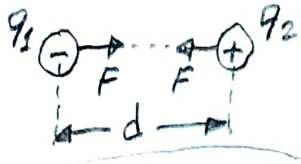
Devre Teorisi



Küreler in ikiside pozitif veya ikiside negatif ise birbirlerini iterler. Biri pozitif diğeri negatif ise birbirlerini çekerler.

$$F = k \frac{q_1 \cdot q_2}{d^2}$$

İtme veya çekme kuvveti

F: Newton (N) olarak elektriksel itme veya çekme kuvveti

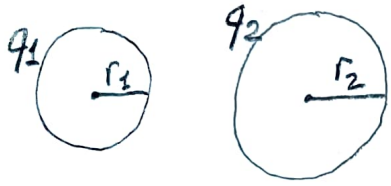
d: Metre (m) olarak iki yük arasındaki uzaklık

q_1 ve q_2 : Coulomb (C) olarak noktasal yüklerin değeri

k: iki yük arasındaki ortamla ilgili bir katsayı

$k = 9 \times 10^9 \ N.m^2/C^2$

Hasan Temurtaş



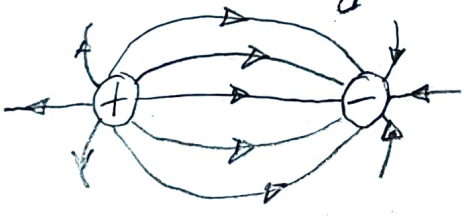
Küreler birbirlerine dokundurulursa üzerlerindeki yeni yükler $\bar{q}_1$ ve $\bar{q}_2$ olur.

$$q_T = q_1 + q_2 = \bar{q}_1 + \bar{q}_2$$

$$\bar{q}_1 = q_T \frac{r_1}{r_1 + r_2} \qquad \bar{q}_2 = q_T \frac{r_2}{r_1 + r_2}$$

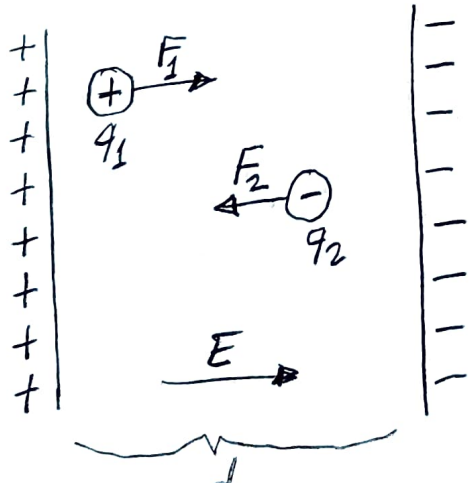
İki küre tel ile birbirlerine bağlansaydı üzerlerindeki yükler dengeye gelene kadar telden elektrik akımı geçerdi.

Kürenin içinde elektrik alan sıfırdır. Yüzeyinde ve dışında ise $E = k \cdot \frac{q}{d^2}$ olur.



Kürenin yükü + ise elektrik alan yönü dışarı, − ise içeri doğrudur.

Voltaj ise yönlü bir büyüklük olmayıp formülü $V = E.d = k.\frac{q}{d}$



$$V = E.d \Rightarrow E = V/d$$

$$F = qE = q\,V/d$$

Farklı yüklü iki levha arasındaki elektriksel alan şiddeti sabittir.

1 C'luk yükte 6.24×10^{18} tane elektron bulunur.

$1e = -1.602 \times 10^{-19}$ C

Bir elektronun yükü

Uygulamalarda birimlerin hem BÜT hem de alt katları kullanılabilir.

$10^{12} \rightarrow$ Tera (T)	$10^{-3} \rightarrow$ Mili (m)
$10^{9} \rightarrow$ Giga (G)	$10^{-6} \rightarrow$ Mikro (μ)
$10^{6} \rightarrow$ Mega (M)	$10^{-9} \rightarrow$ Nano (n)
$10^{3} \rightarrow$ Kilo (K)	$10^{-12} \rightarrow$ Piko (p)

Direnç : 200 KΩ
Akım : 25 μA

$$V = RI = 200\,K\Omega \times 25\,\mu A$$
$$= 200 \times 10^{3}\,\Omega \times 25 \times 10^{-6}\,A = 5V$$

Bir iletkenin herhangi bir kesitinden birim zamanda geçen yük miktarına akım şiddeti denir.

$$Amper = \frac{Coulomb}{Second}$$

1 sn'de 1C'luk yük geçmesi 1A'lik akım manasına gelir.

$$i(t) = \frac{dq(t)}{dt}, \quad q(t) = \int_{-\infty}^{t} i(\tau)\,d\tau = q(t_0) + \int_{t_0}^{t} i(\tau)\,d\tau$$

İş Birimi : Joule (J)
Güç Birimi : Watt (W)

$$Volt = \frac{Joule}{Coulomb}$$

1C'luk yük 1J'lük iş yaparsa 1V'luk voltaj manasına gelir.

$$Watt = Volt \times Amper = \frac{Joule}{Coulomb} \times \frac{Coulomb}{Second} = \frac{Joule}{Second}$$

$$p(t) = \frac{dw(t)}{dt} = \frac{dw(t)}{dq(t)}\,\frac{dq(t)}{dt} = v(t) \cdot i(t)$$

(p: güç, w: iş)

$$w(t) = \int_{-\infty}^{t} p(\tau)\,d\tau = w(t_0) + \int_{t_0}^{t} p(\tau)\,d\tau$$

Kalori (Cal) : Atmosfer basıncında 1 gram suyun sıcaklığını 1 Derece artırmak için gerekli olan enerji miktarıdır.

$$1\,Cal = 4.1868\,J \quad \text{veya} \quad 1\,J = 0.238846\,Cal$$

$$1\,kWh = 1000\,Wh = 1000 \times 3600\,J = 3.6\,MJ$$
$$\approx 864\,kCal$$

Ör Bir lambadan 1 dakika boyunca 2A'lik akım geçmektedir. Lamba 15 kJ'lik enerjiyi ısı ve ışık olarak dışarıya veriyor. Lamba üzerindeki voltajı bulunuz.

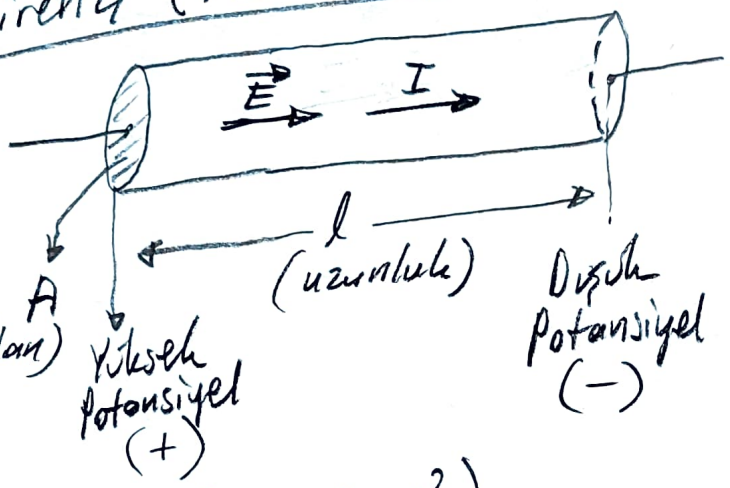
$$q = i.t = 2A \times 60Sec = 120\,C$$

$$v = W/q = \frac{15\,kJ}{120\,C} = \frac{1500}{120}\,J/C = 125\,V$$

Ör 25W'lik bir lamba 8 saatte kaç kJ'lük enerji tüketir.

$$w = p.t = 25W \times 8h = 200\,Wh = 200 \times 3600\,J = 720\,kJ$$

Direnç (Resistance)



Elektronların hareket yönü tanımlanan akım yönünün zıttıdır.

$$I = -I_e$$

ρ : Özdirenç

σ : İletkenlik

$A = \pi r^2$ (Birimi m^2)

r : Telin Yarıçapı (Birimi m)

$$R = \rho \cdot \frac{l}{A} = \frac{l}{\sigma . A}$$

R: Direnç (Ohm = Ω), ρ: Ω.m, σ: S/m

$G = 1/R$ (G: iletkenlik, Simens, S, mho, ℧)

Direnç: Elektrik akımına karşı zorluk göstererek akımı sınırlayan ve gerilimi bölen devre elemanıdır.

Ör Uzunluğu 1 km, yarıçapı 1 mm olan bakır telin direncini bulunuz.

$$\sigma_{Cu} = 5.8 \times 10^7\,S/m$$

$$R_{Cu} = \frac{l}{\sigma_{Cu} . A} = \frac{l}{\sigma_{Cu} . \pi r^2} = \frac{10^3}{5.8 \times 10^7 \times \pi \times 10^{-6}}$$

$$\approx 5.49\,\Omega$$

Direncin Sıcaklıkla Değişimi

Madde	α (1/°C)
Bakır	0.0039
Altın	0.0034
Gümüş	0.0038
Silikon	-0.0075
Karbon	-0.0005

$$R_2 = R_1\left(1 + \alpha(t_2 - t_1)\right)$$

α : Direnç Sıcaklık Katsayısı

Cu, Au, Ag elemetleri ısındıkça dirençleri artar.

Si, C elemetleri ise ısındıkça dirençleri azalır.

Ör Bir telin 20°C'deki direnci 5Ω, 60°C'deki direnci 6Ω ise α = ?

$t_1 = 20°C \quad t_2 = 60°C$

$R_1 = 5\Omega \quad R_2 = 6\Omega$

$R_2 = R_1(1 + \alpha(t_2 - t_1))$

$6 = 5(1 + 40\alpha)$

$\alpha = (\frac{6}{5} - 1)/40 = 1/200$

$= 0.005\ 1/°C$

Ör Bir lambanın direnci 24°C'de 250Ω'dur. Lamba akkor haline (yani 1524°C) geldiğindeki direncini bulunuz. Telin sıcaklık katsayısı 0.004 1/°C olsun.

$t_1 = 24°C \quad t_2 = 1524°C$

$R_1 = 250\Omega \quad R_2 = ?$

$\alpha = 0.004\ 1/°C$

$R_2 = R_1(1 + \alpha(t_2 - t_1)) = 250\Omega\,(1 + 0.004 \times 1500)$

$= 1750\ \Omega$

Ör Direnci 20Ω olan bir ısıtıcı 220V'luk bir gerilime bağlanmıştır. Isıtıcıdan geçen akımı, ısıtıcının gücünü, ısıtıcının 5 dakikada vereceği ısı enerjisini J ve Cal cinsinden bulunuz.

$I = \frac{V}{R} = \frac{220V}{20\Omega} = 11A$

$P = VI = 220V \times 11A = 2420W = 2.42kW$

$W = P.t = 2.42kW \times 5 \times 60Sec = 726\ kJ$

1J ≈ 0.24 Cal olursak

$W = 726 \times 0.24\ kCal$

$= 174.24\ kCal$

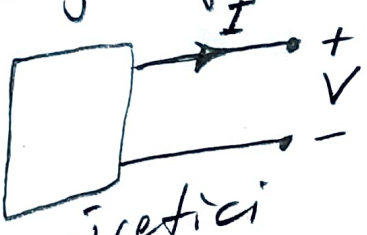
Elektrik Devresi

1 - Kaynak (üreteç)
Voltaj Kaynağı, Akım Kaynağı

2 - İletim Hattı (Tel)

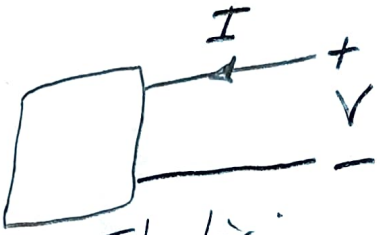
3 - Yük (Tüketeç)
Direnç, Kapasitör, İndiktör
(R) (C) (L)

Bir elektrik devresinde üretilen enerji ile tüketilen enerji birbirine eşittir. Yani, devredeki toplam enerji sıfırdır.



