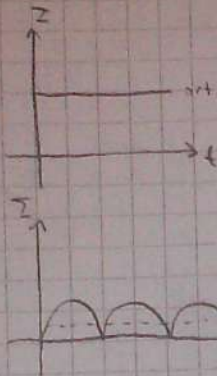
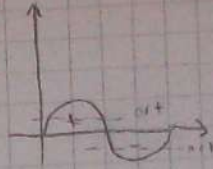


DEVRE TEORİSİ

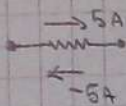


Doğru Akım



Alternatif Akım

Ortalama değeri sıfırdır



$$i = \frac{dq}{dt}$$

$$q = \int i \cdot dt$$

→ Belirli bir zamanda geçen yük miktarı

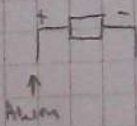
$$V_{ab} = V_a - V_b$$

$$V = \frac{dw}{dq}$$

$$P = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt}$$

$$= V \cdot i$$

$$P = q \cdot V$$



$$P = +V \cdot i$$

Pasif



$$P = -V \cdot i$$

Aktif

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

[Ω]

uzunluk ve alandaki
uzunluk birimine dikkat et

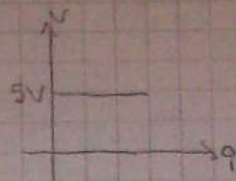
Endirenci
(Ωm)

Örnek

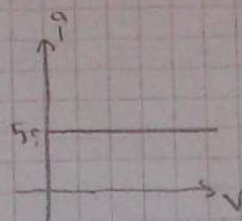
Örnek: $d = 1.63 \text{ nm}$ çaplı 75 metrelik bakır telin direnci? $\rho = 1.723 \cdot 10^{-8} \Omega \cdot \text{m}$

$$A = \pi r^2 = \pi \cdot \left(\frac{1.63 \cdot 10^{-9}}{2} \right)^2$$

$$R = 1.723 \dots$$



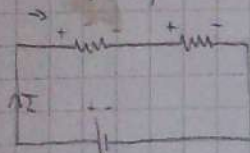
İdeal gerilim kaynağı



İdeal akım kaynağı

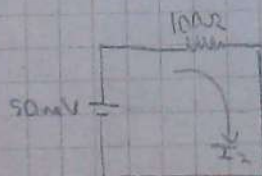
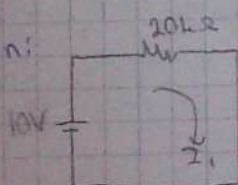
Alınan güç (P) (+)

12V



$$\sum V = 0 \quad (\text{Küçük devre için})$$

Örnek:



a) I_1, I_2 ?

b) Kaynağı 250kΩ ile değiştirilerek amplitüde hesaplanırsa

I_1, I_2 ve η = kılınma etkisini bulur
a) ve b) de bulduğunuz sonuçların oranı (yazdı her biri)

$$a) I_1 = \frac{10}{20000} = 0.5 \text{ mA}$$

$$b) I_1' = \frac{10}{20000 + 250} = 0.494 \text{ mA}$$

$$I_2 = \frac{50 \cdot 10^{-3}}{100} = 0.5 \text{ mA}$$

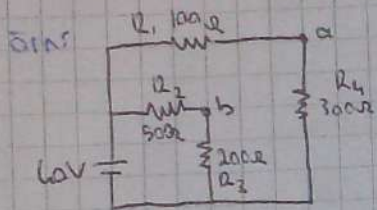
$$I_2' = \frac{50 \cdot 10^{-3}}{100 + 250} = 0.143 \text{ mA}$$

KCL

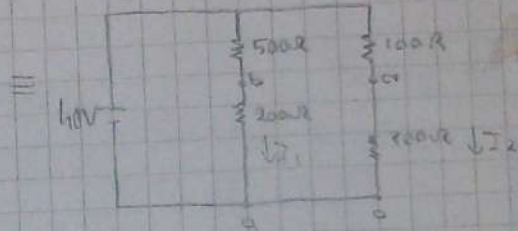
$\sum I = 0$ bir düğümde girilen akım çıkan akımların toplamına eşittir.

$\sum I = 0$ bir düğümde

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots \quad R_T = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

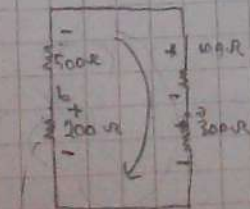


Devredeki V_{ab} 'yi bulun



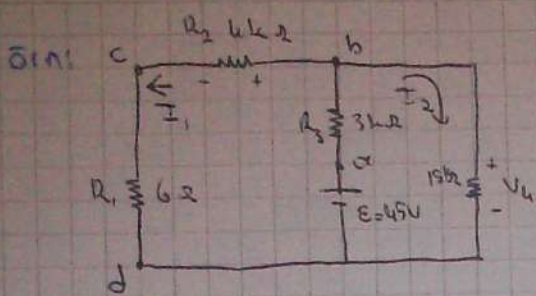
$$\begin{aligned} I_1 &= 0,16A & V_b &= V_5 - V_a = I_1 \cdot R = 0,16 \cdot 200 = 32V \\ I_2 &= 0,1A & V_a &= V_5 - V_b = I_2 \cdot R = 0,1 \cdot 300 = 30V \\ V_{ab} &= V_a - V_b = -2V \end{aligned}$$

veya



$$\begin{aligned} V_{R1} + V_{R2} + V_{R3} &= 0 \\ 0,1 \cdot 100 + V_{ab} - 50 \cdot 0,16 &= 0 \\ 10 - 8 + V_{ab} &= 0 \\ V_{ab} &= -2V \end{aligned}$$

