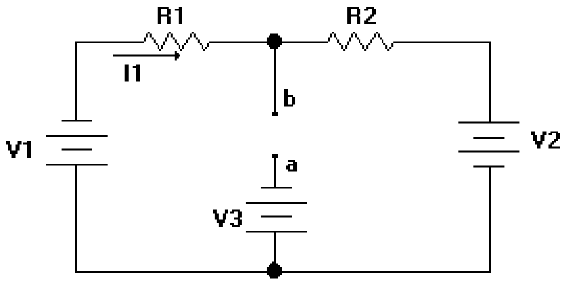


Fig.2-14.1

The equivalent impedance Zab of the circuit is calculated by setting the source equal to zero . Thus

$$R_{ab} = R_1 // R_2 = 22 // 330 = 20{,}625\Omega$$

Norton equivalent curcuit of is fig P2-14given below in fig 2.14.3 and Thevenin equvalent circuit is given in fig 2-14.4

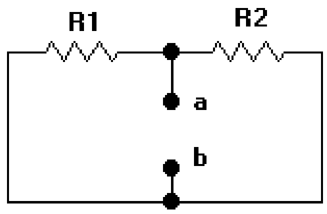


Fig.2-14.2

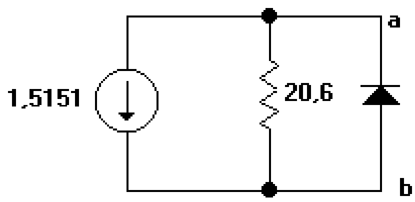


Fig.2-14.3

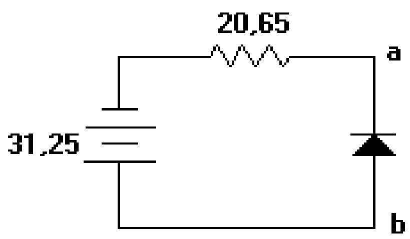
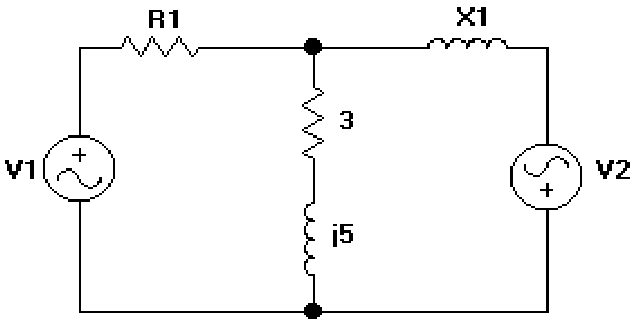


Fig.2-14.3

Prob.2-15 Apply the superposition theorem to the network shown in fig.2-15 and obtain the current in the (3+j5) ohm impedance



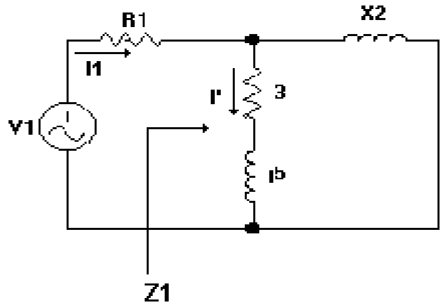
$R_1 = Yellow, Violet, Gold, Gold$
$X_2 = j5\Omega$
$V_1 = 10\angle 0° V$
$V_2 = 20\angle 90° V$

Fig.P2-15

Solution 2-15

Set $V_2 = 0$ and let V_1 be the only source present in the circuit

Then



$R_1 = 4.7\Omega$

Fig.2-15.1

$$Z_1 = 4.7 + \frac{(3+j5)j5}{3+j10} = 4.7 + \frac{(-25+j15)}{3+j10}$$

$$Z_2 = 4.7 + \frac{29.15\angle 150}{10.44\angle 73.3} = 4.7 + 0.833 + j2.5 \quad = 5.34 + j2.72 = 6\angle 27°$$

$$I_1 = \frac{V_1}{Z_1} = \frac{10\angle 0°}{6\angle 27°} = 1.67\angle -27° = 1.49 - j0.76 \text{ A}$$