Üretici

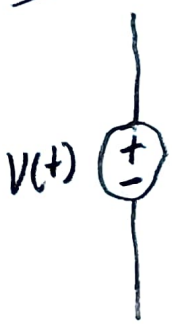
$P_{üret} = V.I$



Tüketici

$P_{tüket} = V.I$

Kaynaklar



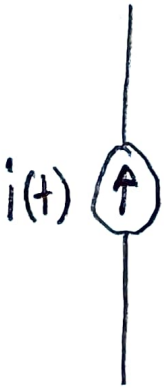
Bağımsız Voltaj Kaynağı

Voltaj Kontrollü Voltaj Kaynağı

$V_1(t) = k\,V_2(t)$

Akım Kontrollü Voltaj Kaynağı

$V_1(t) = k\,i_2(t)$



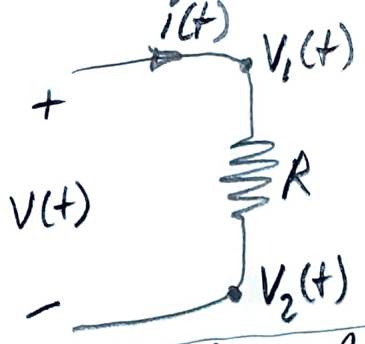
Bağımsız Akım Kaynağı

Voltaj Kontrollü Akım Kaynağı

$i_1(t) = k\,V_2(t)$

Akım Kontrollü Akım Kaynağı

$i_1(t) = k\,i_2(t)$



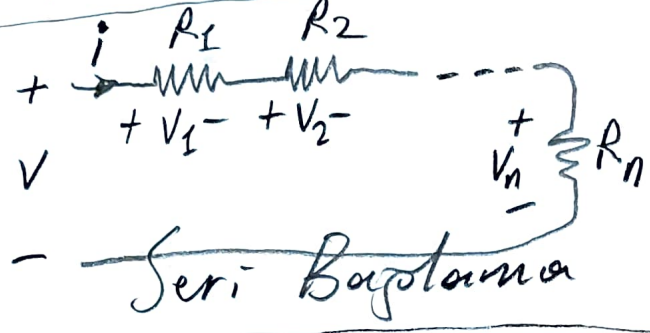
$V(t) = V_1(t) - V_2(t) > 0$

$V(t) = R\, i(t)$

$i(t) = G\, V(t)$

$p(t) = V(t) \cdot i(t)$

$= R\, i^2(t) = \dfrac{V^2(t)}{R}$



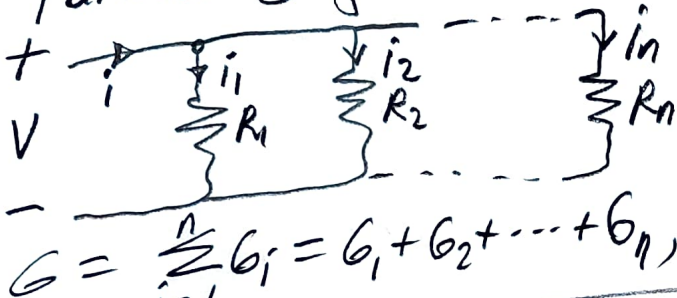
Seri Bağlama

$i = i_1 = i_2 = \cdots = i_n$

$V = \sum_{i=1}^{n} V_i = V_1 + V_2 + \cdots + V_n$

$R_T = \sum_{i=1}^{n} R_i = R_1 + R_2 + \cdots + R_n$

Paralel Bağlama



$V = V_1 = V_2 = \cdots = V_n$

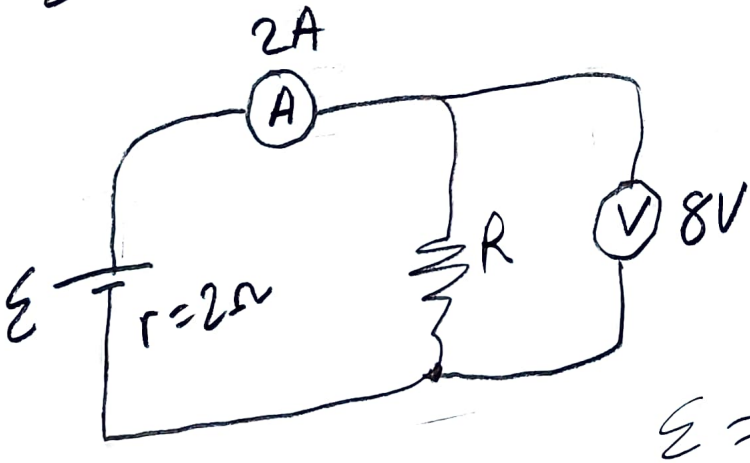
$i = \sum_{i=1}^{n} i_i = i_1 + i_2 + \cdots + i_n$

$\dfrac{1}{R_T} = \sum_{i=1}^{n} \dfrac{1}{R_i} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \cdots + \dfrac{1}{R_n}$

$G = \sum_{i=1}^{n} G_i = G_1 + G_2 + \cdots + G_n$,

Elektromotor Kuvvet (EMK)

Elektrik devresinin açık olduğu ve devreden elektrik akımı çekilmediği durumlardaki devredeki iki kutbu arasındaki potansiyel farkına denir. Elektromotor Kuvvet, EMK harfleri ile tanımlanır. E harfi ile sembolize edilir. Birimi Volt'tur.



Ampermetre 2A, Voltmetre 8V okuyor. Devredeki EMK'ini bulunuz.

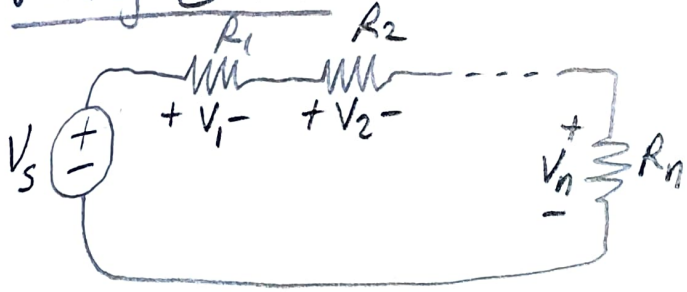
$R = \dfrac{V}{I} = \dfrac{8V}{2A} = 4\Omega$

$\mathcal{E} = (R + r)\, I$

$= (4\Omega + 2\Omega) \times 2A$

$= 6\Omega \times 2A = 12V$

Voltaj Bölücü

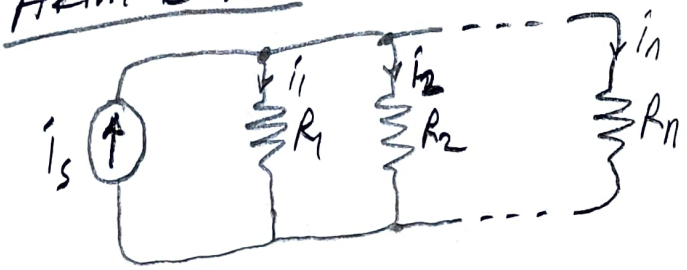


$$R_T = R_1 + R_2 + \cdots + R_n$$

$$\frac{V_s}{R_T} = \frac{V_1}{R_1} = \frac{V_2}{R_2} = \cdots = \frac{V_n}{R_n}$$

$$V_x = \frac{R_x}{R_T} V_s$$

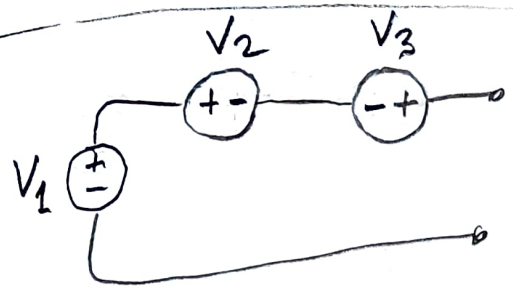
Akım Bölücü



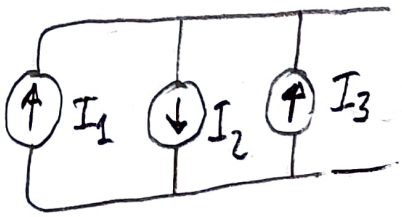
$$G_T = G_1 + G_2 + \cdots + G_N$$

$$\frac{i_s}{G_T} = \frac{i_1}{G_1} = \frac{i_2}{G_2} = \cdots = \frac{i_n}{G_n}$$

$$i_x = \frac{G_x}{G_T} i_s$$



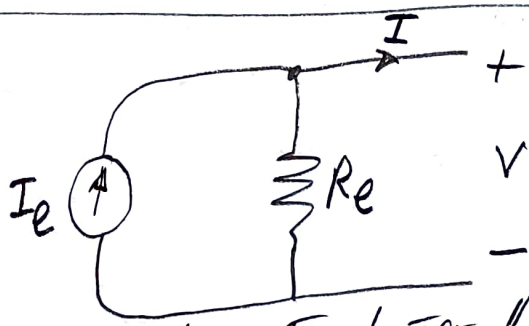
$\equiv$ $V_1 - V_2 + V_3$ — Voltaj Birleştirme



$\equiv$ $I_1 - I_2 + I_3$ — Akım Birleştirme

İdeal voltaj kaynağının iç direnci 0 kabul edilir
İdeal akım kaynağının iç direnci ∞ kabul edilir.

Thevenin Eşdeğer Devre

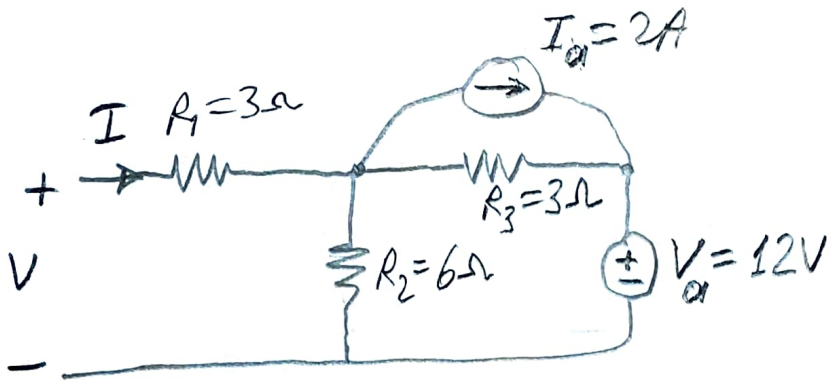


Norton Eşdeğer Devre

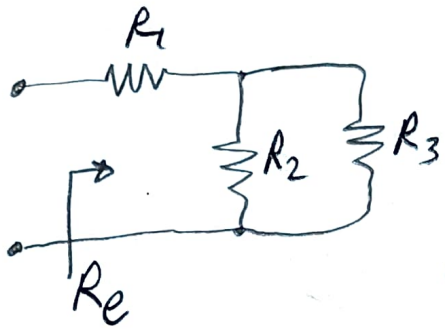
$$V = V_e - R_e I = R_e (I_e - I)$$

$V_e = R_e I_e$ $\Rightarrow V_{oc}$ yap

$I_e = \frac{V_e}{R_e}$ $\Rightarrow I_{sc}$ yap



Yanda verilen devrenin Thevenin ve Norton Eşdeğerini bulunuz.

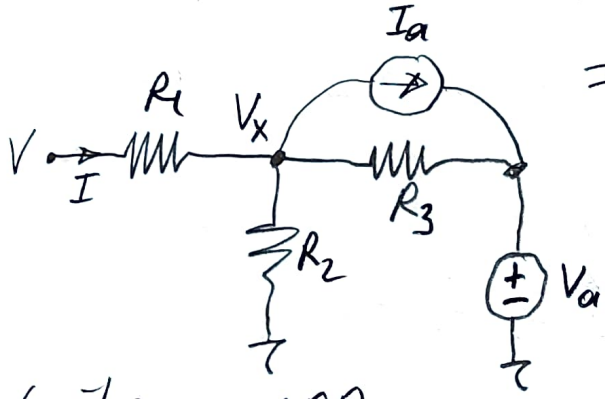


Voltaj kaynağı açık devre, akım kaynağı kapalı devre yapılır.

