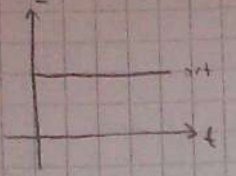
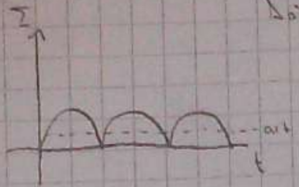
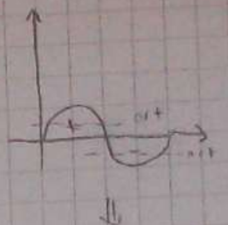
DEVRE TEORİSİ





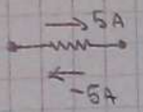
Doğru Akım



Alternatif akım

⇓

Ortalamalar toplamı sıfırdır



$i = \frac{dq}{dt}$ $q = \int i \, dt$

↳ Belli bir zamanda geçen yük miktarı

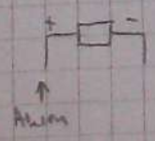
$V_{ab} = V_a - V_b$

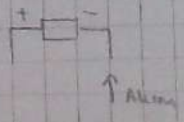
$V = \frac{dw}{dq}$

$P = \frac{dw}{dt} = \underbrace{\frac{dw}{dq}}_{V} \cdot \underbrace{\frac{dq}{dt}}_{I}$

$V_{ab} = -V_{ba}$

$P = i \cdot V$





$P = +V \cdot i$ $P = -V \cdot i$

Pasif Aktif

$R = \rho \cdot \frac{l \rightarrow m}{A \rightarrow m^2}$ $[\Omega]$ uzunluk ve alandaki uzunluk birimine dikkat et

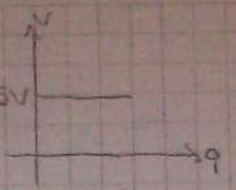
↓

Özdirenç
(Ωm)

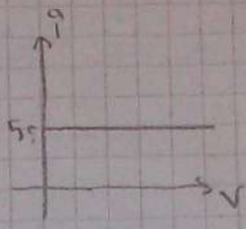
Örn: $d = 1.63$ mm çaplı 75 metrelik bakır telin direnci? $\rho = 1{,}723 \cdot 10^{-8}$ Ωm

$A = \pi r^2 = \pi \cdot \left(\frac{1.63 \cdot 10^{-3}}{2}\right)^2$

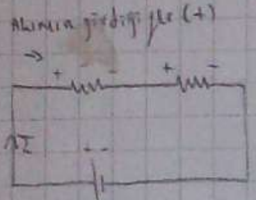
$R = 1.723 \ldots\ldots$



İdeal gerilim kaynağı



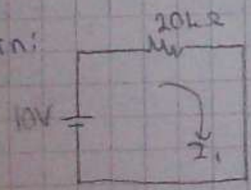
İdeal akım kaynağı

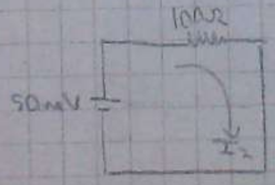


KVL

$\Sigma V = 0$ (kapalı devre için)

Örn:





a) $I_1, I_2 = ?$

b) Devreye 250Ω luk iç direnci olan ampermetre bağlanırsa

$I_1, I_2 = ?$ ve yüklenme etkisini bulun
(a ve b de bulduğun sonuçların oranı (yüzde hatası))

a) $I_1 = \frac{10}{2000} = 0{,}5$mA

$I_2 = \frac{50 \cdot 10^{-3}}{100} = 0{,}5$mA

b) $I'_{1_{ölçülen}} = \frac{10}{20000+250} = 0.494$ mA

$I'_{2_{ölçülen}} = \frac{50 \cdot 10^{-3}}{100+250} = 0.143$mA

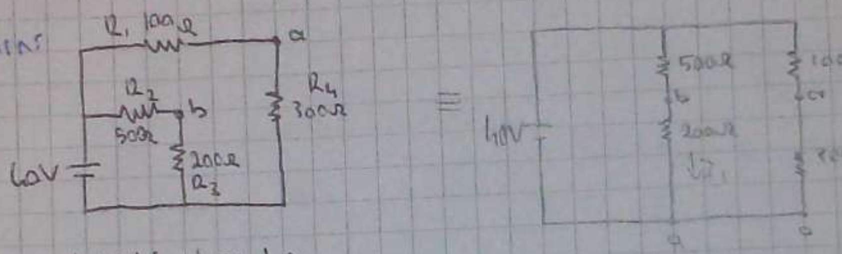
KCL

Düğüme giren akım çıkan akımların toplamına eşittir.

$\sum I = 0$ bir düğümde

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

Örnek:



R_1 100Ω
a
R_2
b
500Ω
R_4
300Ω
200Ω
R_3
60V
=
60V
500Ω
b
200Ω
I_1
100Ω
a
300Ω
I_2
0
0

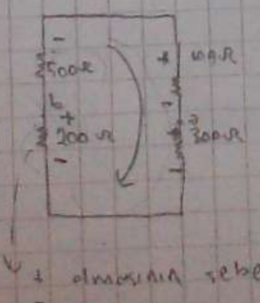
Devredeki V_{ab}'yi bulun

$I_1 = 0{,}16A$ $\quad V_b = V_b - V_0 = I_1 \cdot R = 0.16 \cdot 200 = 32V$

$I_2 = 0{,}1A$ $\quad V_a = V_a - V_0 = I_2 \cdot R = 0{,}1 \cdot 300 = 30V$

$V_{ab} = V_a - V_b = -2V$

veya



−
500Ω
b
+
200Ω
−
+
100Ω
−
300Ω

$V_{R_1} + V_{ab} + V_{R_2} = 0$

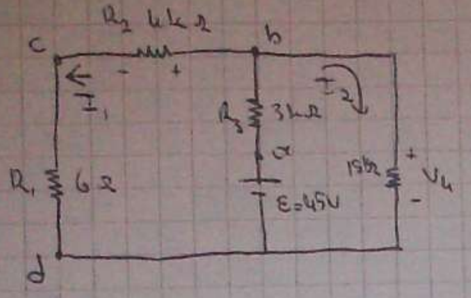
$0{,}1 \cdot 100 + V_{ab} - 50 \cdot 0{,}16$