V_{ab} bulunabilir; V_{ab} 'yi bulmak için alternatif olarak



- a) $R_T = ?$
 b) $I_1, I_2, I_T = ?$
 c) $V_2, V_4 = ?$
 d) $V_{bd} = ?$

a) $R_T = (4+6) // 15 + 3 = 9k\Omega$

$I_T = 45/9 = 5mA$

$I_1 = \frac{R_4}{(R_1+R_2)+R_4} \cdot I_T = 3mA$

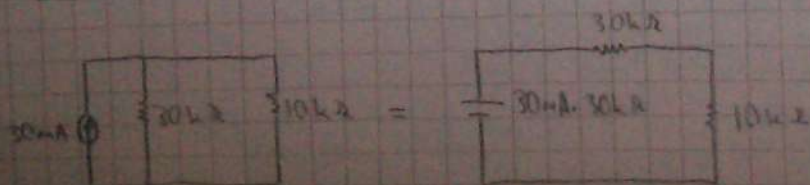
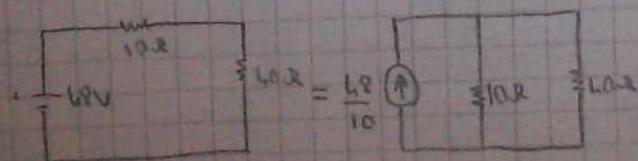
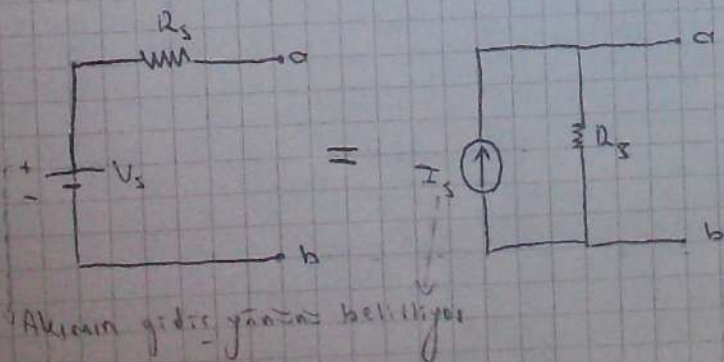
$I_2 = \frac{R_1+R_2}{R_1+R_2+R_4} \cdot I_T = 2mA$

$V_2 = I_1 \cdot R_2 = 3 \cdot 4 = 12V$

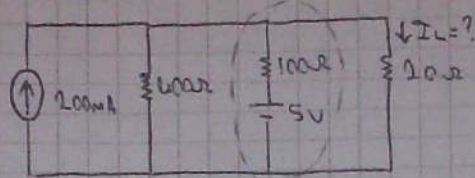
$V_4 = I_2 \cdot R_4 = 2 \cdot 5 = 10V$

$V_{bd} = V_2 + V_4$
 $= I_1 \cdot R_2 + I_2 \cdot R_4$
 $= 12 + 10$
 $= 22V$

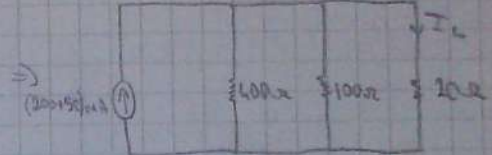
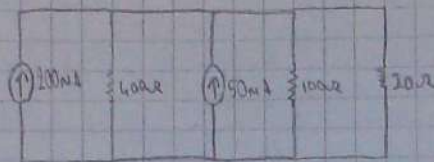
Kaynak Dönüştürme



Örnek:



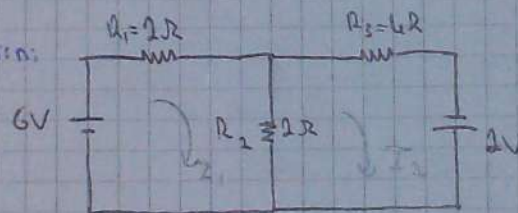
Tek bir akım kaynağı-
na dönüştürerek gözön



$$R_{eq} = 16\Omega$$

$$V = 250mA \cdot 16 = 4V$$

Örnek:



$$R_1 \cdot I_1 + R_2 \cdot I_2 - R_3 \cdot I_3 + E_2 - E_1 = 0 \quad 1. \text{ Çevre}$$

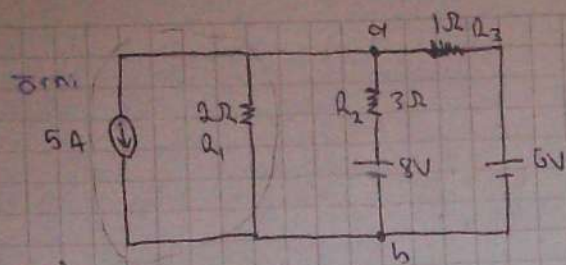
$$I_2 \cdot R_3 - E_2 - E_1 + R_3 \cdot I_3 - R_2 \cdot I_2 = 0 \quad 2. \text{ Çevre}$$