$$R_e = R_1 + R_2 // R_3 = R_1 + \frac{R_2 R_3}{R_2 + R_3}$$

$$= 3\Omega + \frac{6\Omega \times 3\Omega}{6\Omega + 3\Omega} = 3\Omega + 2\Omega$$

$$= 5\Omega$$



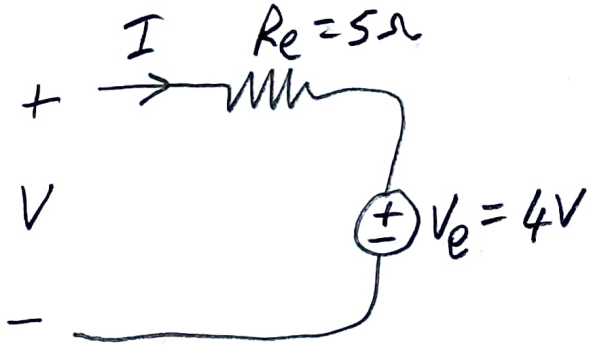
$$I = \frac{V - V_x}{R_1} = \frac{V_x}{R_2} + \frac{V_x - V_a}{R_3} + I_a$$

$$\frac{V - V_x}{3} = \frac{V_x}{6} + \frac{V_x - 12}{3} + 2$$

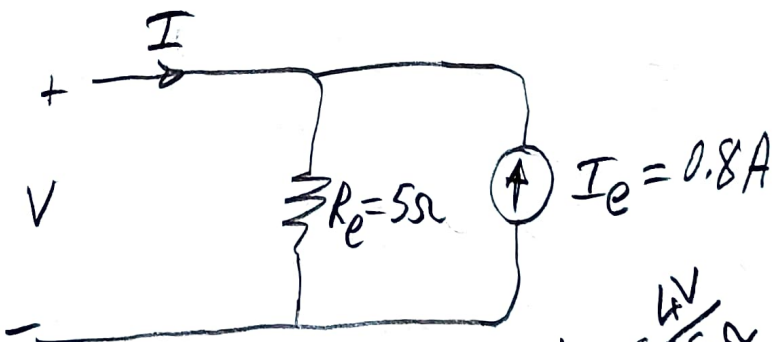
6 ile çarp

$$2V - 2V_x = V_x + 2V_x - 24 + 12 \Rightarrow V_x = \frac{2V + 12}{5}$$

$$I = \frac{V - V_x}{R_1} = \frac{V - \frac{2V+12}{5}}{3} = \frac{V - 4}{5} \quad \begin{matrix} \rightarrow V_e \\ \rightarrow R_e \end{matrix}$$



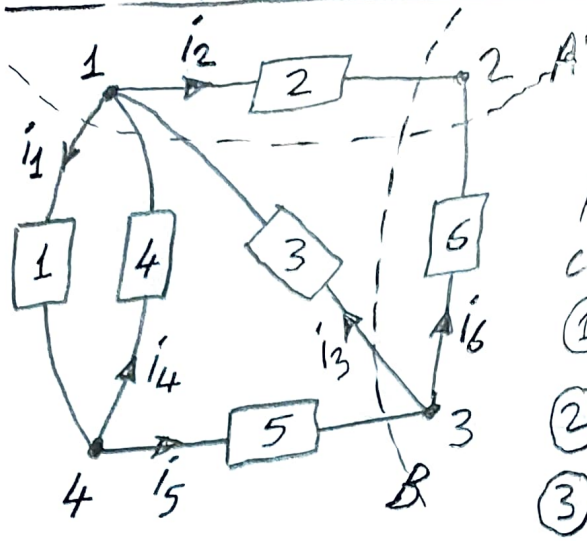
Thevenin Eşdeğer Devresi



Norton Eşdeğer Devresi

$$I_e = \frac{V_e}{R_e} = \frac{4V}{5\Omega} = 0.8A$$

Kirchhoff'un Akım Yasası (KCL) - Nokta Analizi



Çıkan akım pozitif, giren akım negatif alınır.
Her nokta için akımların cebirsel toplamı sıfırdır.

① $i_1 + i_2 - i_3 - i_4 = 0$

② $-i_2 - i_6 = 0 \Rightarrow i_2 + i_6 = 0$

③ $i_3 - i_5 + i_6 = 0$

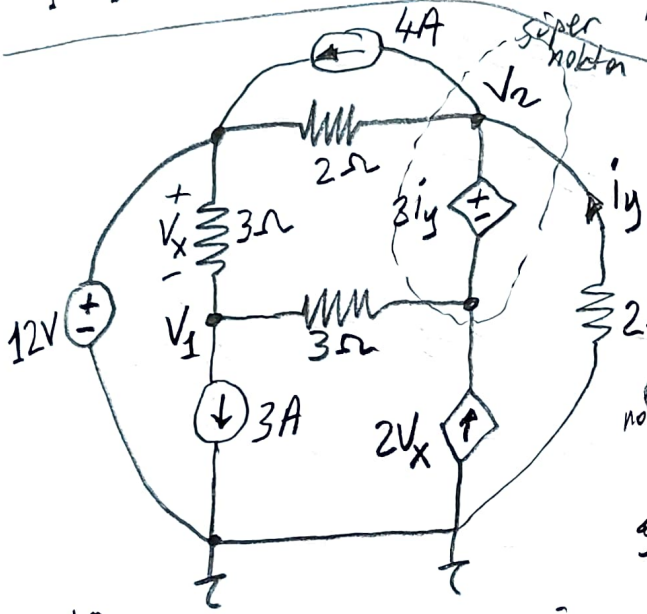
④ $-i_1 + i_4 + i_5 = 0 \Rightarrow i_1 - i_4 - i_5 = 0$

(A) 1. ve 2. denklem birleşince

$i_1 - i_3 - i_4 - i_6 = 0$

(B) 2. ve 3. denklem birleşince

$i_2 - i_3 + i_5 = 0$ eksi ile çarpılmış.



$V_x = ?$ $i_y = ?$ Nokta Analizi yöntemi

6 noktadan sadece 2'si alınır.

$V_1 = 12 - V_x$, $V_2 = -2i_y$

1 nokta: $3 - \frac{V_x}{3} + \frac{V_1 - (V_2 - 3i_y)}{3} = 0$

$9 - V_x + V_1 - V_2 + 3i_y = 0$

$9 - V_x + 12 - V_x + 2i_y + 3i_y = 0$

$2V_x - 5i_y = 21$ 1. denklem

2 nokta: $4 + \frac{V_2 - 12}{2} - i_y - 2V_x + \frac{V_2 - 3i_y - V_1}{3} = 0$

$4 + \frac{-2i_y - 12}{2} - i_y - 2V_x + \frac{-2i_y - 3i_y - 12 + V_x}{3} = 0$

$4 - i_y - 6 - i_y - 2V_x - \frac{5}{3}i_y - 4 + \frac{V_x}{3} = 0 \Rightarrow 5V_x + 11i_y = -18$ 2. denklem

1. denklemden $i_y = \frac{2V_x - 21}{5}$ çekilir. 2. denklemde yerine konur.

$5V_x + 11\,\frac{2V_x - 21}{5} = -18$

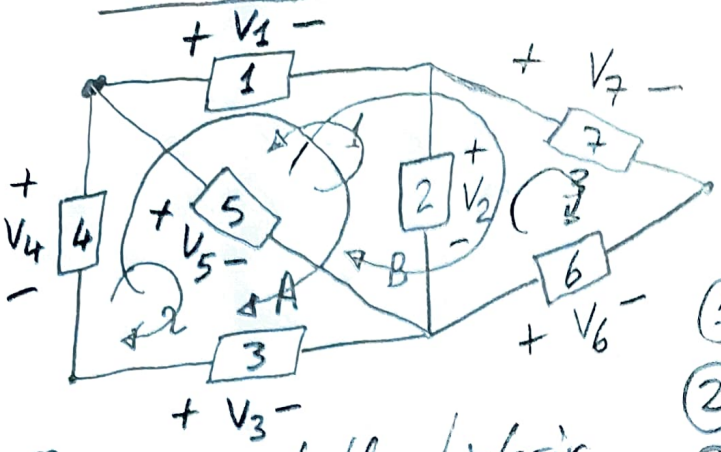
$25V_x + 22V_x - 231 = -90$

$47V_x = 141 \Rightarrow V_x = 3V$

$i_y = \frac{2V_x - 21}{5} = \frac{2 \times 3 - 21}{5}$

$= -3A$

Kirchhoff'un Gerilim Yasası (KVL) - Mesh Analiz



Bir göz içinde belirli bir yönde alınan tüm gerilimlerin toplamı sıfırdır.

(1) $V_1 + V_2 - V_5 = 0$

(2) $V_3 + V_4 - V_5 = 0$

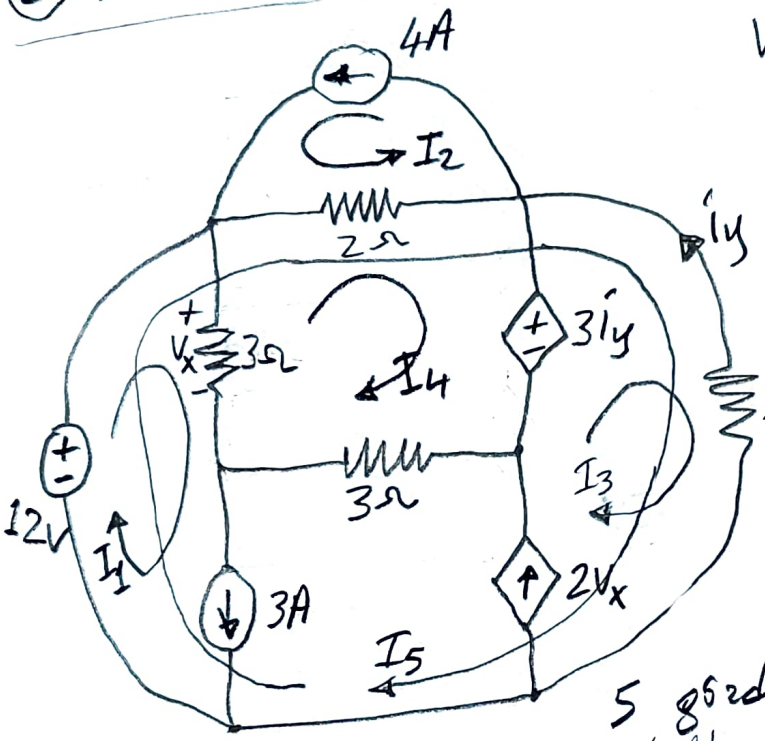
(3) $V_2 + V_6 - V_7 = 0$

(A) 1. ve 2. denklem birleşir

$-V_1 - V_2 + V_3 + V_4 = 0$

(B) 1. ve 3. denklem birleşir. $-V_1 + V_5 + V_6 - V_7 = 0$

$V_x = ?$, $i_y = ?$ Mesh Analiz yöntemi



$I_1 = 3A$, $I_2 = 4A$

$I_3 = 2V_x$

$I_3 + I_5 = -i_y$

$\hookrightarrow I_5 = -2V_x - i_y$

$I_1 - I_4 = V_x/3$

$\hookrightarrow I_4 = 3 - V_x/3$

5 gözden sadece 2'si alınır. (Akım kaynağı olmayanlar)

$12 - 2(I_2 + I_4 + I_5) + 2i_y = 0$

$12 - 2(4 + 3 - V_x/3 - 2V_x - i_y) + 2i_y = 0$

$7V_x + 6i_y = 3$ 1. denklem

$V_x - 2(I_2 + I_4 + I_5) - 3i_y - 3I_4 = 0$

$V_x - 2(4 + 3 - \frac{V_x}{3} - 2V_x - i_y) - 3i_y - 3(3 - V_x/3) = 0$

$V_x - 14 + \frac{2V_x}{3} + 4V_x + 2i_y - 3i_y - 9 + V_x = 0$

$20V_x - 3i_y = 69$ 2. denklem

1. denklemde i_y çekilirse

$i_y = \frac{3 - 7V_x}{6}$

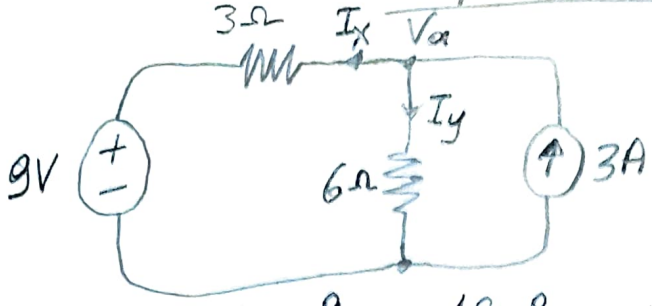
2. denklemde yerine koy

$20V_x - 3\frac{3 - 7V_x}{6} = 69$

$V_x = 3V$

$i_y = \frac{3 - 7 \times 3}{6} = -3A$

Süper Pozisyon



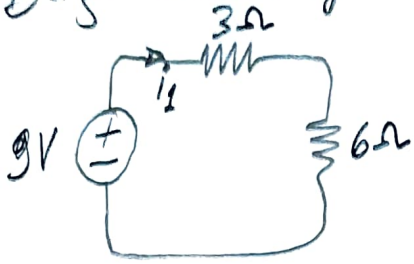
$$\frac{V_a-9}{3}+\frac{V_a}{6}-3=0$$

$$2V_a-18+V_a-18=0$$

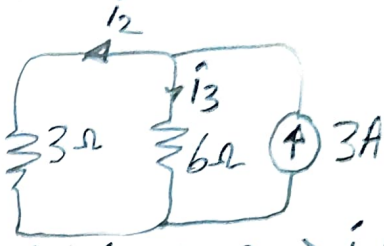
$$3V_a-36=0 \Rightarrow V_a=12V$$

$$I_x=\frac{V_a-9}{3}=\frac{12-9}{3}=1A \qquad I_y=\frac{V_a}{6}=\frac{12}{6}=2A$$