The current in the 3+j5Ω branch due to V_1 alone is

$$I' = I_1 \frac{j5}{3+j10} = \frac{1.67\angle -27 * 5\angle 90°}{10.44\angle 73.3°} \quad = 0.8\angle -10.3 = 0.787 - j0.143 \text{ A}$$

Now set $V_1 = 0$ and let V_2 be the only source in the circuit . Then

$$Z_2 = j5 + 4.7\frac{3+j5}{7.7+j5} = j5 + 4.7\frac{5.83\angle 39}{9.18\angle 33} = 2.98\angle 26 + j5$$

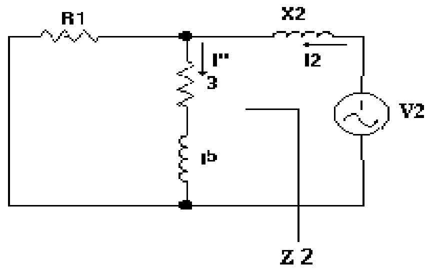


Fig.2-15.2

$$Z_2 = j5 + 2.68 + j1.21 = 2.68 + j6.31 = 6.86\angle 67°$$

$$Y_2 = 0.15\angle -67°$$

$$I_2 = V_2 Y_2 = (20\angle 90°).(0.15\angle -67°) = 3\angle 23° = 2.76 + j1.17 \text{ A}$$

The current in the 3+j5 Ω branch due to V_2 alone is

$$I'' = I_2\frac{4.7}{8.7+j5} = 3\angle 23°\frac{4.7}{8.7+j5}$$

$$= 1.405\angle -6.88° = 1.395 - j0.168 \text{ A}$$

The total current in the 3+j5 Ω branch is

$$I = I' + I'' = 0.8\angle -10.3° + 1.405\angle -6.88°$$

$$= 0.787 - j0.143 + 1.395 - j0.168 = 2.182 - j0.3115 = 2.204\angle -8.124° \text{ A}$$

Prob.2-16 The network of Fig P2-16 contains a single voltage source $200\angle 45°$ V causing a current Iy in the 5 ohm branch. Find Iy and then verify the reciprocity theorem for this circuıt.

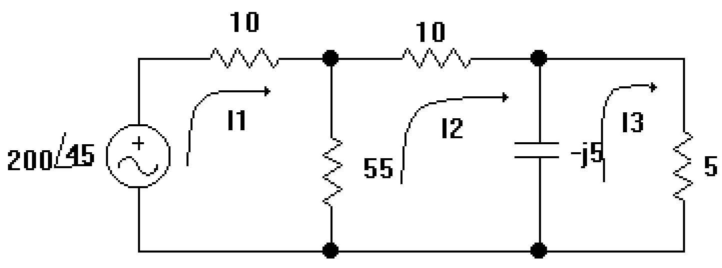


Fig.P2-16

Solution 2-16:

Mash current I_1 , I_2 and I_3 are shown in Fig.P2-16

$$\begin{vmatrix} 10+55 & -55 & 0 \\ -55 & 65-j5 & -(-j5) \\ 0 & -(-j5) & 5-j5 \end{vmatrix} \begin{vmatrix} I_1 \\ I_2 \\ I_3 \end{vmatrix} = \begin{vmatrix} 200\angle 45° \\ 0 \\ 0 \end{vmatrix}$$

The required current Iy is mesh current I_3 $(I_y = I_3)$

$$I_y = I_3 = \frac{\begin{vmatrix} 65 & -55 & 200\angle 45° \\ -55 & 65-j5 & 0 \\ 0 & j5 & 0 \end{vmatrix}}{\begin{vmatrix} 65 & -55 & 0 \\ -55 & 65-j5 & j5 \\ 0 & j5 & 5-j5 \end{vmatrix}} = \frac{200\angle 45 \begin{vmatrix} -55 & 65-j5 \\ 0 & j5 \end{vmatrix}}{65\begin{vmatrix} 65-j5 & j5 \\ j5 & 5-j5 \end{vmatrix} - (-55)\begin{vmatrix} -55 & 0 \\ j5 & 5-j5 \end{vmatrix}}$$

$$I_y = \frac{-j55*10^3\angle 45}{65*325-15125-65*j350+j15125} = \frac{-55*10^3\angle 315}{9702.609\angle -57,8} = 5,6686\angle 366,8$$

$$= 5,6686\angle 6,8°$$

$$= 5,628 + j0,67A$$

Now when the pozitions of the source and the response are interchanged as shown Fig.2-16.1 in using the primary loop currents we have