$$4I_1 - 2I_2 = 2V$$

$$I_1 = 1,2A$$

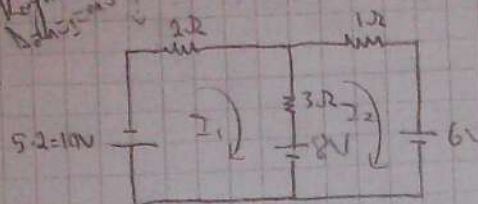
$$-2I_1 + 6I_2 = 6V$$

$$I_2 = 1,6A$$



8V'lık kaynağın geçen akımı bulunuz

Kaynak Değiştirme



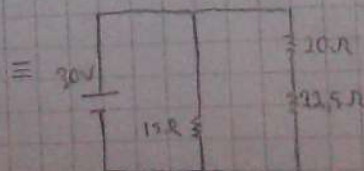
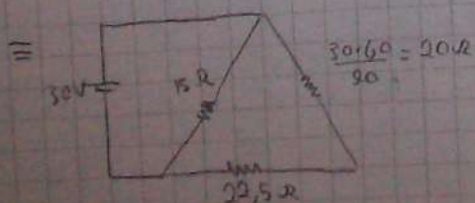
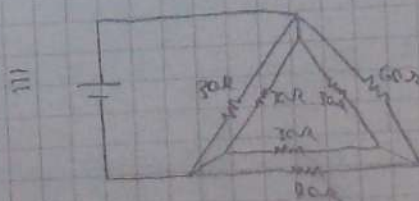
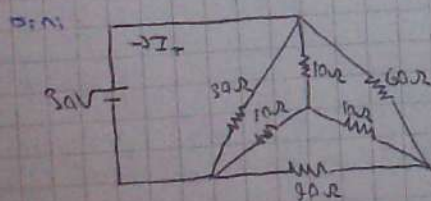
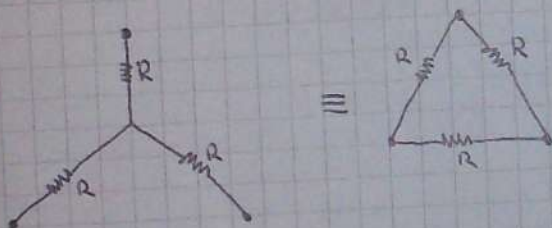
1. Çevre $I_1 \cdot 2 + (I_1 - I_2) \cdot 3 + 8 + 10 = 0$

2. Çevre $I_2 \cdot 1 + 6 - 8 + (I_2 - I_1) \cdot 3 = 0$

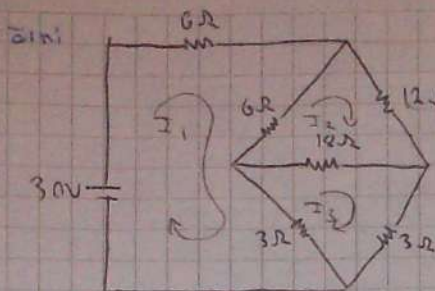
$$5I_1 - 3I_2 = -18 \quad I_1 = -6A$$

$$-3I_1 + 4I_2 = 2 \quad I_2 = -6A$$

Yıldız Üçgen Dönüştürme



$$R_T = 11,09 \Omega$$



$$1. \text{KVL} / I_1 \cdot 6 + (I_1 - I_2) 6 + (I_1 - I_3) \cdot 3 - 30 = 0$$

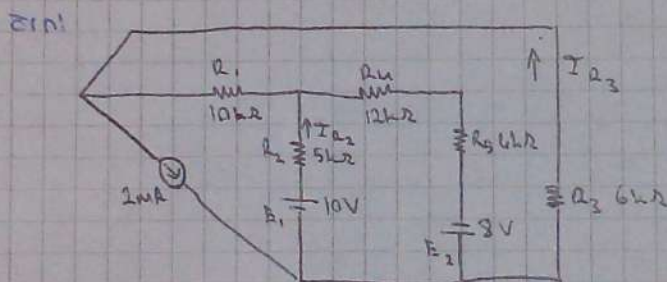
$$2. \text{KVL} / I_2 \cdot 12 + (I_2 - I_3) 18 + (I_2 - I_1) 6 = 0$$

$$3. \text{KVL} / (I_3 - I_2) 18 + I_3 \cdot 3 + (I_3 - I_1) 3 = 0$$

$$6I_1 + 6I_1 - 6I_2 + 3I_1 - 3I_3 = 30 \Rightarrow 15I_1 - 6I_2 - 3I_3 = 30$$

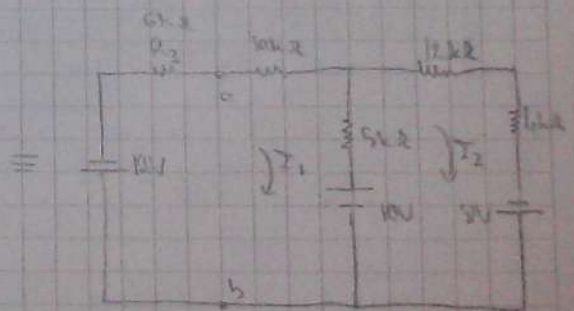
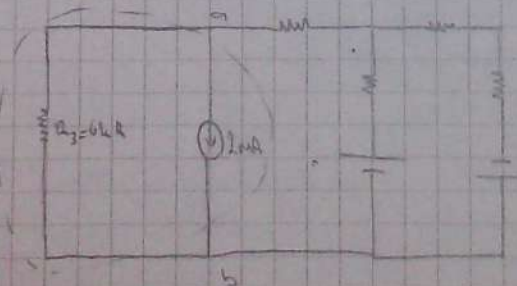
$$12I_2 + 18I_2 - 18I_3 + 6I_2 - 6I_1 = 0 \Rightarrow 36I_2 - 6I_1 - 18I_3 = 0$$

$$18I_3 - 18I_2 + 3I_3 + 3I_3 - 3I_1 = 0 \Rightarrow 24I_3 - 18I_2 - 3I_1 = 0$$



$$I_{a2} = ?$$

$$I_{a2} = ?$$

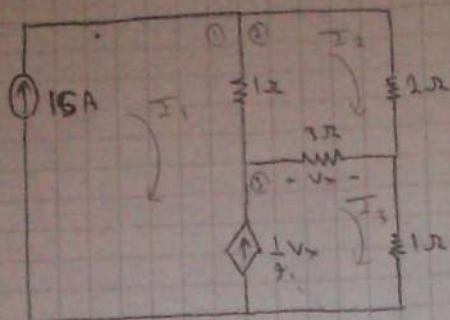


$$\begin{aligned} 1. \text{KVL} & 6I_1 + 10I_1 + 5(I_1 - I_2) + 10 + 12 = 0 \Rightarrow 21I_1 - 5I_2 = -22 \\ 2. \text{KVL} & 16I_2 - 10 - 10 + (I_2 - I_1) 5 = 0 \Rightarrow 21I_2 - 5I_1 = 12 \end{aligned} \quad \left. \begin{aligned} & I_1 = -0,89 \text{ mA} \\ & I_2 = +0,64 \text{ mA} \end{aligned} \right\}$$