Bağımsız kaynaklar ayrı ayrı düşünülürse



$$i_1=\frac{9V}{3\Omega+6\Omega}=\frac{9V}{9\Omega}=1A$$



$$i_2+i_3-3=0 \Rightarrow i_2+i_3=3$$

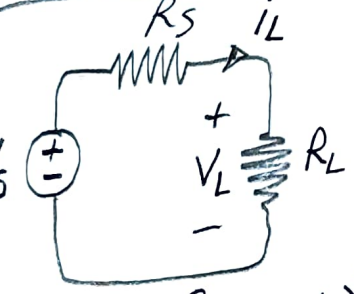
$$3i_2=6i_3 \Rightarrow i_2-2i_3=0$$

$$i_2=2A,\ i_3=1A$$

$$I_x=i_2-i_1=2A-1A=1A$$

$$I_y=i_1+i_3=1A+1A=2A$$

Maksimum Güç Aktarımı



$$i_L=\frac{V_S}{R_S+R_L} \qquad P_L=R_L i_L^2=\frac{R_L V_S^2}{(R_S+R_L)^2}$$

$\frac{dP_L}{dR_L}=0$ olunca maksimum güç aktarımı olur.

$$\frac{dP_L}{dR_L}=\frac{V_S^2(R_S+R_L)^2-R_L V_S^2\cdot 2(R_S+R_L)}{(R_S+R_L)^4}=\frac{V_S^2(R_L+R_S)-2R_L V_S^2}{(R_S+R_L)^3}$$

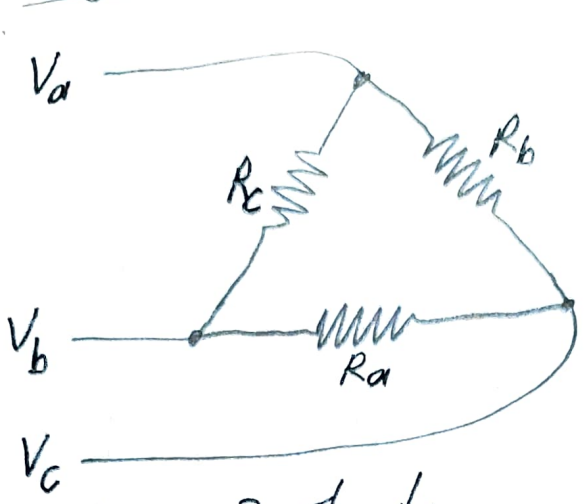
$$=\frac{(R_S-R_L)V_S^2}{(R_S+R_L)^3}=0 \Longrightarrow R_S=R_L$$ alınınca maksimum güç aktarımı olur.

$$P_L=R_L i_L^2 \qquad R_T=R_S+R_L=2R_L$$

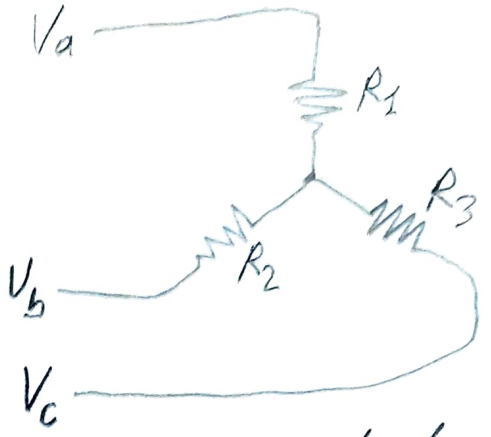
$$P_T=R_T i_L^2=2R_L i_L^2=2P_L$$

$$P_L=P_T/2$$

Üçgen-Yıldız Bağlantı Dönüşümleri



Üçgen Bağlantı



Yıldız Bağlantı

Δ → Y

$$R_\Delta = R_a + R_b + R_c$$

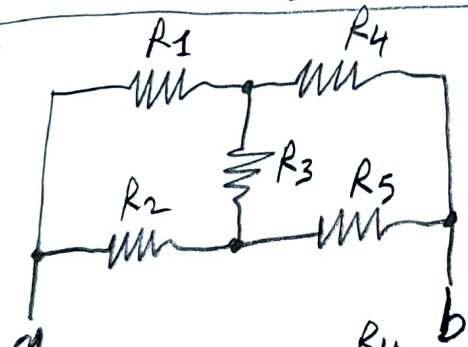
$$R_1 = \frac{R_b R_c}{R_\Delta}, \quad R_2 = \frac{R_a R_c}{R_\Delta}, \quad R_3 = \frac{R_a R_b}{R_\Delta}$$

Y → Δ

$$R_Y = R_1R_2 + R_1R_3 + R_2R_3$$

$$R_a = \frac{R_Y}{R_1}, \quad R_b = \frac{R_Y}{R_2}, \quad R_c = \frac{R_Y}{R_3}$$

6c

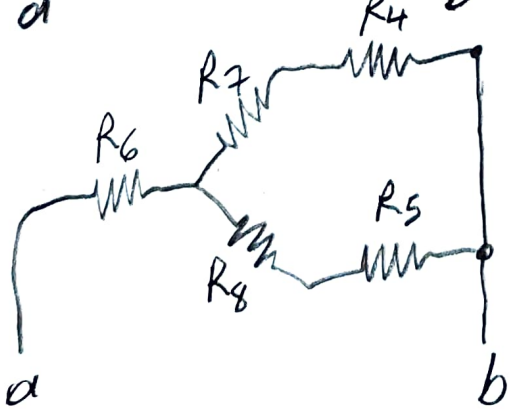


$R_1 = 36\Omega$, $R_2 = 60\Omega$, $R_3 = 48\Omega$

$R_4 = 8\Omega$, $R_5 = 22\Omega$

$R_{ab} = ?$

$R_\Delta = R_1 + R_2 + R_3 = 36\Omega + 60\Omega + 48\Omega = 144\Omega$



$$R_6 = \frac{R_1R_2}{R_\Delta} = \frac{36\Omega \times 60\Omega}{144\Omega} = 15\Omega$$

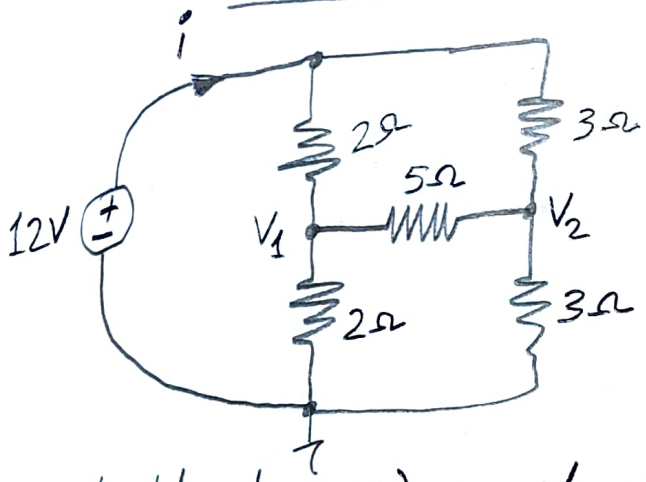
$$R_7 = \frac{R_1R_3}{R_\Delta} = \frac{36\Omega \times 48\Omega}{144\Omega} = 12\Omega$$

$$R_8 = \frac{R_2R_3}{R_\Delta} = \frac{60\Omega \times 48\Omega}{144\Omega} = 20\Omega$$