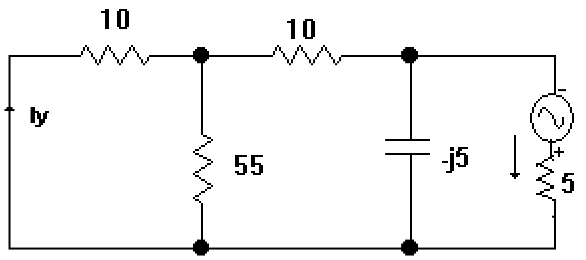


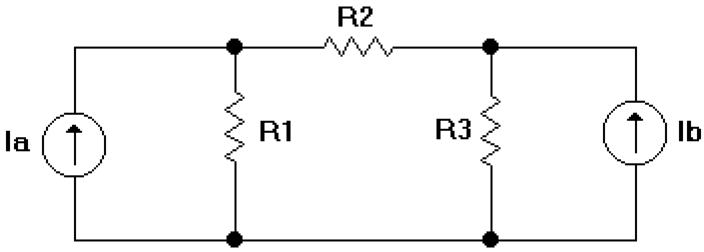
Fig.2-16.1

$$\begin{vmatrix} 65 & -55 & 0 \\ -55 & 65-j5 & j5 \\ 0 & j5 & 5-j5 \end{vmatrix} \begin{vmatrix} I_1 \\ I_2 \\ I_3 \end{vmatrix} = \begin{vmatrix} 0 \\ 0 \\ 200\angle 45 \end{vmatrix}$$

$$I_y = I_1 = \frac{\begin{vmatrix} 0 & -55 & 0 \\ 0 & 65-j5 & j5 \\ 200\angle 45° & j5 & 5-j5 \end{vmatrix}}{\Delta_2} = \frac{200\angle 45 \begin{vmatrix} -55 & 0 \\ 65-j5 & j5 \end{vmatrix}}{\Delta_2} = \frac{200\angle 45°(-55)(j5)}{9702{,}609\angle -51{,}8°} = 5{,}686\angle 6{,}8°\,A$$

Iy is the same in both circuits and the reciprocity theorem is thus verified.

Prob.2-18 In the network of Fig .P2-18 determine the components of branch voltage V_{12} due to each current source Ia and Ib. $I_a = 6A$ $I_b = 8A$



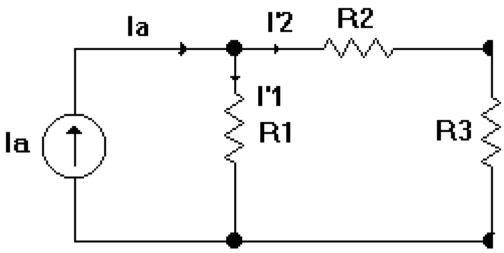
$R_1 = Yellow, Violet, Gold, Gold$
$R_2 = Brown, Green, Black, Gold$
$R_3 = Blue, Grey, Black, Silver$

Fig.P2-18

Solution 2-18:

$R_1 = 4.7\Omega$, $R_2 = 15\Omega$, $R_3 = 68\Omega$

We can apply the superposition theorem to the network of fig.P2-18



Let the source $I_a = 6A$ act on the network and set the source $I_b = 0$

Fig.2-18.1

$$I_a R_{eq} = R_1 I_1^{'} \Rightarrow I_1^{'} = I_a \frac{R_{eq}}{R_1} = I_a \frac{R_1(R_2 + R_3)}{R_1(R_1 + R_2 + R_3)}$$

$$I_1^{'} = I_a \frac{R_2 + R_3}{R_1 + R_2 + R_3} = 6\frac{15 + 68}{4.7 + 15 + 68} = 5.678A$$