$$\begin{aligned} & I_{a2} \text{ is the current through } R_2 \text{ in the } V_{ab} \text{ branch} \\ & V_{R1} + V_{R2} + 10 - V_{ab} = 0 \\ & V_{ab} = -6,44 \text{ V} \end{aligned}$$

$$I_{a2} = I_1 - I_2$$

Örnek



$V_x = ?$

$$I_1 = 16A$$

$$I_3 - I_2 = \frac{1}{3} V_x$$

$$V_x = (I_3 - I_2) \cdot 3 = 3(I_3 - I_2)$$

2. Çevre

$$-1 \cdot I_1 + 6I_2 - 3I_3 = 0$$

$$6I_2 - 3I_3 = 16$$

$$2I_2 - I_3 = 16/3$$

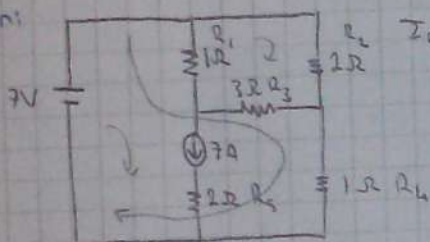
$$V_x = (17 - 11) \cdot 3 = 18V$$

$$I_3 - I_2 = \frac{1}{3} \cdot 3(I_3 - I_2)$$

$$3I_3 - 3I_2 = I_3 - I_2$$

$$2I_3 - I_2 = 45$$

Örnek



$$I_{a3} = I_1 - I_3 = 7A$$

$$V_{a1} + V_{a3} + V_{a4} - 7 = 0$$

$$-I_1 \cdot 1 + 6I_2 - 3I_3 = 0$$

$$V_{a1} = (I_1 - I_3) \cdot 1\Omega$$

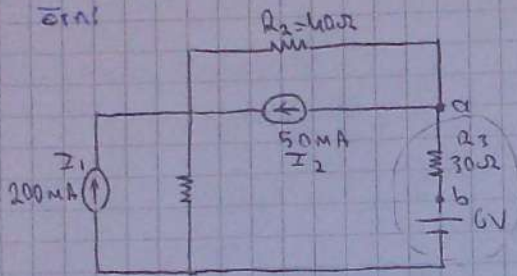
$$V_{a3} = (I_3 - I_2) \cdot 3\Omega$$

$$V_{a4} = I_3$$

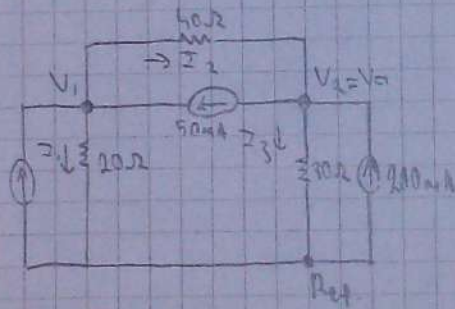
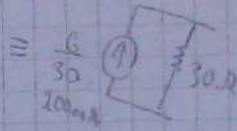
Düğüm Gerilimleri Yöntemi

- 1- Referans düğüm belirlenir.
- 2- Referans düğüm hariç her bir düğüm numaralandırılır.
- 3- Düğüme bağlı elementler için akım yönü seçilir.
- 4- KCL → Her bir düğüme Kirchhoff Akım Kanunu uygulanır.

Örnek



V_{ab} gerilimini düğüm gerilimleri yöntemi kullanarak soruyoruz



I_1, I_2, I_3 'ü başlarına göre seçtik

2. düğüme KCL uygulanır

$$200mA + I_2 - I_3 - 50mA = 0$$

$$I_1 = \frac{V_1 - V_{ref}}{20\Omega} = \frac{V_1}{20}$$

$$I_2 = \frac{V_1 - V_2}{40}$$

$$I_3 = \frac{V_2 - V_{ref}}{30} = \frac{V_2}{30}$$

1. düğüme KCL uygulanır

$$+200mA + 50mA - I_1 - I_2$$

$$1. \text{ Denklemler } 250 \cdot 10^{-3} - \frac{V_1}{20} - \frac{V_1 - V_2}{40} = 0$$

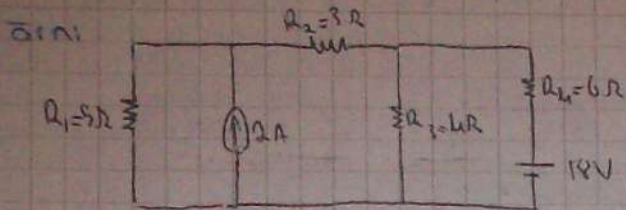
$$V_1 = 4.89V$$

$$2. \text{ Denklemler } 150 \cdot 10^{-3} + \frac{V_1 - V_2}{40} - \frac{V_2}{30} = 0$$

$$V_2 = 4.67V$$

$$V_{ab} = V_a - V_b = 6 - V_b = 6$$

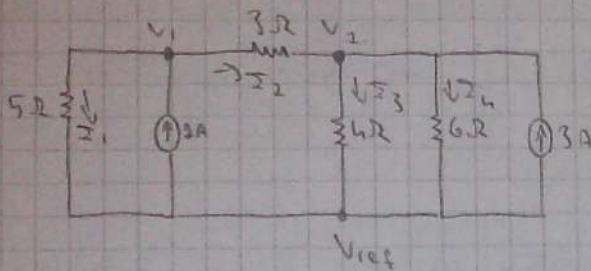
$$V_{ab} = V_a - V_b = V_2 - 6 = 4.67 - 6 = -1.33V$$