$$R_{ab} = R_6 + (R_4+R_7) /\!/ (R_5+R_8) = 15\Omega + 21\Omega /\!/ 42\Omega$$

$$= 15\Omega + 14\Omega = 29\Omega$$

Simetrik Devreler



$$\frac{V_1-V_2}{5}+\frac{V_1}{2}+\frac{V_1-12}{2}=0$$

$6V_1-V_2=30$ 1.denklem

$$\frac{V_2-V_1}{5}+\frac{V_2}{3}+\frac{V_2-12}{3}=0$$

$-3V_1+13V_2=60$ 2.denklem

1.denklemden V_2'yi çek

$V_2=6V_1-30$

2.denklemde yerine koy

$-3V_1+13\times(6V_1-30)=60$

$V_1=V_2=6V$

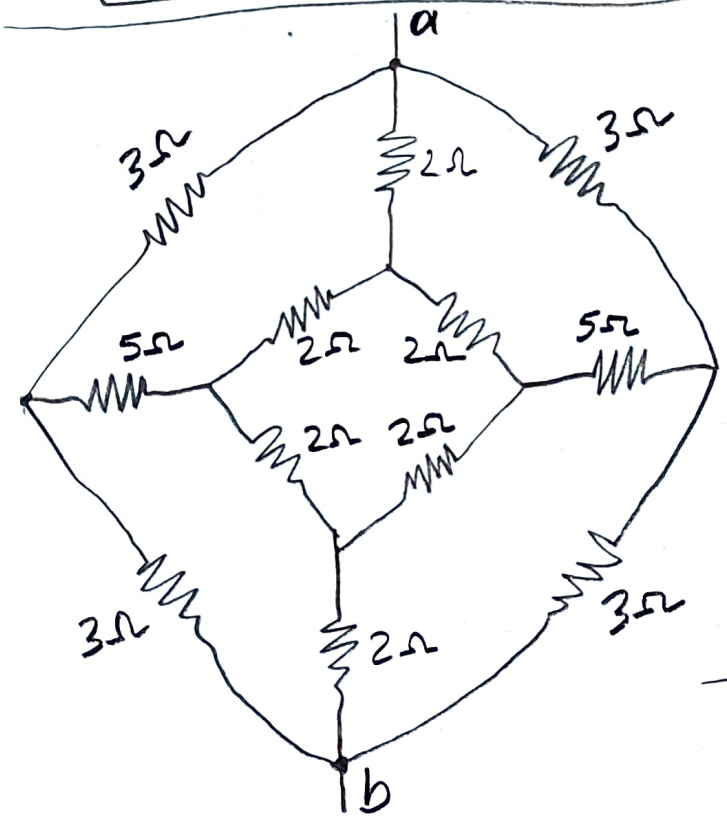
5Ω üzerinden akım geçmiyor

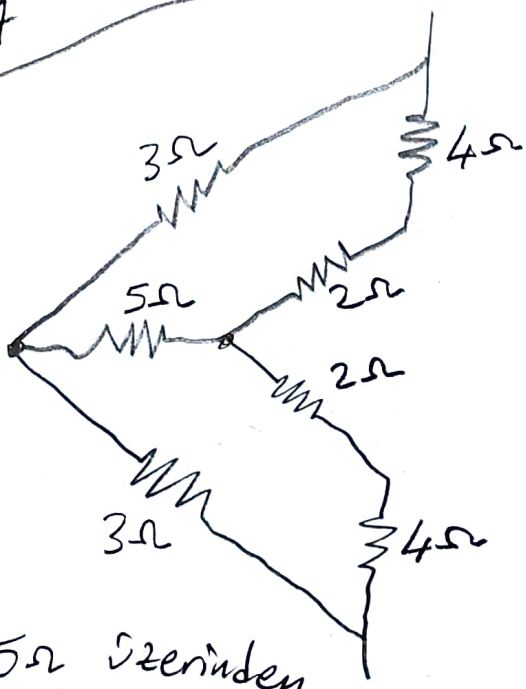
Simetrik devre olduğundan

$i_1=\frac{6V}{2\Omega}=3A$

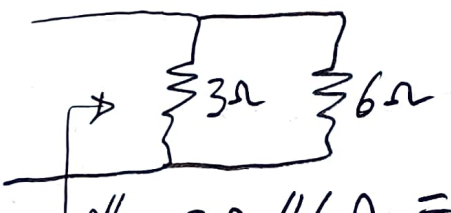
$i_2=\frac{6V}{3\Omega}=2A$

$i=i_1+i_2=3A+2A=5A$





5Ω üzerinden akım geçmez

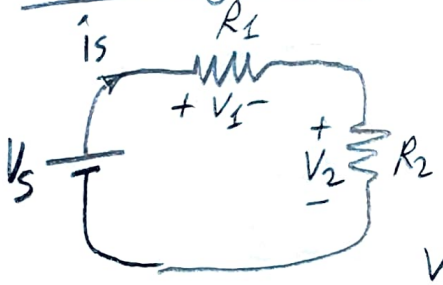


$R''=3\Omega//6\Omega=2\Omega$

$R'=2R''=4\Omega$

$R_T=R'/2=2\Omega$

Seri Bağlama



$R_1 = 2k$, $R_2 = 3k$, $V_s = 10V$

$R_T = R_1 + R_2 = 2k + 3k = 5k$

$i_s = V_s / R_T = \frac{10V}{5k} = 2mA$

$V_1 = R_1 i_s = 2k \times 2mA = 4V$

$V_2 = R_2 i_s = 3k \times 2mA = 6V$

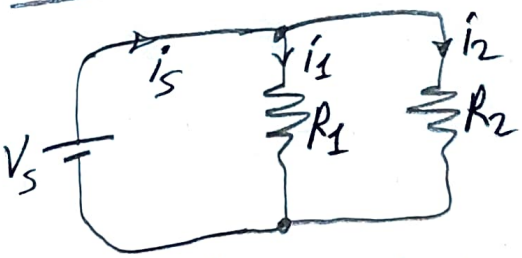
$P_1 = V_1 i_s = 4V \times 2mA = 8mW$

$P_2 = V_2 i_s = 6V \times 2mA = 12mW$

$P_{tük} = P_1 + P_2 = 8mW + 12mW = 20mW$

$P_{üret} = V_s i_s = 10V \times 2mA = 20mW$

Paralel Bağlama



$R_1 = 3k$, $R_2 = 6k$, $V_s = 12V$

$i_1 = V_s / R_1 = \frac{12V}{3k} = 4mA$

$i_2 = V_s / R_2 = \frac{12V}{6k} = 2mA$

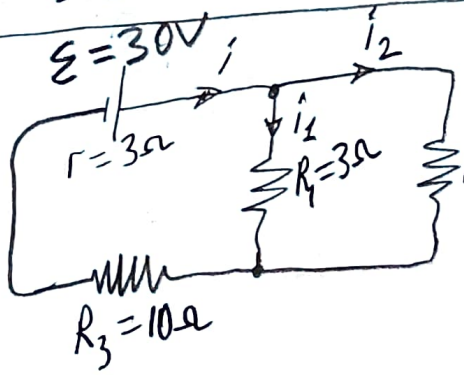
$i_s = i_1 + i_2 = 4mA + 2mA = 6mA$

$P_1 = V_s i_1 = 12V \times 4mA = 48mW$

$P_2 = V_s i_2 = 12V \times 2mA = 24mW$

$P_{tük} = P_1 + P_2 = 48mW + 24mW = 72mW$

$P_{üret} = V_s i_s = 12V \times 6mA = 72mW$



üretecin uçları arasındaki potansiyel farkı $E = ?$

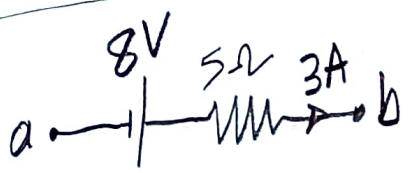
$R_T = r + R_1 // R_2 + R_3$

$= 3\Omega + 3\Omega // 6\Omega + 10\Omega$

$= 3\Omega + 2\Omega + 10\Omega = 15\Omega$

$i = \mathcal{E} / R_T = \frac{30V}{15\Omega} = 2A$

$V = \mathcal{E} - r.i = 30V - 3\Omega \times 2A = 30V - 6V = 24V$

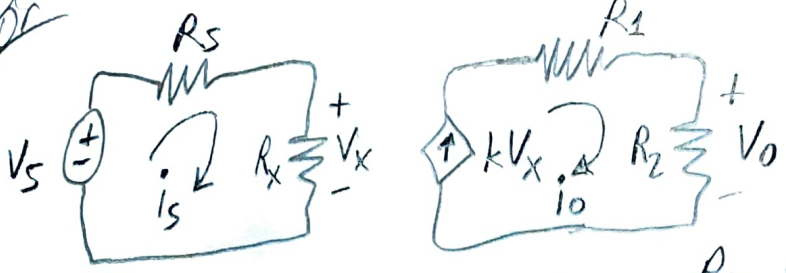


$V_a + 8V - 5\Omega \times 3A = V_b$

$V_{ab} = V_a - V_b = -8V + 5\Omega \times 3A$

$= -8V + 15V = 7V$

Örnek: $\frac{V_o}{V_s}$ kazancını bulunuz



$$i_s = \frac{V_s}{R_s+R_x} \Rightarrow V_x = R_x i_s = \frac{R_x}{R_s+R_x} V_s$$

$$i_o = kV_x \Rightarrow V_o = R_2 i_o = kR_2 V_x = k\frac{R_2R_x}{R_s+R_x} V_s \Rightarrow \text{kazanç } \frac{V_o}{V_s} = \frac{R_2R_x}{R_s+R_x}$$

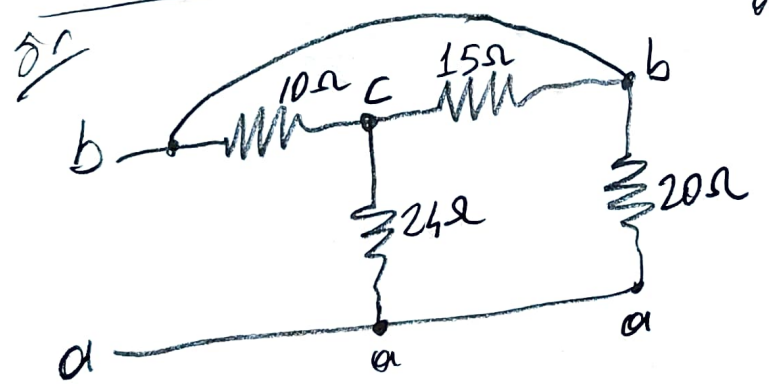
Örnek: $\frac{V_o}{V_s}$ kazancını bulunuz

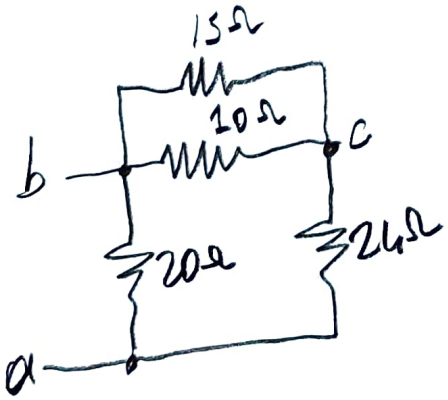
$$i_s = \frac{V_s}{R_s+R_x}$$

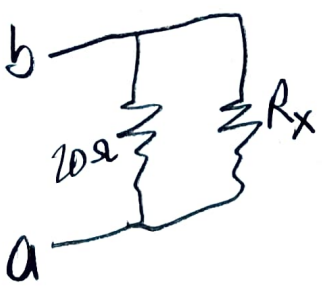
$$i_o = \frac{ki_s}{R_1+R_2} = \frac{kV_s}{(R_1+R_2)(R_s+R_x)}$$

$$V_o = R_2 i_o = \frac{kR_2V_s}{(R_1+R_2)(R_2+R_s)} \Rightarrow \frac{V_o}{V_s} = \text{kazanç } \frac{kR_2}{(R_1+R_2)(R_2+R_s)}$$

Örnek: ab uçları arasındaki eşdeğer direnci (R_e) bulunuz.







$$R_x = 10\Omega // 15\Omega + 24\Omega$$

$$= \frac{10\Omega \times 15\Omega}{10\Omega+15\Omega} + 24\Omega$$

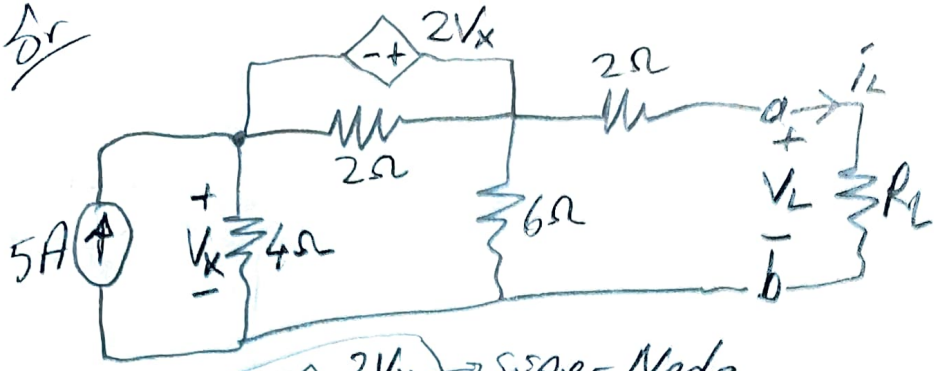
$$= 6\Omega + 24\Omega = 30\Omega$$

$$R_e = 20\Omega // R_x$$

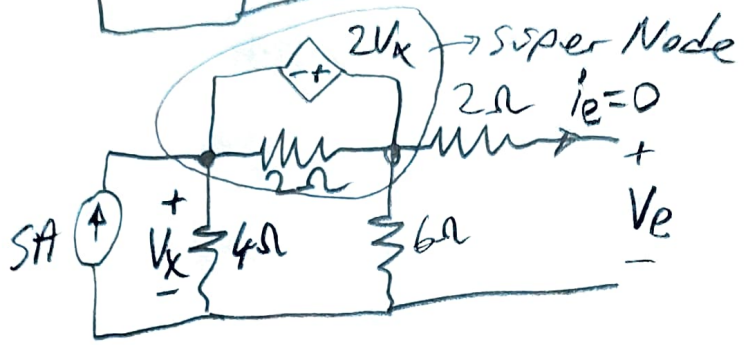
$$= 20\Omega // 30\Omega$$

$$= \frac{20\Omega \times 30\Omega}{50\Omega} = 12\Omega$$

Or



Thevenin Eşdeğer Devresini bulup $R_L = 4\Omega$ için $V_L = ?$



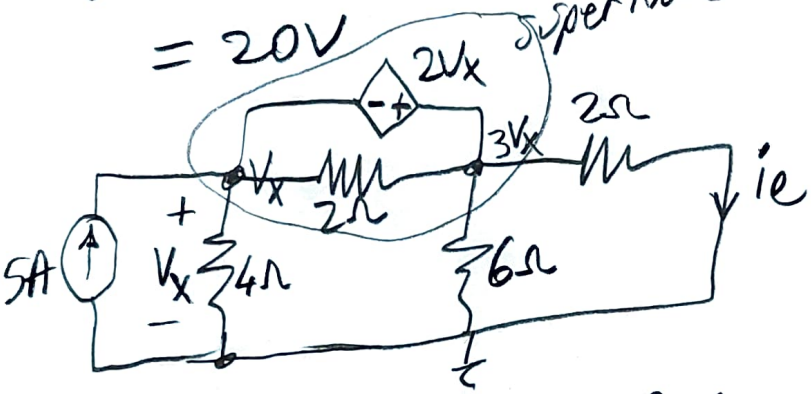
$$-5 + \frac{V_x}{4} + \frac{V_x + 2V_x}{6} = 0$$

(3) (2)

$$\frac{9V_x}{12} = 5 \Rightarrow V_x = \frac{20}{3}\,V$$

$$V_e = V_x + 2V_x = 3V_x$$

$$= 20V$$



$$-5 + \frac{V_x}{4} + \frac{3V_x}{6} + \frac{3V_x}{2} = 0$$

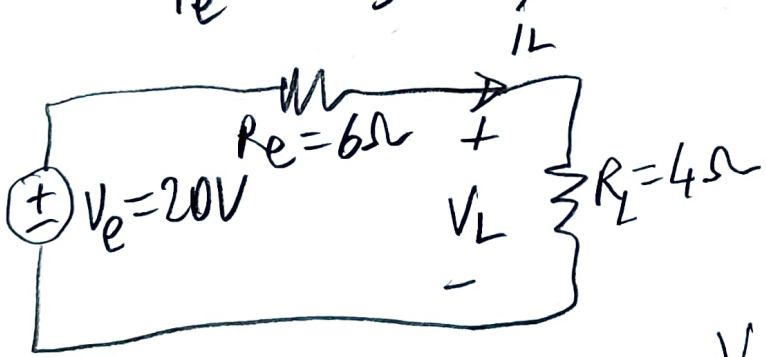
(3) (2) (6)