$10 - 8 + V_{ab} = 0$

$V_{ab} = -2V$

$\pm$ olmasının sebebi; V_{ab}'yi bütün olarak almamız

Örn:


c
b
d
R_2 4kΩ
I_1
I_2
R_3 3kΩ
a
R_1 6Ω
E=45V
15kΩ
V_4
+
-

a) $R_T = ?$

b) $I_1, I_2, I_T = ?$

c) $V_2, V_4 = ?$

d) $V_{bd} = ?$

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

$I_T = 45/9 = 5 mA$

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

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

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

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

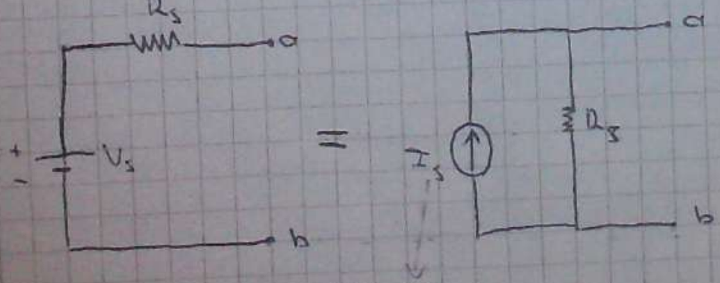
$V_{bd} = V_2 + V_1$

$= I_1 \cdot R_2 + I_1 \cdot R_1$

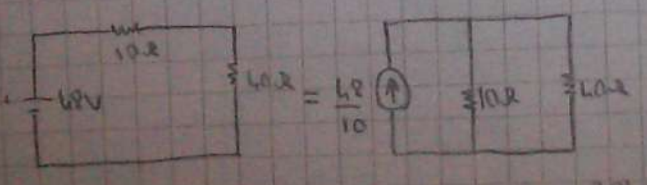
$= 12 + 18$

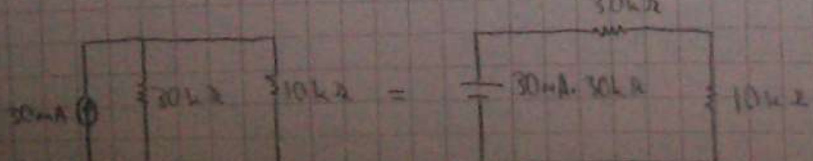
$= 30$

Kaynak Dönüşümü

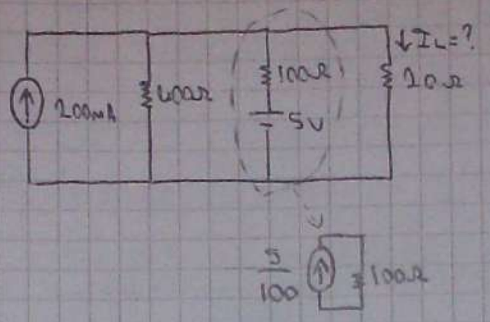

R_s
a
b
+
-
V_s
=
I_s
R_s
a
b

Akımın gidiş yönünü belirliyor

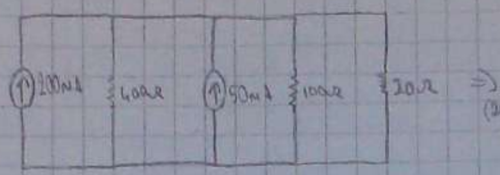

10Ω
48V
40Ω
= $\frac{48}{10}$
10Ω
40Ω

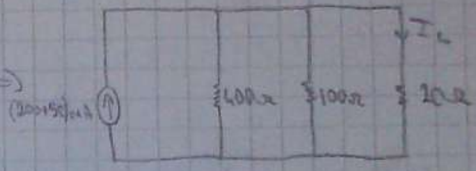

30mA
30kΩ
10kΩ
=
30kΩ
30mA. 30kΩ
10kΩ

Örn:


$\downarrow I_L = ?$
200mA
400Ω
100Ω
5V
20Ω
$\frac{5}{100}$
100Ω

Tek bir akım kaynağına dönüştürerek çözün

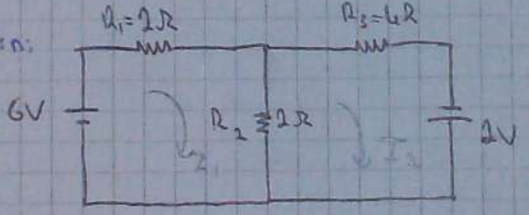

200mA
400Ω
50mA
100Ω
20Ω
=>


I_L
(200+50)mA
400Ω
100Ω
20Ω

$R_{eş} = 16Ω$

V = 250mA · 16 = 4V

Örn:


$R_1 = 2Ω$
$R_3 = 4Ω$
6V
R_2 2Ω
I_1
I_2
2V

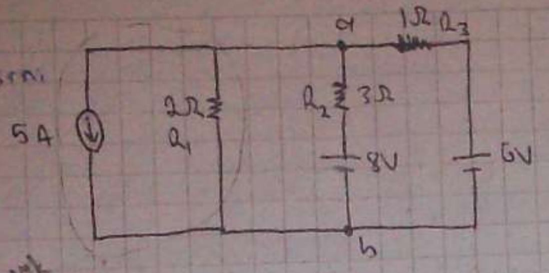
$R_1 \cdot I_1 + R_2 \cdot I_1 - R_2 \cdot I_2 + E_2 - E_1 = 0$ 1. Çevre

$I_2 \cdot R_3 - E_3 - E_2 + R_2 \cdot I_2 - R_2 I_2 = 0$ 2. Çevre

$4I_1 - 2I_2 = 2V$ $I_1 = 1{,}2\,A$

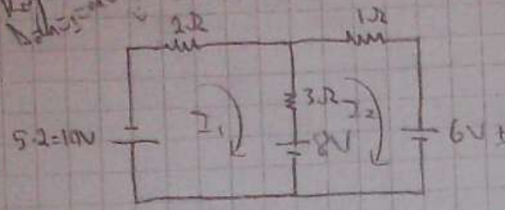
$-2I_1 + 6I_2 = 6V$ $I_2 = 1{,}4A$

örnek


5A
2Ω
R_1
a
1Ω R_3
R_2 3Ω
8V
6V
b

8V'luk kaynaktan geçen akımı bulunuz

Kaynak Dönüşümü


2Ω
1Ω
5·2=10V
I_1
3Ω
I_2
8V
6V

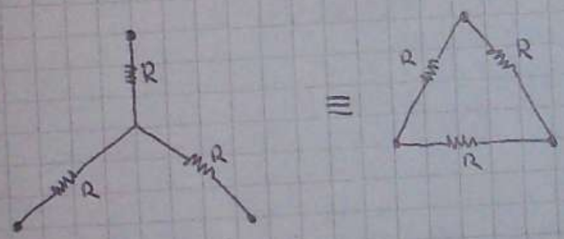
1. Çevre $I_1 \cdot 2 + (I_1 - I_2)3 + 8 + 10 = 0$