Düğüm gerilimleri
yönteminde çözüm yaparken
akımlar üzerinde çalıştığımız
için, kaynak dönüşümü yapıp
V'yi A'ya çevir

$$V_1 = 8,65V$$

$$V_2 = 7,85V$$



1. Düğüm

$$2 - I_1 - I_2 = 0$$

2. Düğüm

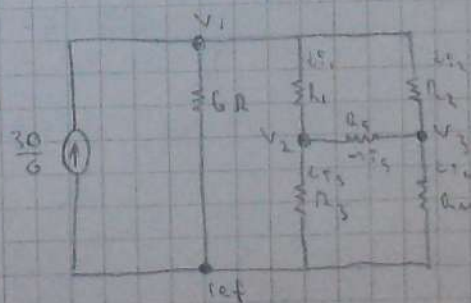
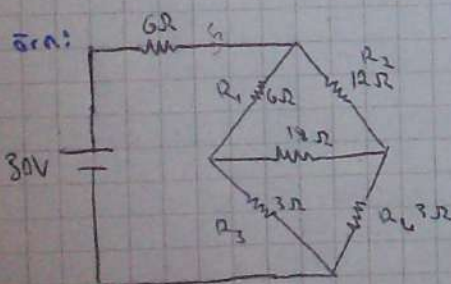
$$3 + I_2 - I_3 - I_4 = 0$$

$$I_1 = \frac{V_1 - V_{ref}}{R_1}$$

$$I_2 = \frac{V_1 - V_2}{3}$$

$$I_3 = \frac{V_2 - V_{ref}}{4}$$

$$I_4 = \frac{V_2 - V_{ref}}{6}$$



Düğüm gerilimleri yöntemi ile $V_{AB} = ?$

$$V_{ref} = 0$$

$$\sum I_{gelen} = \sum I_{giden}$$

V_1 için

$$5 = \frac{V_1 - V_{ref}}{6} + \frac{V_1 - V_2}{6} + \frac{V_1 - V_3}{12}$$

V_2 için

$$\frac{V_1 - V_2}{6} = \frac{V_2 - V_{ref}}{3} + \frac{V_2 - V_3}{12}$$

V_3 için

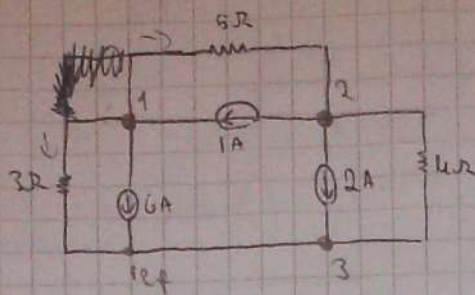
$$\frac{V_2 - V_{ref}}{3} = \frac{V_1 - V_3}{12} + \frac{V_2 - V_3}{12}$$

$$V_1 = 14,68V$$

$$V_2 = 4,66V$$

$$V_3 = 3,10V$$

örni



1. dengelem

$$I = \frac{V_1 - V_2}{5} + \frac{V_1 - V_{ref}}{3} + 6$$

bu dengelem için dengelem terimlerini topladık

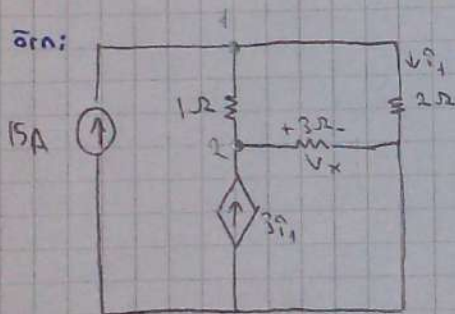
$$\left(\frac{1}{3} + \frac{1}{5}\right)V_1 - \frac{1}{5}V_2 = 1 - 6$$

$$\left(\frac{1}{3} + \frac{1}{5}\right)V_1 - \frac{1}{5}V_2 = -5$$

$$\left(-\frac{1}{5}\right)V_1 + \left(\frac{1}{3} + \frac{1}{5}\right)V_2 = -1 - 2$$

$$-\frac{1}{5}V_1 + \left(\frac{1}{3} + \frac{1}{5}\right)V_2 = -3$$

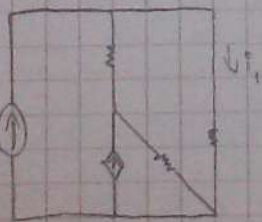
örni



Bağımlı akım kaynağı tarafından harcanan güç nedir?

$$i_1 = \frac{V_1 - V_{ref}}{2} = \frac{V_1}{2}$$

$$P_{3i_1} = \frac{3}{2}V_1$$



2. dengelem

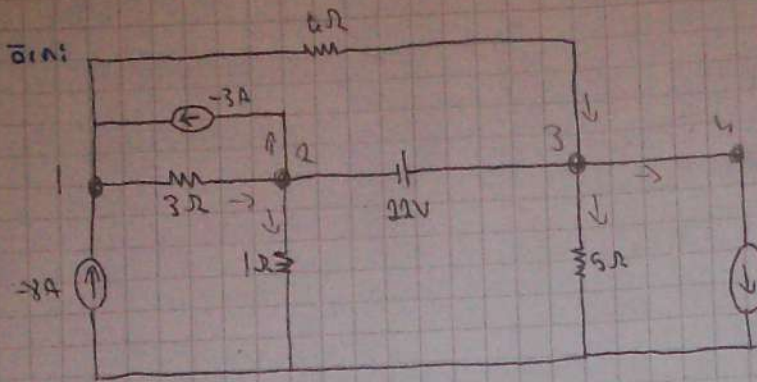
1. dengelem

$$\frac{V_1 - V_2}{1} + \frac{3V_1}{2} - \frac{(V_2 - V_{ref})}{3} = 0 \quad 15 - \frac{(V_1 - V_2)}{1} - \frac{(V_1 - V_{ref})}{2} = 0$$

$$-15V_1 + 8V_2 \quad \left. \begin{array}{l} V_1 = -40V \\ V_2 = -75V \end{array} \right\}$$

$$12V_1 - 8V_2 = 120$$

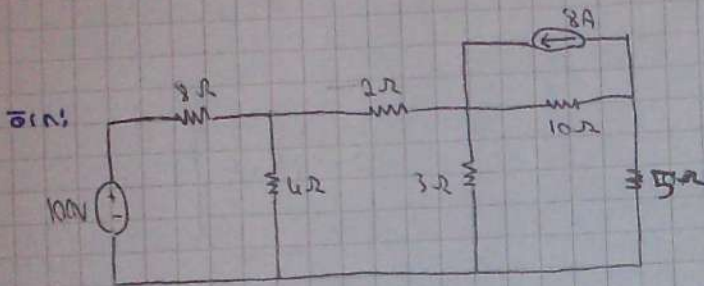
$$P = \frac{3}{2}V_1(V_2 - V_{ref}) = -4,5 \text{ kW}$$