$$\frac{(3+6+18)V_x}{12} = 5$$

$$V_x = \frac{12 \times 5}{27}\,V = \frac{20}{9}\,V$$

$$i_e = \frac{3V_x}{2} = \frac{3}{2}\,\frac{20}{9}\,A = \frac{10}{3}\,A$$

$$R_e = \frac{V_e}{i_e} = \frac{20V}{10/3\,A} = 6\Omega$$

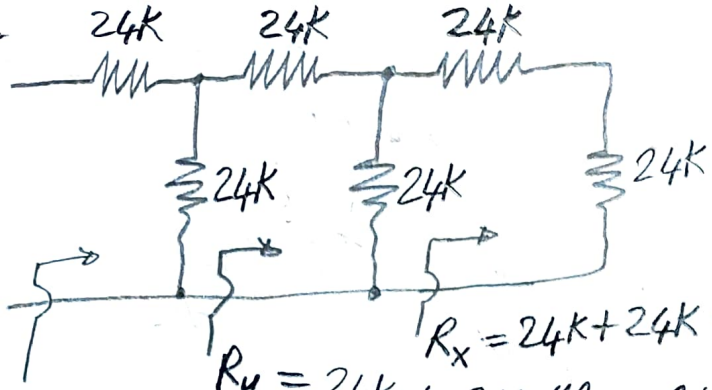


$$i_L = \frac{V_e}{R_e + R_L}$$

$$= \frac{20V}{6\Omega + 4\Omega} = \frac{20V}{10\Omega} = 2A$$

$$V_L = R_L i_L = 4\Omega \times 2A$$

$$= 8V$$



$R_x = 24K + 24K = 48K$

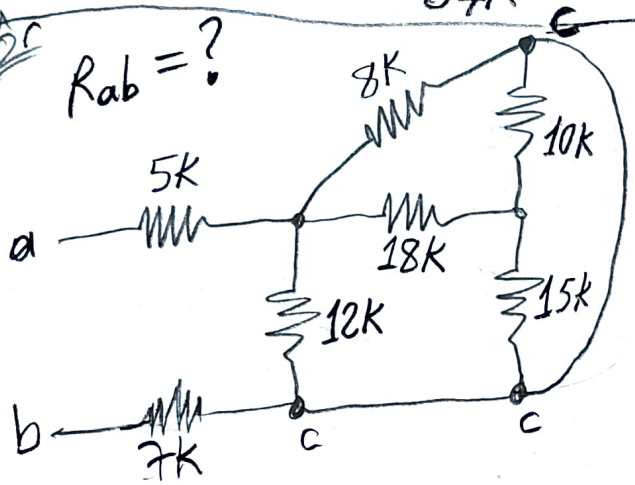
$R_y = 24K + 24K // R_x = 24K + \frac{24K \times 48K}{72K} = 24K + 16K = 40K$

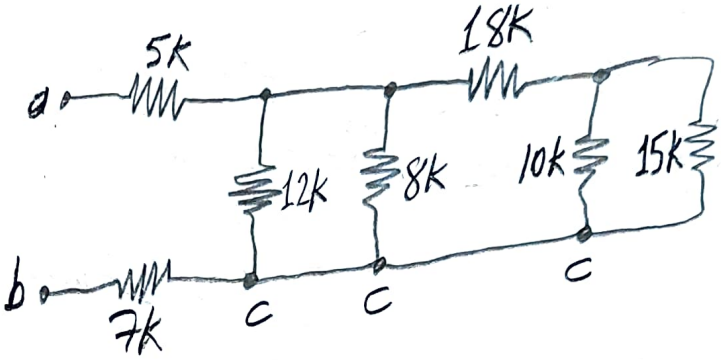
$R_z = 24K + 24K // R_y$

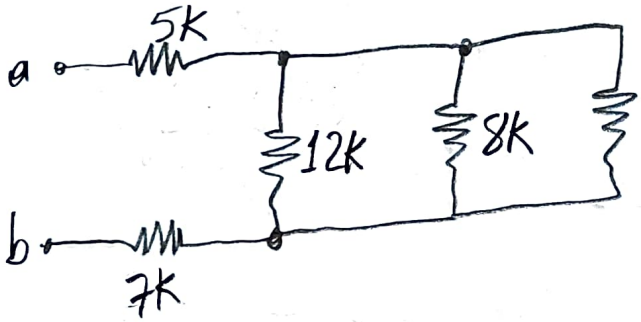
$= 24K + \frac{24K \times 40K}{64K} = 24K + 15K = 39K$

Dr

$R_{ab} = ?$



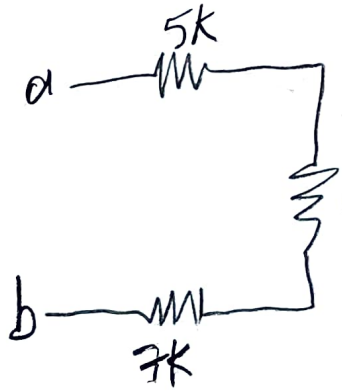




$R_x = 18K + 10K // 15K$

$= 18K + \frac{10K \times 15K}{25K}$

$= 18K + 6K = 24K$



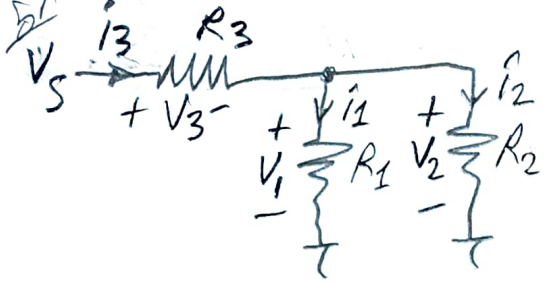
$R_y = 12K // 8K // 24K$

$\frac{1}{R_y} = \frac{1}{12} + \frac{1}{8} + \frac{1}{24} = \frac{2+3+1}{24} = 1/4$

(2) (3) (1)

$R_y = 4K$

$R_{ab} = 5K + R_y + 7K = 5K + 4K + 7K = 16K\Omega$



$R_1 = 3k$, $R_2 = 6k$, $R_3 = 3k$

$V_S = 15V$

Her bir direnç üzerindeki voltajları, akımları ve güçleri bulunuz. Toplam üretilen ve tüketilen güçleri bulunuz.

$R_T = R_3 + R_1 // R_2$

$= 3k + 3k // 6k = 3k + 2k = 5k$

$$i_3 = \frac{V_S}{R_T} = \frac{15V}{5k} = 3mA$$

$$V_1 = V_2 = V_S - R_3 i_3 = 15V - 3k \times 3mA = 15V - 9V = 6V$$

$$i_1 = V_1 / R_1 = \frac{6V}{3k} = 2mA, \quad i_2 = V_2 / R_2 = \frac{6V}{6k} = 1mA$$

$$V_3 = R_3 i_3 = 3k \times 3mA = 9V$$

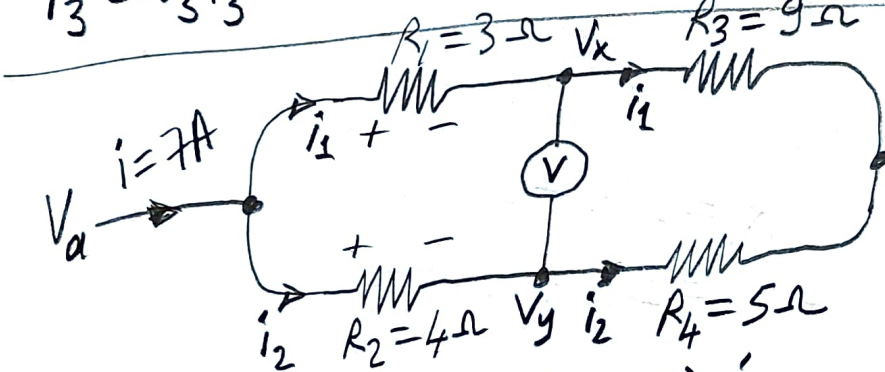
$$P_1 = V_1 i_1 = 6V \times 2mA = 12mW$$

$$P_2 = V_2 i_2 = 6V \times 1mA = 6mW$$

$$P_3 = V_3 i_3 = 9V \times 3mA = 27mW$$

$$P_{tük} = P_1 + P_2 + P_3 = 12mW + 6mW + 27mW = 45mW$$

$$P_{üret} = V_S i_3 = 15V \times 3mA = 45mW$$



Voltmetrenin gösterdiği voltajı bulunuz.

$$V_{ab} = (R_1 + R_3) i_1 = (R_2 + R_4) i_2$$

$$(3+9) i_1 = (4+5) i_2 \Rightarrow 12 i_1 = 9 i_2$$

$$i_2 = \frac{4}{3} i_1$$

$$i = i_1 + i_2 = 7A$$

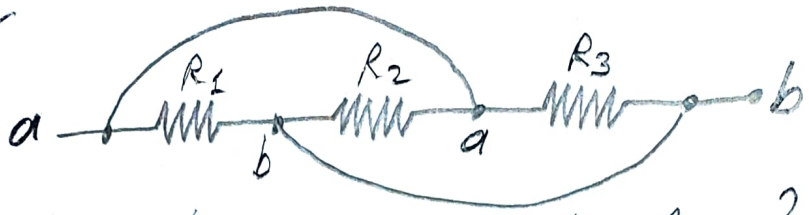
$$i_1 + \frac{4}{3} i_1 = 7 \Rightarrow i_1 = 3A$$

$$i_2 = \frac{4}{3} i_1 = 4A$$

$$V = V_x - V_y = R_2 i_2 - R_1 i_1 = 4\Omega \times 4A - 3\Omega \times 3A$$

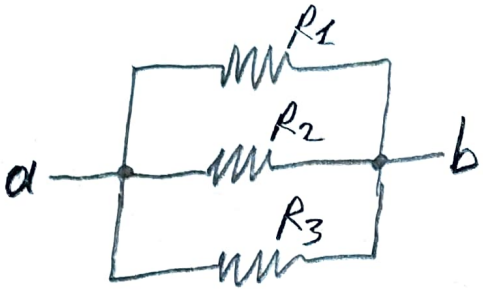
$$= 16V - 9V = 7V$$

5)



$R_1 = 20\,\Omega$
$R_2 = 12\,\Omega$
$R_3 = 15\,\Omega$

ab uçları arasındaki $R_T = ?$



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

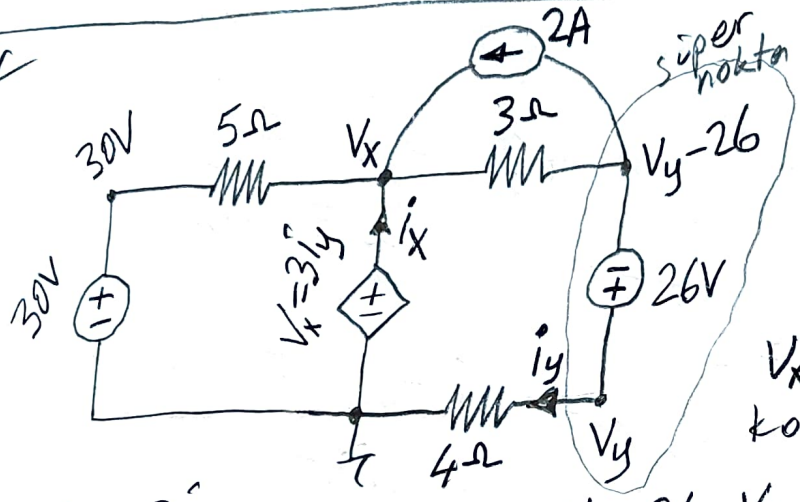
$$\frac{1}{R_T} = \frac{1}{20} + \frac{1}{12} + \frac{1}{15}$$

(3) (5) (4)

$$\frac{1}{R_T} = \frac{3+5+4}{60} = \frac{12}{60} = \frac{1}{5} \Rightarrow R_T = 5\,\Omega$$

---

6)



Node Analiz (KCL) yöntemini kullanarak i_y akımını, V_x voltajını, P_x gücünü bulunuz. V_x üretici mi tüketici mi konumdadır.