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

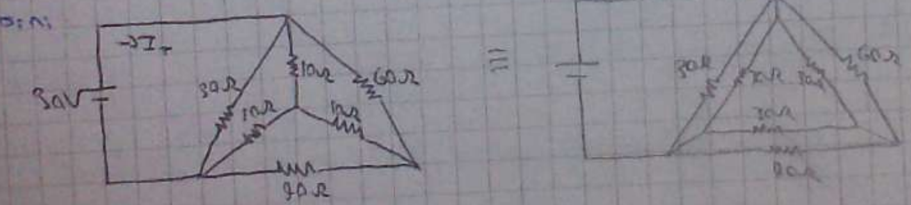
$5I_1 - 3I_2 = -18$ $\qquad I_1 = -6A$

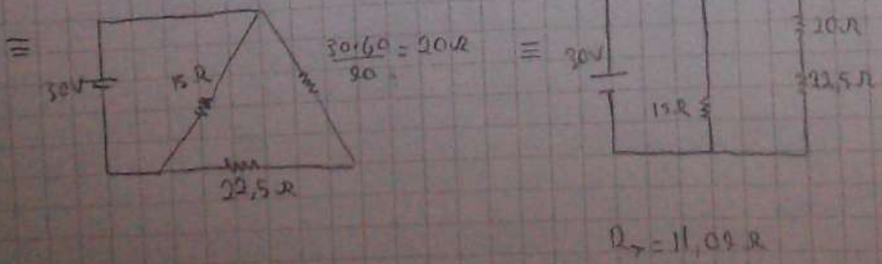
$-3I_1 + 4I_2 = 2$ $\qquad I_2 = -4A$

Yıldız Üçgen Dönüşümü



örnek

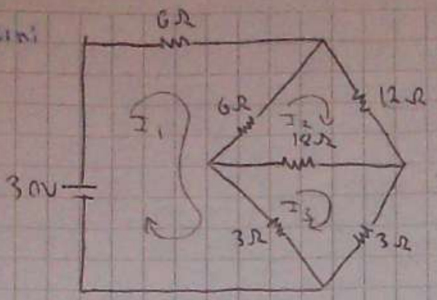

$\rightarrow I_T$
30V
30Ω
10Ω
60Ω
10Ω
10Ω
90Ω
≡
30Ω
30Ω
30Ω
60Ω
30Ω
90Ω


≡
30V
15Ω
22,5Ω
≡
30V
15Ω
20Ω
22,5Ω

$\frac{30 \cdot 60}{90} = 20\Omega$

$R_T = 11{,}02\ \Omega$

örn:



6Ω
6Ω
12Ω
I_1
I_2
18Ω
30V
I_3
3Ω
3Ω

1.Çevre / $I_1 \cdot 6 + (I_1 - I_2)6 + (I_1 - I_3)\cdot 3 - 30 = 0$

1.Çevre / $I_2 \cdot 12 + (I_2 - I_3)18 + (I_2 - I_1)6 = 0$

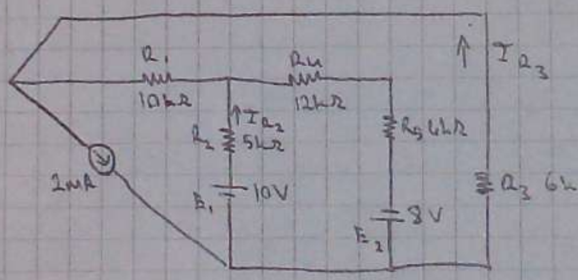
3.Çevre / $(I_3 - I_2)18 + I_3 \cdot 3 + (I_3 - I_1)3 = 0$

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

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

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

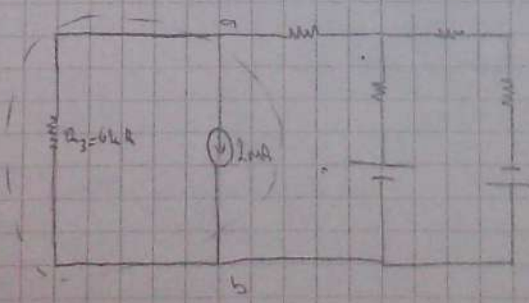
örn:



R_1
10kΩ
R_4
12kΩ
I_{R_2}
R_2 5kΩ
R_5 6kΩ
2mA
E_1
10V
8V
E_2
I_{R_3}
R_3 6kΩ

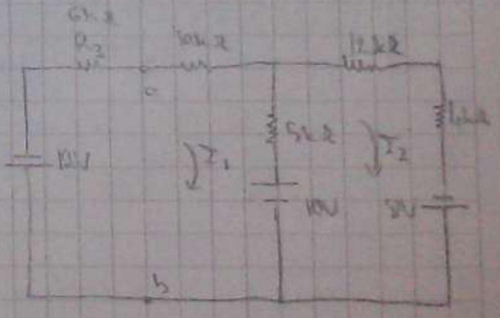
$I_{R_2} = ?$

$I_{R_3} = ?$



a
R_3=6kΩ
2mA
b

=

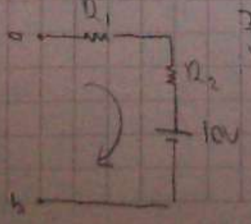


6kΩ
R_3
10kΩ
12kΩ
a
12V
5kΩ
I_1
10V
6kΩ
I_2
8V
b

1.Çevre $6I_1 + 10I_1 + 5(I_1 - I_2) + 10 + 12 = 0 \Rightarrow 21I_1 - 5I_2 = -22$