$V_1 = ?$

İki deq=11 alınırsa
sadece gerilim kaynağı varken
2. ve 3. deq=0 olur
Sadece deq=11 alınırsa
tek deq=11 kabul et

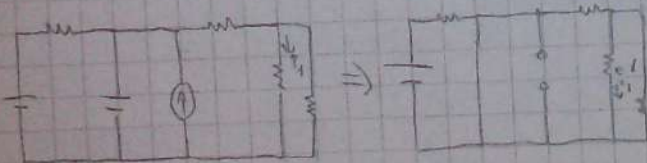
$$V_2 - V_3 = -22 \quad \frac{V_1 - V_3}{3} + \frac{V_1 - V_3}{5} = \frac{V_2}{1} + \frac{V_3}{5} - 25 - 3$$



$V_x = ?$

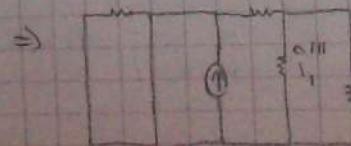
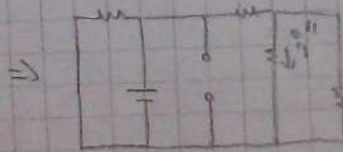
TOPLAMSALLIK TEORİSİ

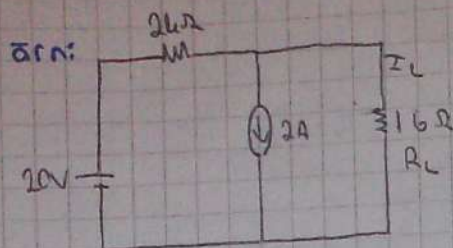
* Lineer devrelerde kullanılabilir



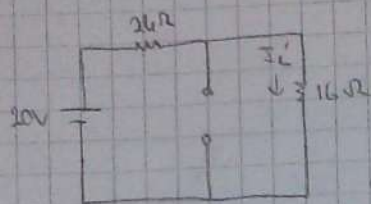
$$I_1 = I_1^I + I_1^{II} + I_1^{III}$$

* Bağımlı olan
kaynağına uygulanır



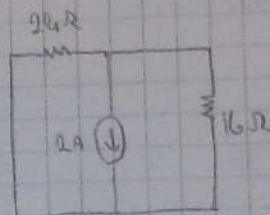


$$I_L = ?$$



$$I_L' = \frac{20}{40} = 0.5 \text{ A}$$

$$I_L = I_L' + I_L'' = 0.5 + 1.2 = 1.7 \text{ A}$$

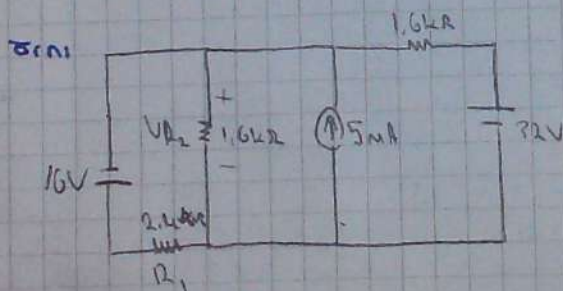


$$2k \parallel 16$$

$$R_{eq} = 9.6$$

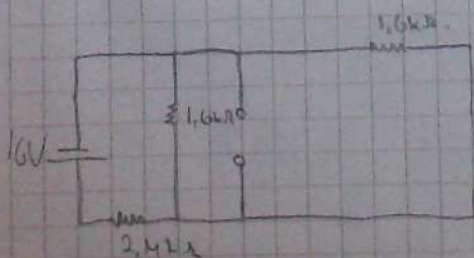
$$\Rightarrow \downarrow 2A \Rightarrow 9.6 \Omega$$