$V_x = 3i_y$
$V_y = 4i_y$

$$i_y + 2 + \frac{V_y - 26 - V_x}{3} = 0$$

$$i_y + 2 + \frac{4i_y - 26 - 3i_y}{3} = 0$$

$$3i_y + 6 + 4i_y - 26 - 3i_y = 0 \Rightarrow i_y = 5A$$

$$\frac{V_x - 30}{5} - i_x - 2 + \frac{V_x - V_y + 26}{3} = 0$$

$$\frac{3i_y - 30}{5} - i_x - 2 + \frac{3i_y - 4i_y + 26}{3} = 0 \quad \text{, 15 ile çarp}$$

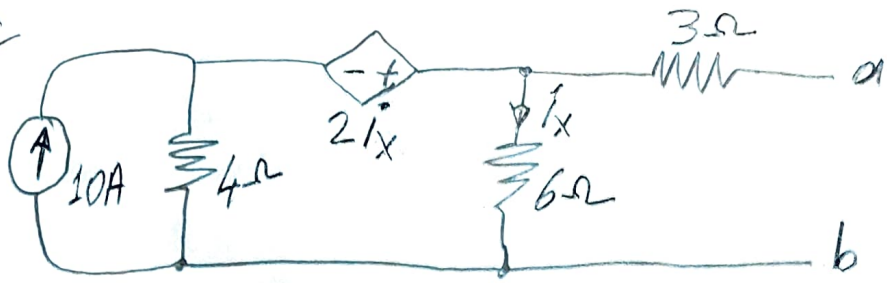
$$9i_y - 90 - 15i_x - 30 - 5i_y + 130 = 0 \Rightarrow i_x = \frac{4i_y + 10}{15}$$

$$i_x = \frac{4\times5 + 10}{15} = \frac{30}{15} = 2A \qquad P_x = V_x i_x = 15V \times 2A = 30W$$

$$V_x = 3i_y = 3\times5 = 15V$$

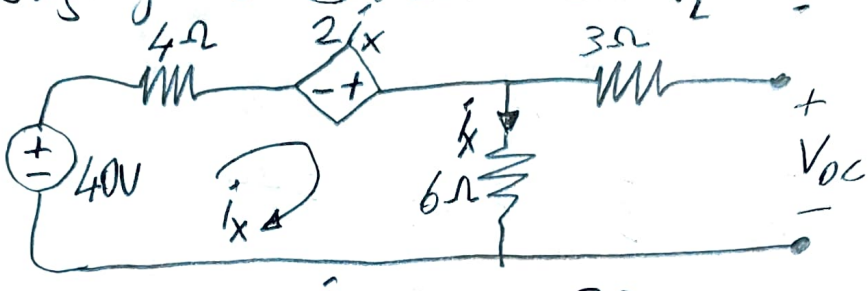
Üretici konumunda

bir

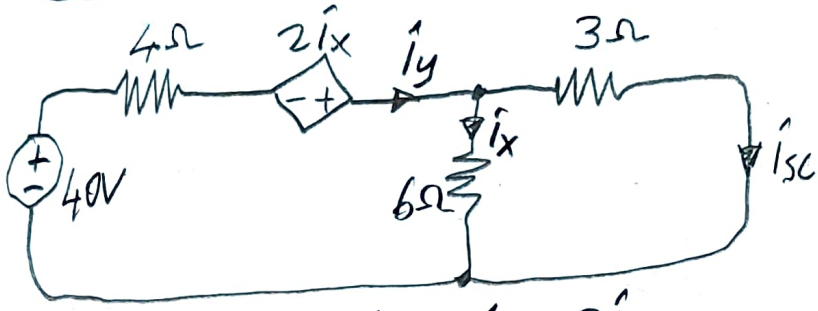


ab uçlarını önce açık devre yapıp V_{oc}, sonra kısa devre yapıp i_{sc} bulunuz.

Devrenin Thevenin eşdeğerini bulup uçlarına $R_L = 4\Omega$ direncini bağlayınız. Bu durumda $V_L = ?$



$$40 - 4i_x + 2i_x - 6i_x = 0$$
$$40 - 8i_x = 0$$
$$i_x = 5A$$
$$V_{oc} = 6i_x = 30V$$

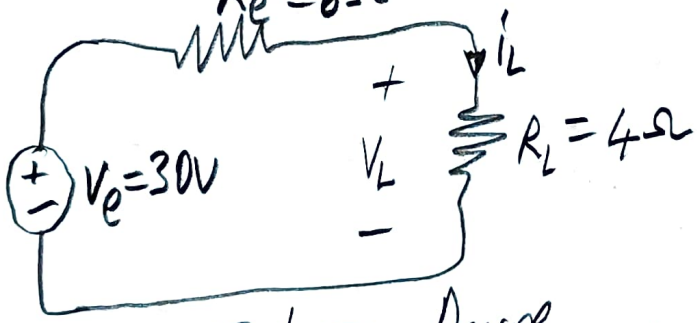


$$6i_x = 3i_{sc}$$
$$i_{sc} = 2i_x$$

$$i_y = i_x + i_{sc} = i_x + 2i_x = 3i_x$$

$$40 - 4i_y + 2i_x - 6i_x = 0 \Rightarrow 40 - 4\times 3i_x - 4i_x = 0$$
$$i_x = 2.5A$$

$$V_e = V_{oc} = 30V$$
$$i_e = i_{sc} = 2i_x = 5A$$
$$R_e = \frac{V_e}{i_e} = \frac{30V}{5k} = 6\Omega$$

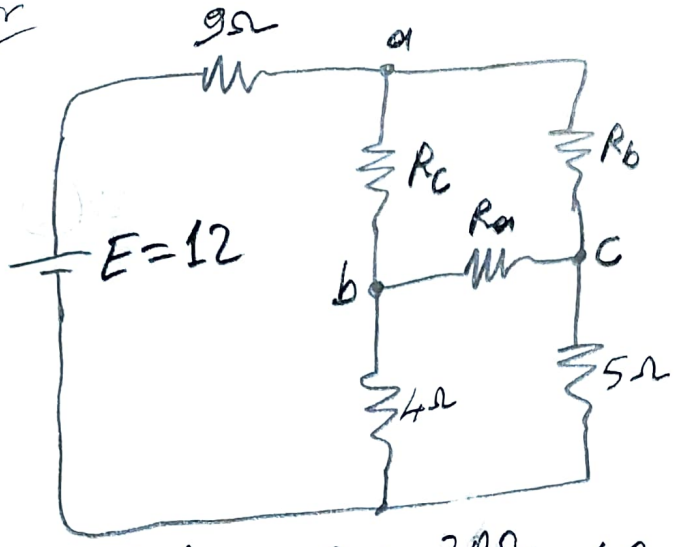


Thevenin Eşdeğer Devre

$$i_L = \frac{V_e}{R_e + R_L} = \frac{30V}{6\Omega + 4\Omega} = \frac{30V}{10\Omega} = 3A$$

$$V_L = R_L i_L = 4\Omega \times 3A = 12V$$

5)



$R_a = 20\Omega$, $R_b = 50\Omega$, $R_c = 30\Omega$ (21)

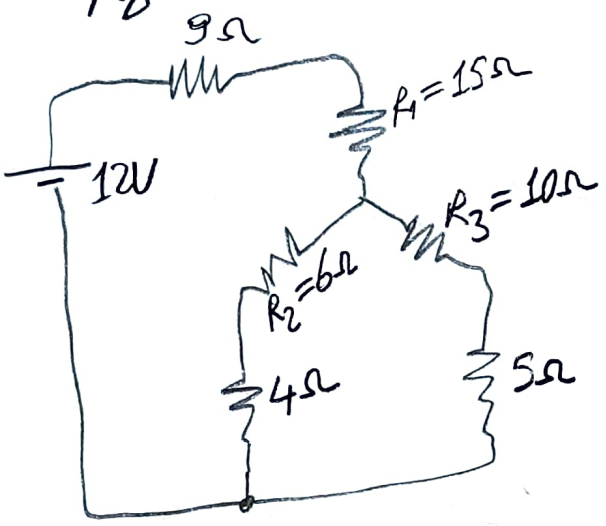
$E = 12V$ ise E'nin ürettiği gücü bulunuz.

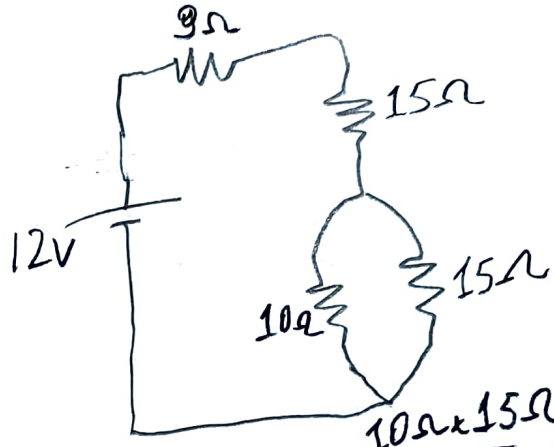
$$R_\Delta = R_a + R_b + R_c = 100\Omega$$

$$R_1 = \frac{R_b R_c}{R_\Delta} = \frac{50\Omega \times 30\Omega}{100\Omega} = 15\Omega$$

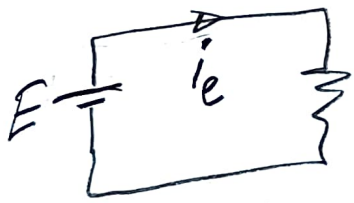
$$R_2 = \frac{R_a R_c}{R_\Delta} = \frac{20\Omega \times 30\Omega}{100\Omega} = 6\Omega$$

$$R_3 = \frac{R_a R_b}{R_\Delta} = \frac{20\Omega \times 50\Omega}{100\Omega} = 10\Omega$$





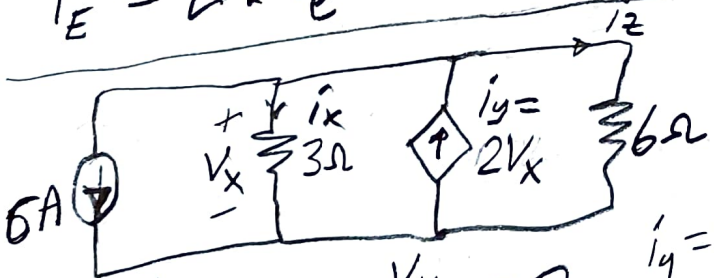
$$10\Omega // 15\Omega = \frac{10\Omega \times 15\Omega}{25\Omega} = 6\Omega$$



$$R_e = 9\Omega + 15\Omega + 6\Omega = 30\Omega$$

$$i_e = E/R_e = 12V/30\Omega = 0.4A$$

$$P_E = E \times i_e = 12V \times 0.4A = 4.8W$$



Node Analiz

$V_x = ?$ $i_y = ?$ $i_z = ?$

$$6 + \frac{V_x}{3} - 2V_x + \frac{V_x}{6} = 0$$

6 ile çarp

$$36 + 2V_x - 12V_x + V_x = 0$$

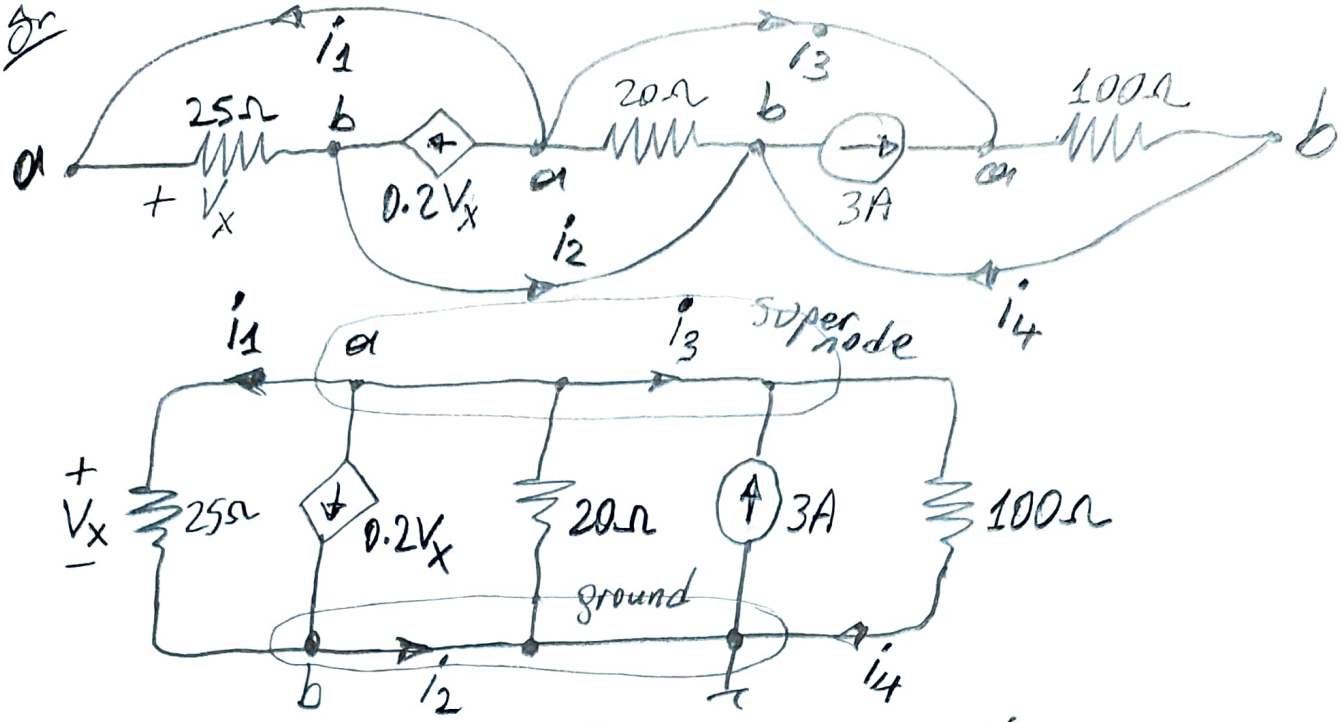
$$9V_x = 36 \Rightarrow V_x = 4V$$

$$i_y = 2V_x = 8A$$

$$i_z = \frac{V_x}{6} = \frac{4V}{6\Omega} = \frac{2}{3}A$$

$$i_x = \frac{V_x}{3} = \frac{4V}{3\Omega} = \frac{4}{3}A$$

Ör



$\frac{V_x}{25} + 0.2V_x + \frac{V_x}{20} - 3 + \frac{V_x}{100} = 0$, 100 ile çarp