2.Çevre $16I_2 - 8 - 10 + (I_2 - I_1)5 = 0 \Rightarrow 21I_2 - 5I_1 = 18$

$\left.\right\} I_1 = -0,894\text{mA} \quad I_2 = +0,644\text{mA}$



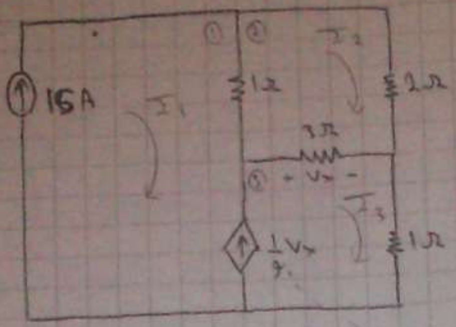
I_{R_3}' ı bulabilmemiz için V_{ab} gerekli

$V_{R_1} + V_{R_2} + 10 - V_{ab} = 0$

$V_{ab} = -6,44\,V$

$I_{R_2} = I_1 - I_2$

örn:



①
②
③
15A
I_1
I_2
I_3
1Ω
2Ω
3Ω
+ V_x -
$\frac{1}{9}V_x$
1Ω

$V_x = ?$

$\boxed{I_1 = 15A}$

$\boxed{I_3 - I_1 = \frac{1}{9}V_x}$

$V_x = (I_3 - I_2)R_3 = 3(I_3 - I_2)$

$\Downarrow$

$I_3 - I_1 = \frac{1}{9}\, 3(I_3 - I_2)$

$3I_3 - 3I_1 = I_3 - I_2$

$\boxed{2I_3 - I_2 = 45}$

2.Çevre

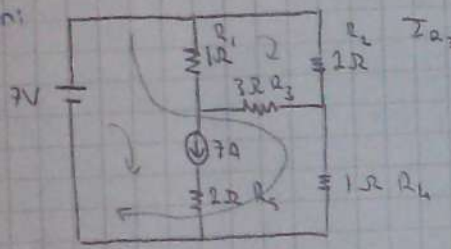
$-1 \cdot I_1 + 6I_2 - 3I_3 = 0$

$\boxed{6I_2 - 3I_3 = 15}$

$I_2 + 2I_3 = 45$

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

örn:



7V
R_1
1Ω
2
R_2
2Ω
3Ω R_3
7A
2Ω R_5
1Ω R_4

$I_{R_3} = ?$

$* \; I_1 - I_3 = 7A$

$* \; V_{R_1} + V_{R_3} + V_{R_4} - 7 = 0$

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

$V_{R_1} = (I_1 - I_2) \cdot 1\Omega$

$V_{R_3} = (I_3 - I_2) \cdot 3\Omega$

$V_{R_4} = I_3$

Düğüm Gerilimleri Yöntemi

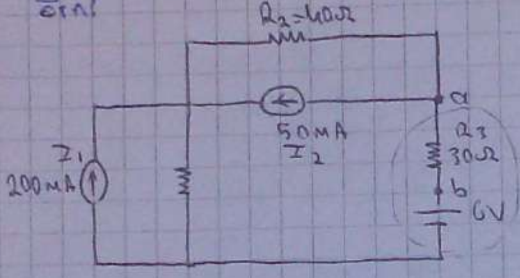
1- Referans düğüm belirliyoruz.

2- Referans düğüm harici her bir düğümü numaralandırıyoruz

3- Düğüme bağlı elemanlar için akım yönü seçiyoruz

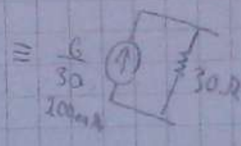
4- KCL → Her bir düğüme Kirchhoff Akım Kanunu uyguluyoruz

Örn:

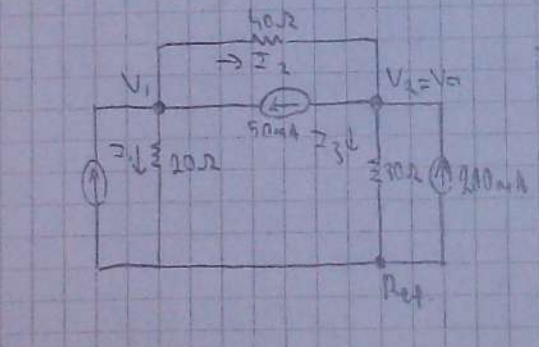


$R_2 = 40\Omega$
a
50mA
I_2
R_3
30Ω
I_1
200mA
b
6V

V_{ab} gerilimini düğüm gerilimleri yöntemini kullanarak çözünüz



≡
$\frac{6}{30}$
200mA
30Ω



40Ω
$\rightarrow I_2$
V_1
$V_2 = V_a$
50mA
I_3
I_1
20Ω
30Ω
200mA
Ref

I_1, I_2, I_3'ü kafamıza göre seçtik

2. Düğüme KCL uygularsak

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

$$I_1 = \frac{V_1 - \overset{0V}{V_{ref}}}{20\Omega} = \frac{V_1}{20}$$

1. Düğüme KCL uygulanır

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

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

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

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

$V_1 = 4.89V$

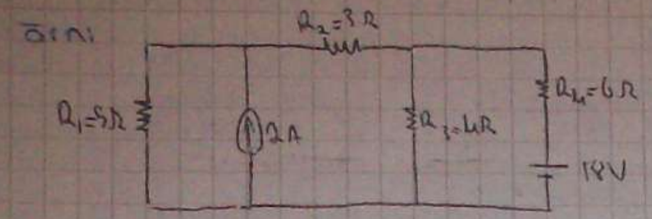
2. Denklem $150 \cdot 10^{-3} + \frac{V_1 - V_2}{40} - \frac{V_2}{30} = 0$

$V_2 = 4.67V$

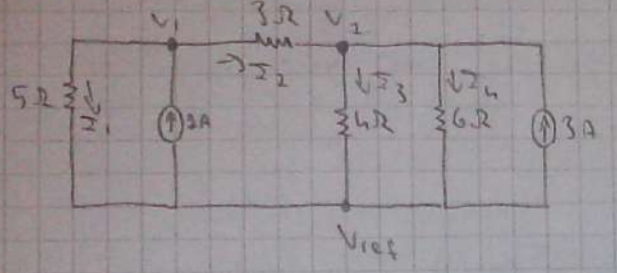
$V_B - \overset{0}{V_{ref}} = 6 \quad V_B = 6$

$V_{AB} = V_A - V_B = V_2 - 6 = 4.67 - 6 = -1.33V$

örn:


$R_2=3\Omega$
$R_1=5\Omega$
2A
$R_3=4\Omega$
$R_4=6\Omega$
18V

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


V_1
3Ω
V_2
I_2
5Ω
I_1
2A
I_3
4Ω
I_4
6Ω
3A
V_{ref}

$V_1 = 8,65V$

$V_2 = 7,85V$

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

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

$I_3 = V_2 - V_{ref}$

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

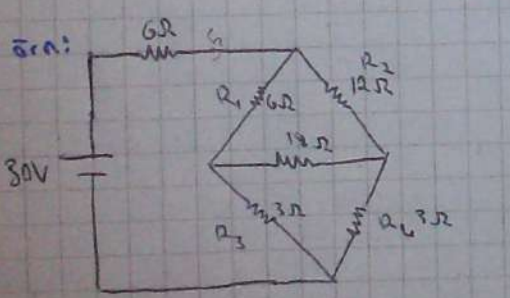
1.Düğüm

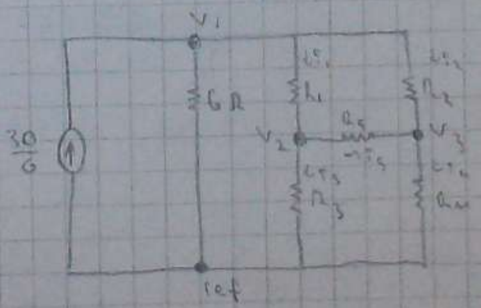
$2 - I_1 - I_2 = 0$

1.Düğüm

$3 + I_2 - I_3 - I_4 = 0$

örn:


6Ω
R_1 6Ω
R_2 12Ω
18Ω
R_3 3Ω
R_4 3Ω
30V


V_1
$\frac{30}{6}$
6Ω
I_1
R_1
I_2
R_2
V_2
R_5
I_5
V_3
I_3
R_3
I_4
R_4
ref

Düğüm gerilimleri yöntemi ile V_{R_3}=?

$V_{ref} = 0$

$\Sigma I_{gelen} = \Sigma I_{çıkan}$

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

$\frac{V_1 - V_2}{6} = \frac{V_2 - V_{ref}}{3} + \frac{V_2 - V_3}{18}$

V_3 için

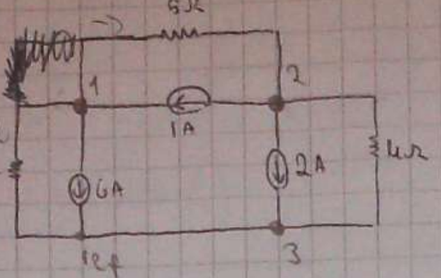
$\frac{V_3 - V_{ref}}{3} = \frac{V_1 - V_3}{12} + \frac{V_2 - V_3}{18}$

$V_1 = 14,48V$

$V_2 = 4,66V$

$V_3 = 3,10V$

örn:



1. Düğüm

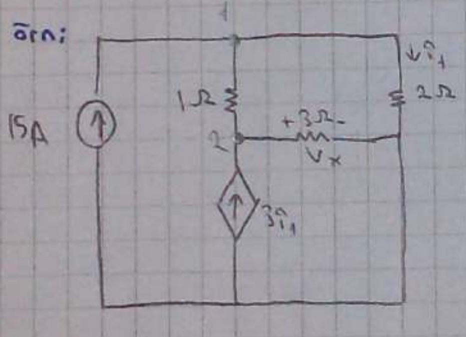
$1 = \frac{V_1 - V_2}{5} + \frac{V_1 - V_{ref}}{3} + 6$

bunu bağlar
→ Düğüme giren dirençlerin terslerinin toplamı

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

$\left(-\frac{1}{5}\right)V_1 + \left(\frac{1}{4}+\frac{1}{5}\right)V_2 = -1-2 \rightarrow -\frac{1}{5}V_1 + \left(\frac{1}{4}+\frac{1}{5}\right)V_2 = -3$

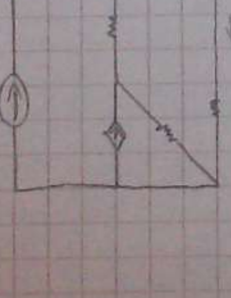
örn:



Bağımlı akım kaynağı tarafından harcanan güç nedir?

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

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



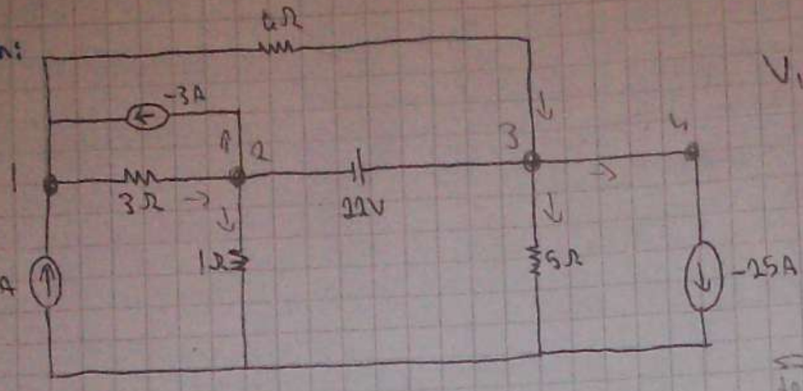
2. Nolu düğüm 1. Nolu düğüm

$\frac{V_1 - V_2}{1} + 3i_1 - \frac{(V_2 - V_{ref})}{3} = 0 \qquad 15 - \frac{(V_1 - V_2)}{1} - \frac{(V_1 - V_{ref})}{2} = 0$

$$\left.\begin{array}{l} -15V_1 + 8V_2 \\ 12V_1 - 8V_2 = 120 \end{array}\right\} \begin{array}{l} V_1 = -40V \\ V_2 = -75V \end{array}$$

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

Örn:

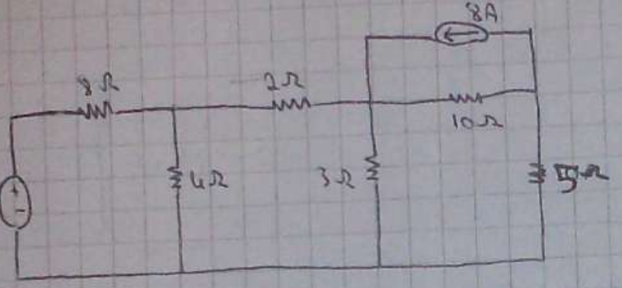

4Ω
-3A
1
2
3
4
3Ω
1Ω
22V
5Ω
-8A
-25A

$V_1 = ?$

İki düğüm arasında sadece gerilim kaynağı varsa 2. ve 3. düğümler süper düğüm olur. Bunları tek düğüm kabul et