$$2 \cdot 9.6 = 19.2 \text{ V} \quad I_L'' = \frac{19.2}{16} = 1.2 \text{ A}$$

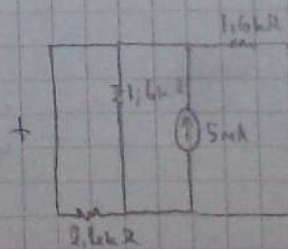


$$V_{A2} = ?$$

$$V_{A2} = V_{A2}' + V_{A2}'' + V_{A2}'''$$



$$V_{A2}' = -\frac{16}{2.4 + 1.6} \cdot 0.8 = -4 \text{ V}$$

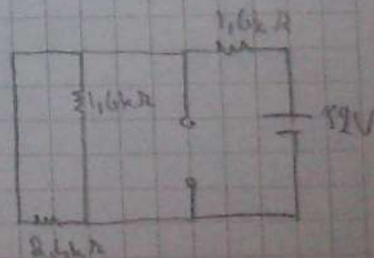


$$2.4 \parallel 1.6 \parallel 1.6$$

$$2.4 \parallel 0.8 = 0.6 \text{ k}\Omega$$

$$0.6 \text{ k}\Omega \cdot 5 \text{ mA} = 3 \text{ V}$$

$$V_{A2}'' = 3 \text{ V}$$

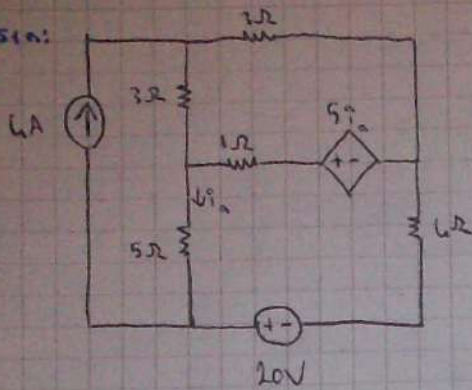


$$2.4 \parallel 1.6 + 1.6 = 2.5 \text{ k}\Omega$$

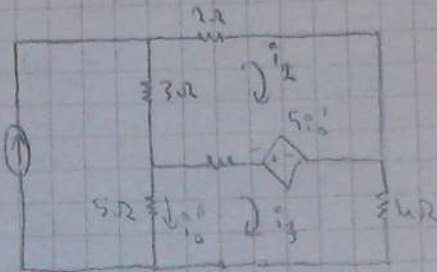
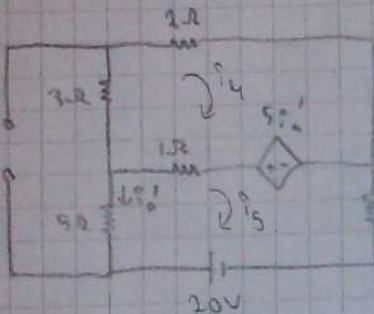
$$I = \frac{32}{2.5}$$

$$V_{A2}''' = 12 \text{ V}$$

5in:



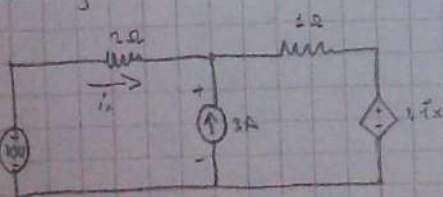
i_a akımını toplamsallık teoremiyle hesaplayın.
* Bağımlı kaynakların bulunmamasından çözüm yapıyoruz.



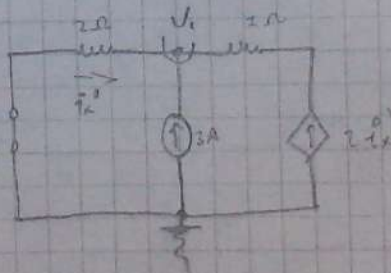
1. Kaynak
 $6i_4' - 1i_5' = 5i_a'$

2. Kaynak
 $-1i_4'' + 10i_5'' = 20 - 5i_a''$

$i_a' = -i_5'$



2. Kaynak toplamsallık teoremi ile bulunur.



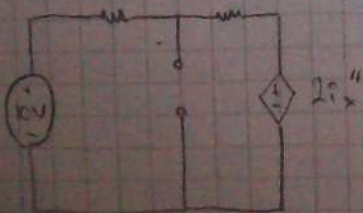
$$\frac{0 - V_1}{2} + \left(\frac{V_1 - 2i_x'}{1} \right) + 3 = 0$$

Gelen akım pozitif alırsak

$$-\frac{V_1}{2} - \frac{V_1}{1} + \frac{2i_x'}{1} + 3 = 0$$

$$i_x' = -0.6A$$

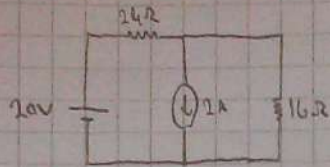
$$I = i_x''$$



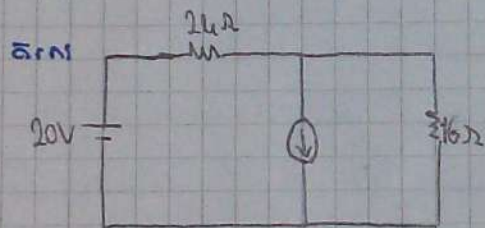
$$27 + 12 + 2i_x'' - 10 = 0$$

$$2i_x'' + 1 - 1i_x'' + 3 = 10 \quad i_x'' = 10/5 = 2A$$

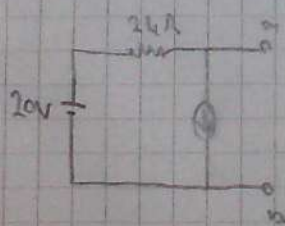
THEVENIN TEOREMİ



İlk adım \rightarrow V_{oc} devreden \pm kartıyoruz

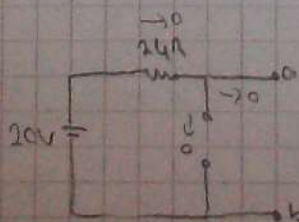


16Ω yük direnci = zerinden geçen
akımı Theveninden bulun



V_{oc}' hesapla

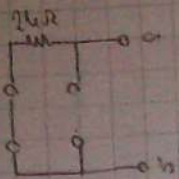
Toplamsal
kullanılacak



$$V_{oc}' = 20V$$

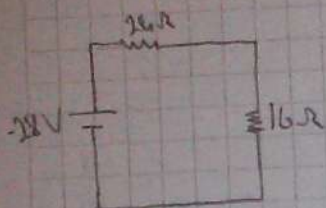
$$V_{oc}'' = -48V$$

$$V_{oc} = V_{oc}' + V_{oc}'' = -28V$$

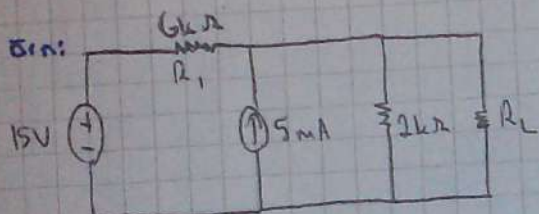


Boşlukta kayanların aynı olduğu süperilasyon

$$R_{eq} = 2k\Omega = R_{TH}$$



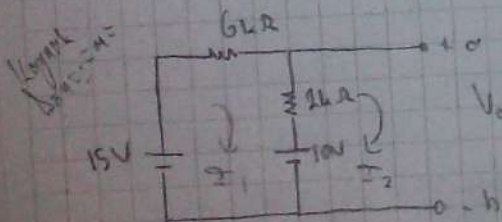
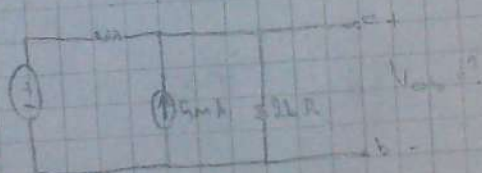
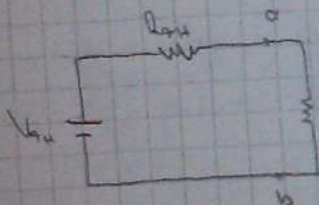
$$I = \frac{-28}{16+2k} = -0,7 \text{ A}$$