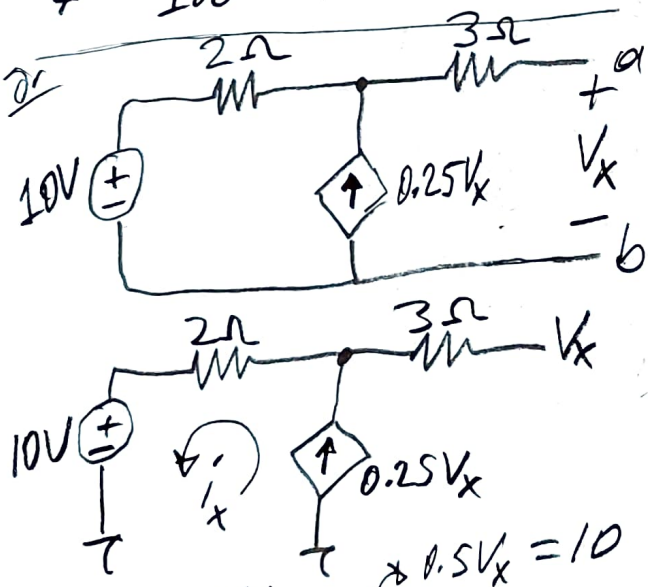
$4V_x + 20V_x + 5V_x - 300 + V_x = 0 \Rightarrow V_x = 10V$

$i_1 = \frac{V_x}{25} = \frac{10V}{25\Omega} = 0.4A$

$i_2 = i_1 + 0.2V_x = 0.4A + 0.2 \times 10\,\Omega = 0.4A + 2A = 2.4A$

$i_4 = \frac{V_x}{100} = \frac{10V}{100\Omega} = 0.1A$, $i_3 = i_4 - 3 = -2.9A$

Ör



$i_x = 0.25V_x$

$V_x = 10V + 2i_x$

$V_x = 10V + 0.5V_x$

$0.5V_x = 10$

$V_x = 20V$

$V_e = V_x = 20V$

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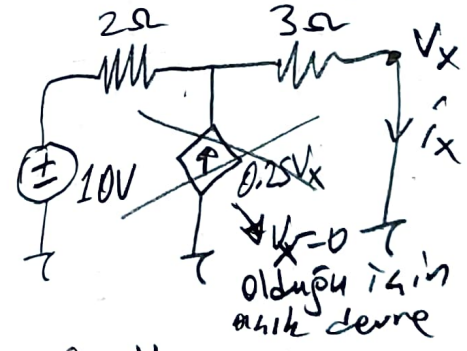
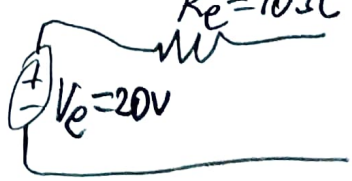
ab uçları arasındaki Re direncini bul. Thevenin eşdeğerini çiz.



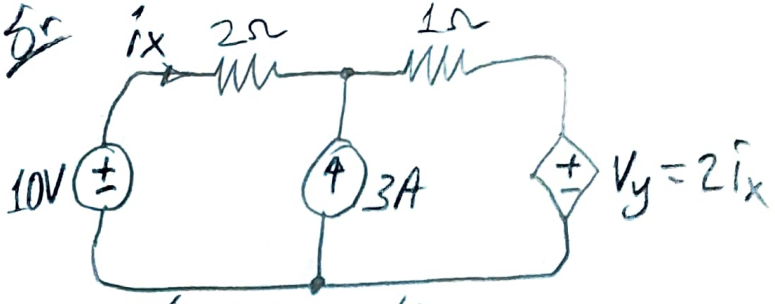
$i_x = \frac{10V}{2\Omega + 3\Omega} = \frac{10V}{5\Omega} = 2A$

$i_e = i_x = 2A$

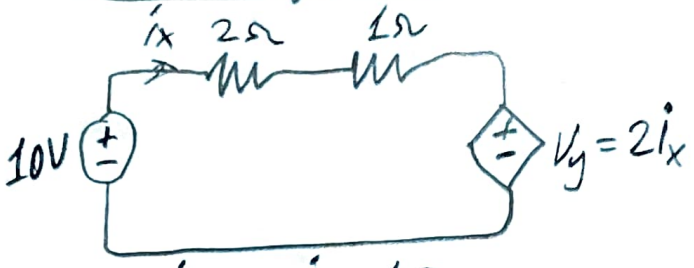
$R_e = V_e / i_e = \frac{20V}{2A} = 10\Omega$



Ör

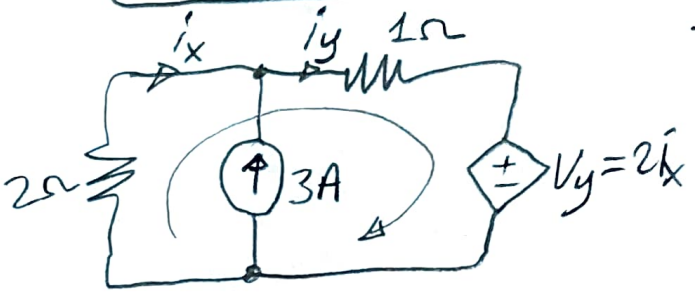


i_x akımının bileşenlerini bulup $i_x = ?$



$10 - 3i_x - 2i_x = 0$

$i_x = 2A$ 1. bileşen



$-2i_x - i_y - 2i_x = 0$

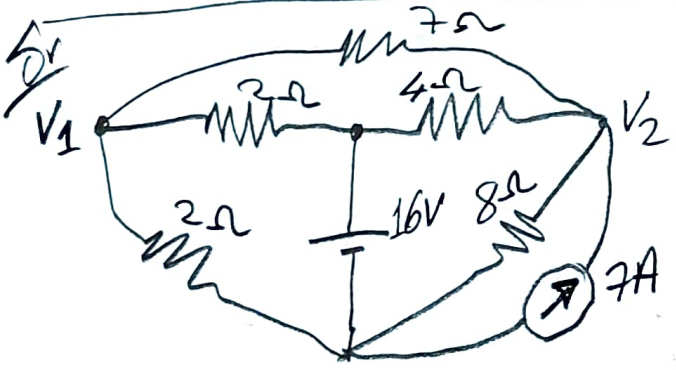
$i_y = -4i_x = i_x + 3$

$-5i_x = 3$

$i_x = -0.6A$ 2. Bileşen

$$i_x = i_x(1) + i_x(2) = 2A - 0.6A = 1.4A$$

Ör



Node Analiz

$V_1 = ?$, $V_2 = ?$

$$\frac{V_1}{2} + \frac{V_1 - 16}{2} + \frac{V_1 - V_2}{7} = 0$$

14 ile çarp

$$7V_1 + 7V_1 - 112 + 2V_1 - 2V_2 = 0$$

$$8V_1 - V_2 = 56$$ 1. denklem

$$\frac{V_2 - V_1}{7} + \frac{V_2 - 16}{4} + \frac{V_2}{8} - 7 = 0$$

56 ile çarp

$$8V_2 - 8V_1 + 14V_2 - 224 + 7V_2 - 392 = 0 \Rightarrow 29V_2 - 8V_1 = 616$$ 2. denklem

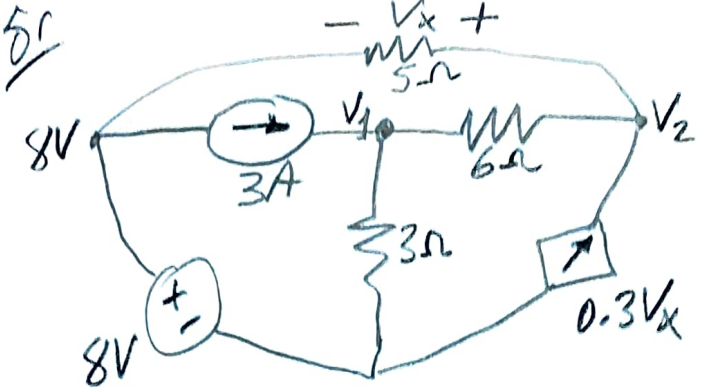
$$\begin{bmatrix} 8 & -1 & 56 \\ -8 & 29 & 616 \end{bmatrix} \sim \begin{bmatrix} 8 & -1 & 56 \\ 0 & 28 & 672 \end{bmatrix} \sim \begin{bmatrix} 8 & -1 & 56 \\ 0 & 1 & 24 \end{bmatrix}$$

$$\sim \begin{bmatrix} 8 & 0 & 80 \\ 0 & 1 & 24 \end{bmatrix} \sim \begin{bmatrix} 1 & 0 & 10 \\ 0 & 1 & 24 \end{bmatrix}$$

$V_1 = 10V$

$V_2 = 24V$

5r



Node Analiz

$V_1 = ?$, $V_2 = ?$

$V_x = V_2 - 8$

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

$3V_1 - V_2 = 18$ 1. denklem

$-0.3V_x + \frac{V_2 - V_1}{6} + \frac{V_2 - 8}{5} = 0$

$-0.3(V_2 - 8) + \frac{V_2 - V_1}{6} + \frac{V_2 - 8}{5} = 0$, 30 ile çarp

$-9V_2 + 72 + 5V_2 - 5V_1 + 6V_2 - 48 = 0 \Rightarrow 5V_1 - 2V_2 = 24$ 2. denklem

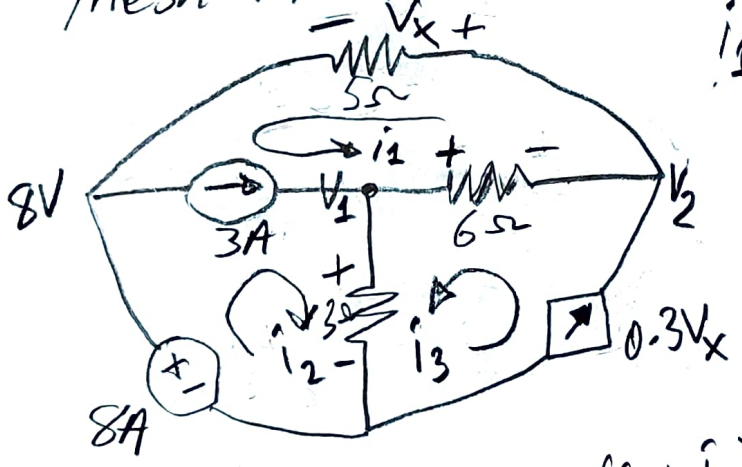
$$\begin{bmatrix} 3 & -1 & 18 \\ 5 & -2 & 24 \end{bmatrix} \sim \begin{bmatrix} 6 & -2 & 36 \\ 5 & -2 & 24 \end{bmatrix} \sim \begin{bmatrix} 1 & 0 & 12 \\ 5 & -2 & 24 \end{bmatrix}$$

$$\sim \begin{bmatrix} 1 & 0 & 24 \\ 0 & -2 & -36 \end{bmatrix} \sim \begin{bmatrix} 1 & 0 & 12 \\ 0 & 1 & 18 \end{bmatrix}$$

$V_1 = 12V$

$V_2 = 18V$

Mesh Analizle çözersek



$i_1 + i_2 = 3 \Rightarrow i_2 = 3 - i_1$

$V_x = 5i_1$

$i_3 = 0.3V_x = 1.5i_1$

$8 + 5i_1 + 6(i_1 - i_3) - 3(i_2 + i_3) = 0$

$8 + 5i_1 + 6i_1 - 6i_3 - 3i_2 - 3i_3 = 0$

$11i_1 - 3i_2 - 9i_3 = -8$

$11i_1 - 3(3 - i_1) - 13.5i_3 = -8$

$0.5i_1 = 1 \Rightarrow i_1 = 2A$

$i_2 = 3 - i_1$

$= 3A - 2A = 1A$

$i_3 = 1.5i_1 = 3A$

$V_1 = 3(i_2 + i_3)$

$= 3 \times 4V = 12V$

$V_2 = 8 + 5i_1 = 8 + 5 \times 2$

$= 18V$