$$V_{12}^{'} = R_1 I_1^{'} = 4.7 * 5.678 = 26.69V$$

Now set $I_1 = 0$ and let I_b 8A act on the network

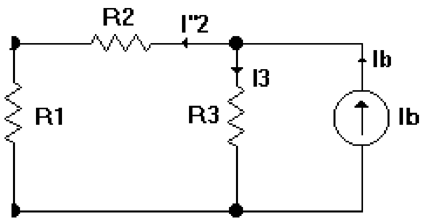


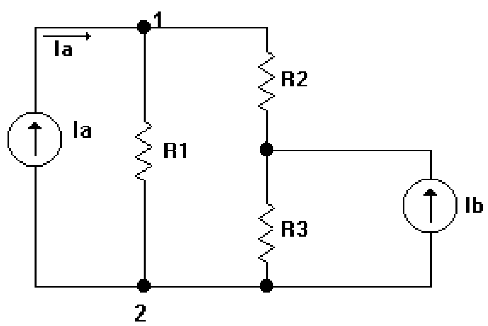
Fig.2-18.2

Then $I_2^{''} = I_b \frac{R_3}{R_1 + R_2 + R_3} = 8\frac{68}{4,7 + 15 + 68} = 6,2A$

$$V_{12}^{''} = R_1 I_2^{''} = 4.7 * 6.2 = 29.15V$$

$$V_{12} = V_{12}^{'} + V_{12}^{''} = 26.69 + 29.15 = 55.84V$$

Prob.2-19 Yalnız Ia kaynağından dolayı meydana gelen V_{12} gerilimi 25V 'dur. Her iki kaynak birlikte devrede iken V_{12}=55V 'dur. Toplamsallık teoreminden faydalanarak I_a ve I_b 'yi bulunuz.

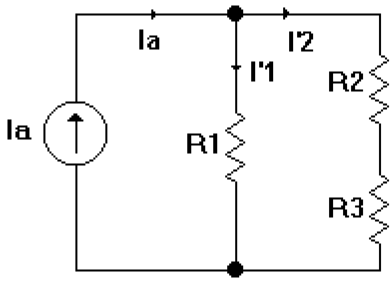


$R_1 = Gr, Kı, Al, Al$
$R_2 = Ka, Gr, Si, Al$
$R_3 = Sa, Mo, Si, Gü$

Şek.P2-19

Çöz.2-19

$I_a \neq 0$, $I_b = 0$ için devrenin yeni şekli



$R_1 = 8{,}2\Omega$
$R_2 = 18\Omega$
$R_3 = 47\Omega$

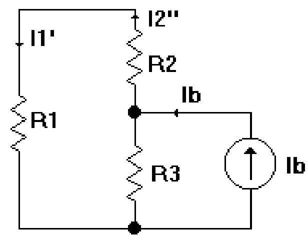
Şek. 2-19.1

$V_{12} = V_{12}^{'} + V_{12}^{''} \quad \Rightarrow V_{12}^{'} = V_{12} - V_{12}^{'} = 55 - 25 = 30V$

$I_{ak} \rightarrow V_{12}^{'} = 25V$, $I_b \rightarrow V_{12}^{'} = 30V$, $V_{12}^{'} = R_1 I_1^{'} = I_{C1} R_{eş}^{'}$

$$I_a = \frac{V_{12}^{'}}{R_{eş}^{'}} = \frac{25}{R_1 // (R_2 + R_3)} = \frac{25}{8{,}2 // (18 + 47)} = \frac{25}{7{,}28} = 3{,}433A$$

$I_a = 0$, $I_b \neq 0$ koşulu için devrenin yeni şekli



Şek.2-19.2

$$I^{''}{}_2 = \frac{V_{12}^{''}}{R_1} = \frac{R_3}{R_1 + R_2 + R_3} I_b$$

$$I_b = V_{12}^{'} \frac{R_1 + R_2 + R_3}{R_1 R_3} = 30 \frac{8{,}2 + 18 + 47 +}{8{,}2.47} = 5{,}698A$$

Kaynaklar

1. C. K. Alexander, M. N. O. Sadiku, “ Fundamentals of Electric Circuits” 3rd New York, Mc Graw-Hill, 2000
2. H. Dinçer “Elektronik Mühendisliğine Giriş, ***Genel Bilgiler, çözülmüş ve Ek problemler***” KOÜ Yayınları No 14, Haziran 1999 Kocaeli