$$R_L \rightarrow 0\Omega \rightarrow I_1$$

$$R_L \rightarrow 2k\Omega \rightarrow I_2$$

$$R_L \rightarrow 5k\Omega \rightarrow I_3$$



$$I_2 = 0$$

$$(6+2)I_1 - 2I_2 + 10 - 15 = 0$$

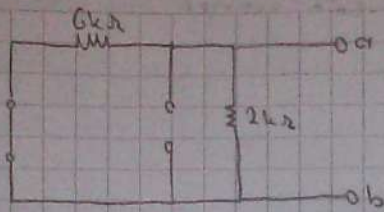
$$8I_1 = 5 \quad I_1 = 5/8 = 0,625 \text{ A}$$

$$2I_2 - 2I_1 + V_{th} - 10 = 0$$

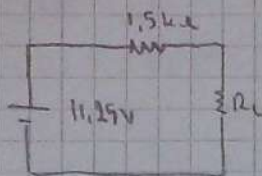
$$-2I_1 + V_{th} = 10$$

$$V_{th} = 2(0,625) + 10$$

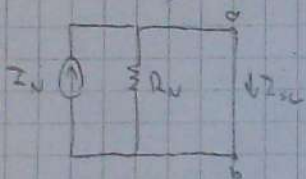
$$= 11,25 \text{ V} = V_{TH}$$



$$R_{eq} = \frac{6 \cdot 2}{2+6} = 1,5 k\Omega = 0,5 \text{ k}\Omega$$

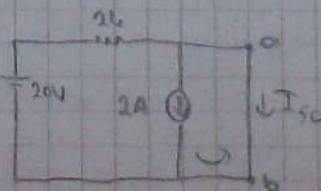
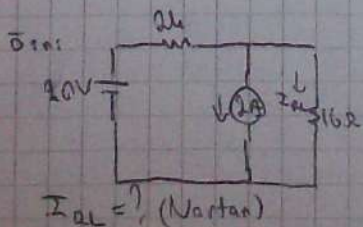
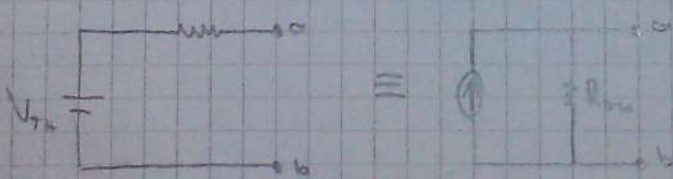


NORTON TEOREMİ



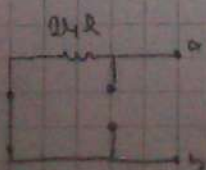
- İlk olarak ilk devreden çıkartıyoruz
- a-b uçlarını kısa devre yaparak I_{sc} olmasını hesaplıyoruz $I_{sc} = I_N$

- Batıya bakıyoruz kaynağın etkisini a-b uçlarında görülen R_{eq} buluyoruz $R_N = R_{eq} = R_{th}$

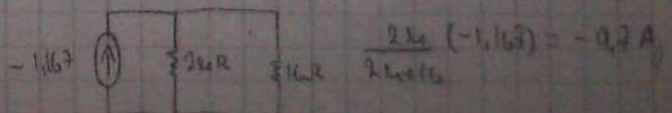


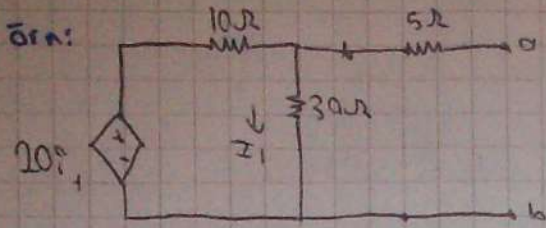
$$\frac{20}{2k} - 2 = 0,93 - 2 = -1,067A$$

$$I_{sc} = -1,067A$$



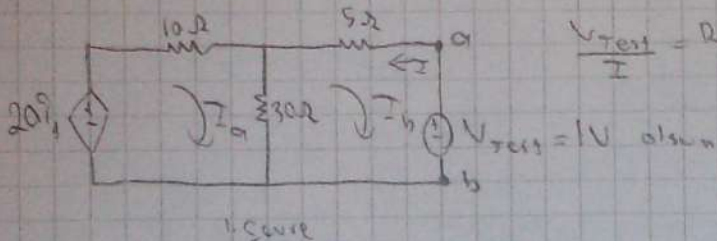
$$R_{eq} = 2k\Omega$$





Thevenin eşdeğer devresini bulun
* Bağımlı kaynağı sıfırlamıyoruz

İlk durum için devreye girecek bir yük yok $I_1 = 0 \Rightarrow V_{TH} = 0$
 $V_{ab} = 0 \Rightarrow$



$$\frac{V_{Test}}{I} = R_{eq} = R_{TH} \quad I = ?$$

$V_{Test} = 1V$ olsun

1. Çevre

2. Çevre

$$I_r = I_a - I_b$$

$$10I_a + 30(I_a - I_b) = 20$$

$$40I_a - 30I_b = 20$$

$$20I_a - 10I_b = 0$$

$$2I_a = I_b$$

$$5I_b + 30(I_b - I_a) + V_{Test} = 0$$

$$35I_b - 30I_a = -V_{Test}$$

$$35I_b - 30I_a = -1$$

$$I_b = -0.05 \Rightarrow I = 0.05A$$

$$I_a = -0.025$$

$$\frac{V_{Test}}{I} = \frac{1}{0.05} = 20\Omega$$