$V_2 - V_3 = -22$ $\frac{V_1-V_2}{3} + \frac{V_1-V_3}{4} = \frac{V_2}{1} + \frac{V_3}{5} - 25 - 3$

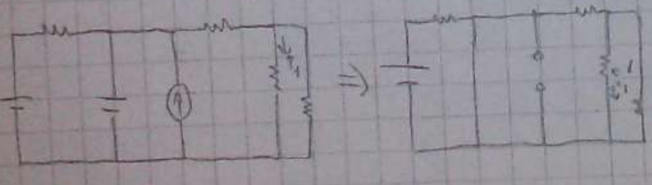
Örn:


8Ω
2Ω
8A
10Ω
100V
4Ω
3Ω
5Ω

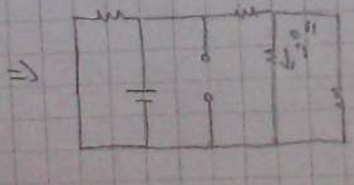
$i_x = ?$

TOPLAMSALLIK TEORİSİ

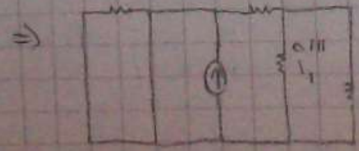
* Lineer devrelerde kullanılabilir



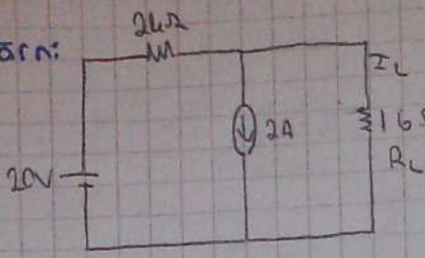
$i_1 = i_1' + i_1'' + i_1'''$



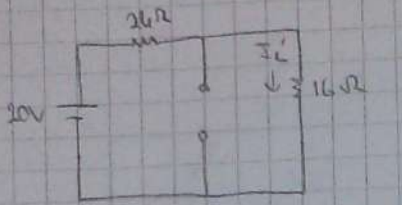
* Bağımlı akım kaynağına uygulanmaz

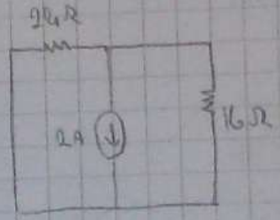


örn:


2kΩ
20V
2A
I_L
16Ω
R_L

$I_L = ?$

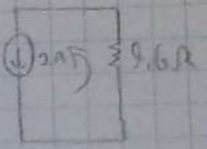

2kΩ
20V
I_L'
16Ω



2k // 16

$R_{eş} = 9,6$

$\Rightarrow$



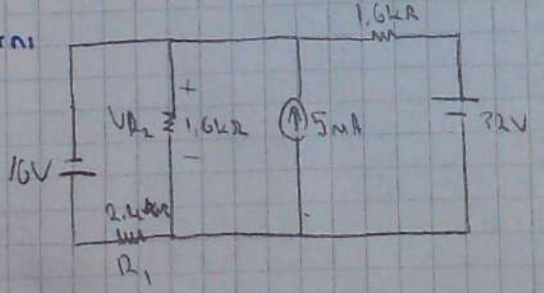
$I_L' = \frac{20}{40} = 0,5\ A$

$2 \cdot 9,6 = 19,2\ V \Big\{ I_L'' = \frac{19,2}{16} = 1,2A$

$I_L = I_L' + I_L''$

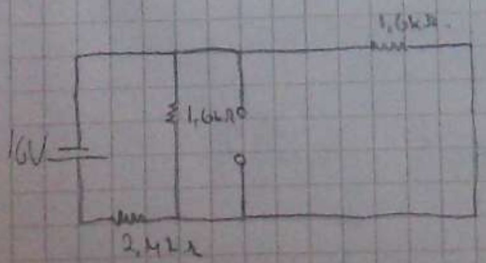
$= 0,5 + 1,2 = 1,7\ A$

örn:

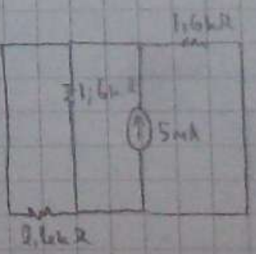

1,6kΩ
+
V_{R_2}
1,6kΩ
−
5mA
32V
16V
2,4kΩ
R_1

$V_{R_2} = ?$

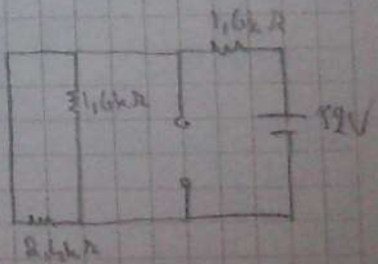
$V_{R_2} = V_{R_2}' + V_{R_2}'' + V_{R_2}'''$


1,6kΩ
1,6kΩ
16V
2,4kΩ

+


1,6kΩ
1,6kΩ
5mA
2,4kΩ

+


1,6kΩ
1,6kΩ
32V
2,4kΩ

$V_R' = -\frac{16}{2,4+0,8} 0,8 = -4V$

$\underbrace{2,4 // 1,6 // 1,6 //}$

$2,4 // 0,8 = 0,6k\Omega$

$0,6k\Omega \cdot 5mA = 3V$

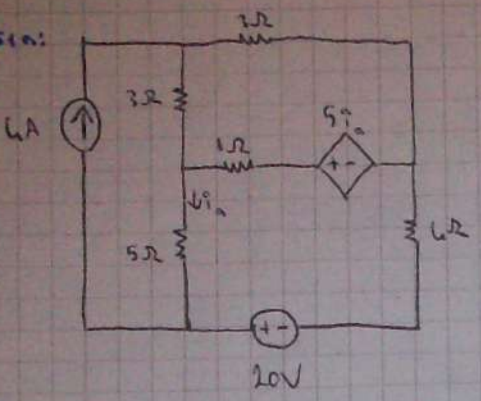
$V_{R_2}'' = 3V$

$2,4 // 1,6 + 1,6 = 2,5k\Omega$

$I = \frac{32}{2,5}$

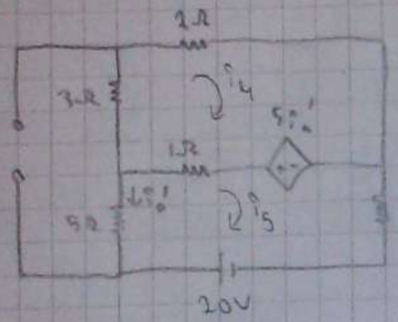
$V_R''' = 12V$

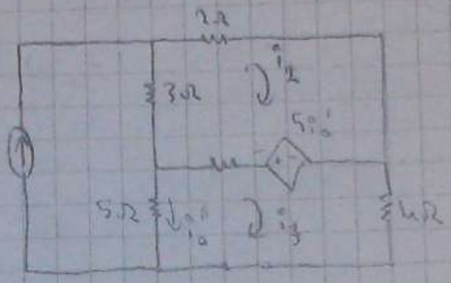
Soru:


2Ω
3Ω
6A
$5i_a$
1Ω
i_a
5Ω
6Ω
20V

i_a akımını toplamsallık teoremiyle hesaplayın

* Bağımlı kaynaklara dokunmadan çözüm yapıyoruz


2Ω
3Ω
i_4
$5i_a'$
1Ω
i_a'
5Ω
i_5
20V


2Ω
3Ω
i_2
$5i_a'$
5Ω
i_a''
i_3
6Ω

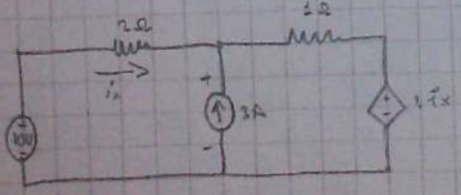
1.çevre

$$6i_4 - 1 \cdot i_5 = 5i_a'$$

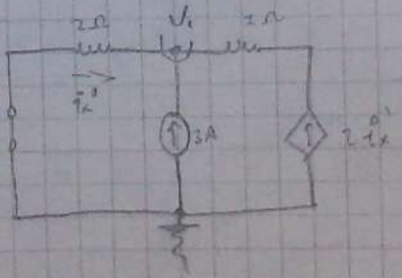
2.çevre

$$-1 \cdot i_4 + 10 \cdot i_5 = 20 - 5i_a'$$

$$i_a' = -i_5$$

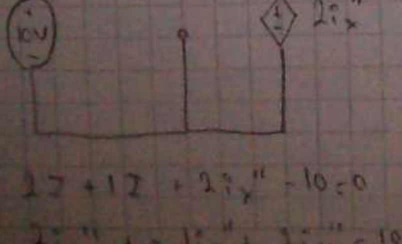

2Ω
1Ω
i_x
10V
+
3A
-
$2i_x$

i_x akımını toplamsallık teoremini kullanarak bulunuz


2Ω
V_1
1Ω
i_x'
3A
$2i_x'$

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

Gelen akım pozitif alınırsa



$$i_x' = -\frac{V_1}{2}$$

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

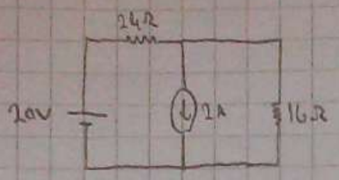
$$i_x' = -0{,}6A$$

$$I = i_x''$$

$$2I + 1I + 2i_x'' - 10 = 0$$

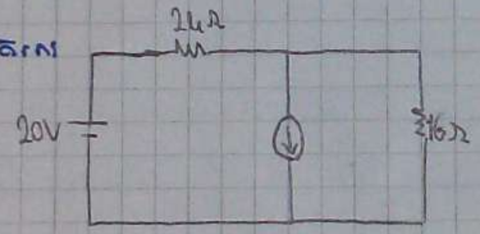
$$2i_x'' + 1i_x'' + 2i_x'' = 10 \qquad i_x'' = 10/5 = 2A$$

THEVENIN TEOREMİ

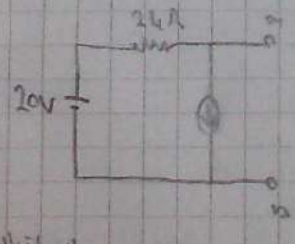

24Ω
20V
2A
16Ω

İlk adım → yükü devreden çıkartıyoruz

örn

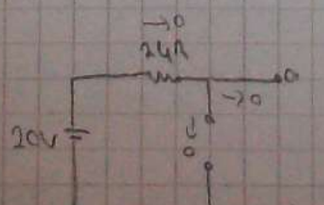


16Ω luk direnç üzerinden geçen akımı Theveninden bulun

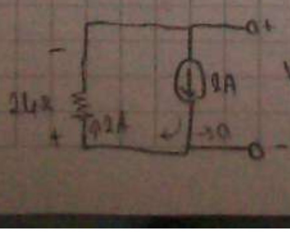


V_{ab}'yi [illegible]

Toplamsallığı kullanıyoruz

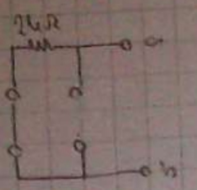


$V_{ab}' = 20V$



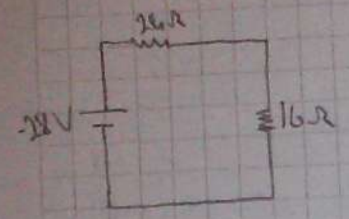
$V_{ab}'' = -48V$

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



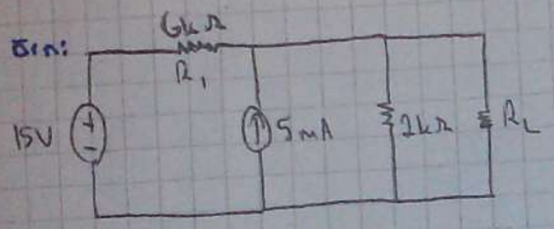
Bağımsız kaynakları açık devre sıfırlıyoruz

$R_{eş} = 2k\Omega = R_{TH}$



$I = \frac{-28}{16+26} = -0,7\ A$

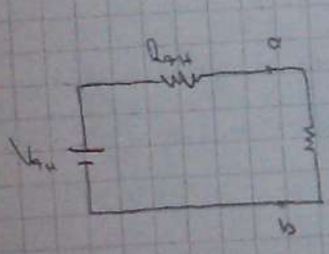
Örn:

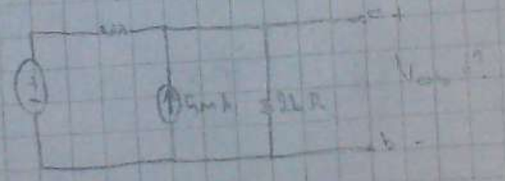

6kΩ
R1
15V
5mA
2kΩ
RL

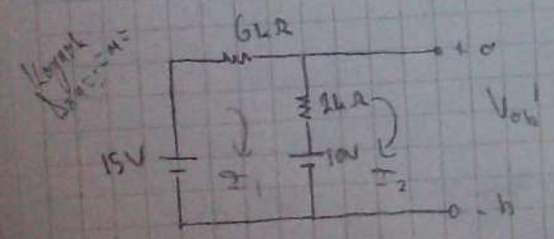
$R_L \to 0\Omega \to I_1$

$R_L \to 2k\Omega \to I_2$

$R_L \to 5k\Omega \to I_3$




5mA
2kΩ
a +
Vab ?
b -


Kaynak dönüşümü
6kΩ
+ a
2kΩ
15V
10V
I1
I2
Vab'
- b

$I_2 = 0$

$(6+2)I_1 - 2\overset{0}{I_2} + 10 - 15 = 0$

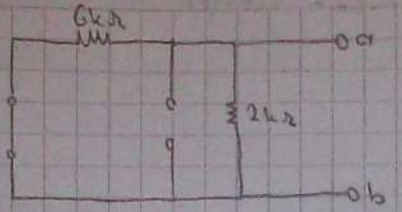
$8I_1 = 5 \quad I_1 = 5/8 = 0{,}625A$

$2\overset{0}{I_2} - 2I_1 + V_{ab} - 10 = 0$

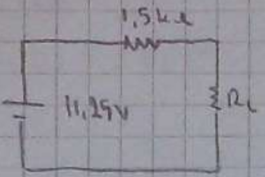
$-2I_1 + V_{ab} = 10$

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

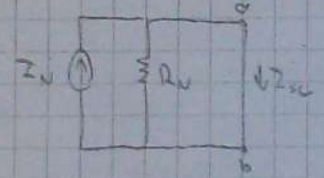
$= 11{,}25V = V_{TH}$



$R_{eş} = \frac{6 \cdot 2}{2+6} = 1,5\,k\Omega = R_{Th}$

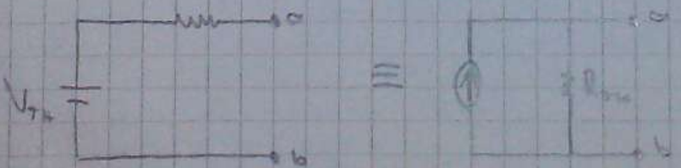

1,5kΩ
11,25V
R_L

NORTON TEOREMİ

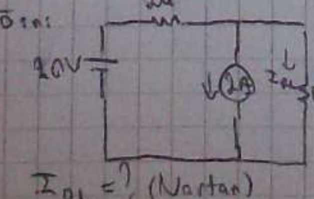


- İlk olarak yükü devreden çıkartıyoruz
- a-b uçlarını kısa devre yaparak I_{sc} akımını hesaplıyoruz $I_{sc} = I_N$

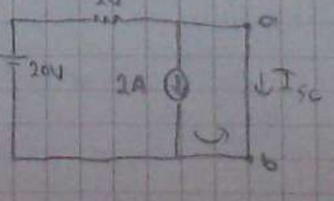
- Bütün bağımsız kaynakları [illegible] a-b uçlarında görülen $R_{eş}$ bulunuyor. $R_N = R_{eş} = R_{Th}$


a
V_{Th}
b
≡
R_{Th}
a
b

Örn:

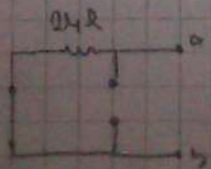

24k
20V
2A
I_{aL}
16Ω

$I_{aL} = ?$ (Norton)

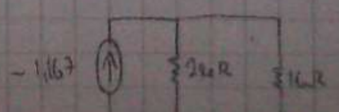

24k
20V
2A
I_{sc}
a
b

$\frac{20}{24k} - 2 = 0,83 - 2, = -1,167A$

$I_{sc} = -1,167A$

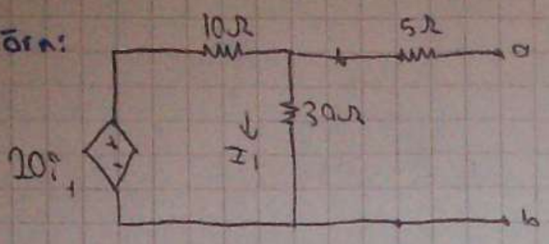


$R_{eş} = 24k\Omega$


−1,167
24kΩ
16kΩ

$\frac{24k}{24k+16}(-1,167) = -0,7\,A$

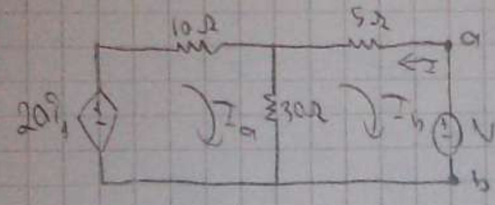
Örn:


10Ω
5Ω
a
I_1
30Ω
$20i_1$
+
−
b

Thevenin eşdeğer devresini bulun

* Bağımlı kaynağı çıkaramayız

İlk durum için devreye güç veren bir kaynak yok $I_1 = 0 \Rightarrow V_{TH} = 0$
$V_{ab} = 0 \Rightarrow$


10Ω
5Ω
a
I
$20i_1$
I_a
30Ω
I_b
b

$\frac{V_{Test}}{I} = R_{eş} = R_{th}$ $I = ?$

$V_{Test} = 1V$ olsun

1. çevre

2. çevre

$i_1 = I_a - I_b$

$10I_a + 30(I_a - I_b) = 20i_1$

$40I_a - 30I_b = 20i_1$

$20I_a - 10I_b = 0$

$2I_a = I_b$

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

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

$35I_b - 30I_a = -1$

$I_b = -0{,}05 \Longrightarrow I = 0{,}05\text{ A}$
$I_a = -0{,}025$

$\frac{V_{Test}}{I} = \frac{1}{0{,}05} = 20\,\Omega$