

# SERİ PARALEL DİRENÇ BİRLEŞTİRMELERİ

Şimdiye kadar KGK (tek gözü) veya KAK (tek düğüm çiftli) uygulaması ile analiz edilebilen devreleri inceledik,

Bazı durumlarda, bir devrenin analizini basitleştirmek için dirençleri birleştirmenin avantajlı olduğunu gördük

Şimdi dirençleri birleştirme tekniğini kullanarak analizi basitleştirebileceğimiz bazı daha karmaşık devreleri inceleyeceğiz ...

## SERİ BİRLEŞTİRMELER

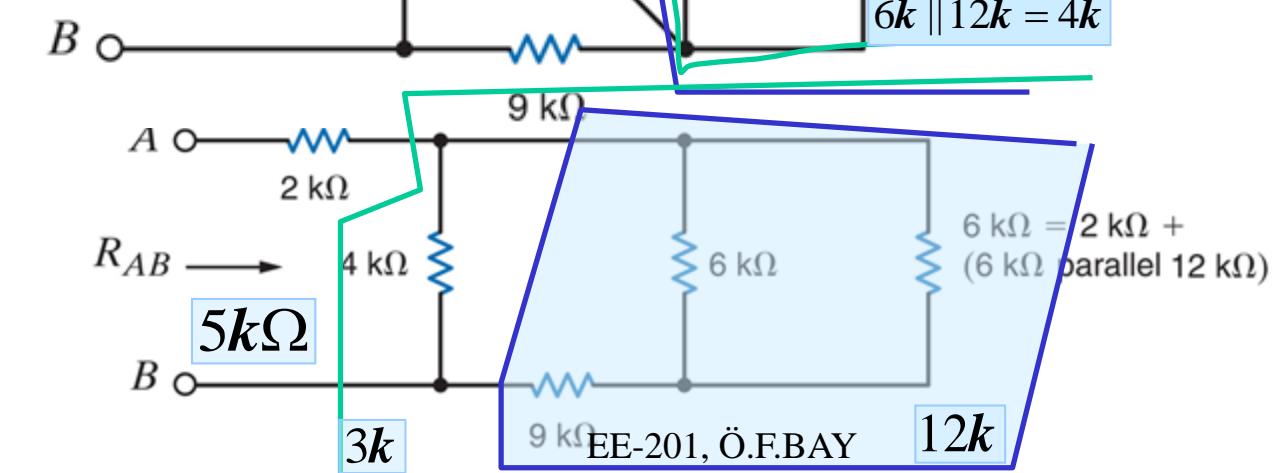
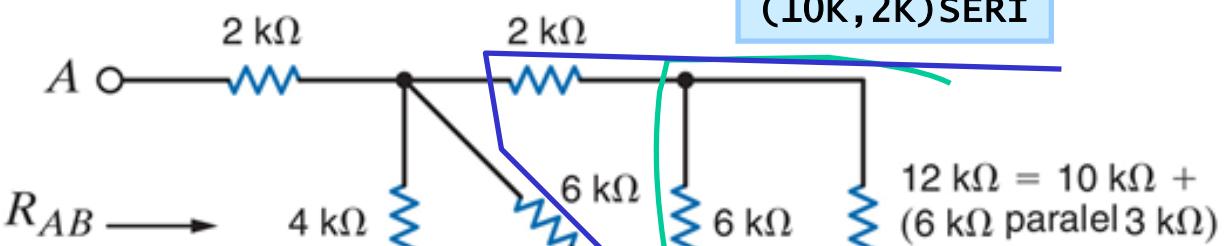
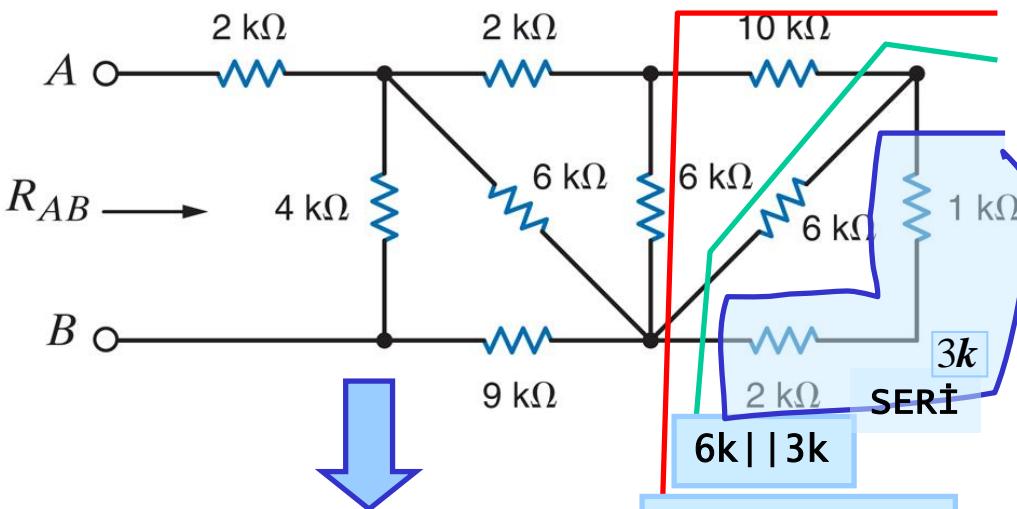
$$R_s = R_1 + R_2 + \dots + R_N$$

## PARALEL BİRLEŞTİRMELER

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_N}$$

$$G_p = G_1 + G_2 + \dots + G_N$$

## İLK ÖNCE DİRENÇLERİN BİRLEŞTİRİLMESİ İŞLEMİNİ YAPIYORUZ



# PROBLEM-SOLVING STRATEGY

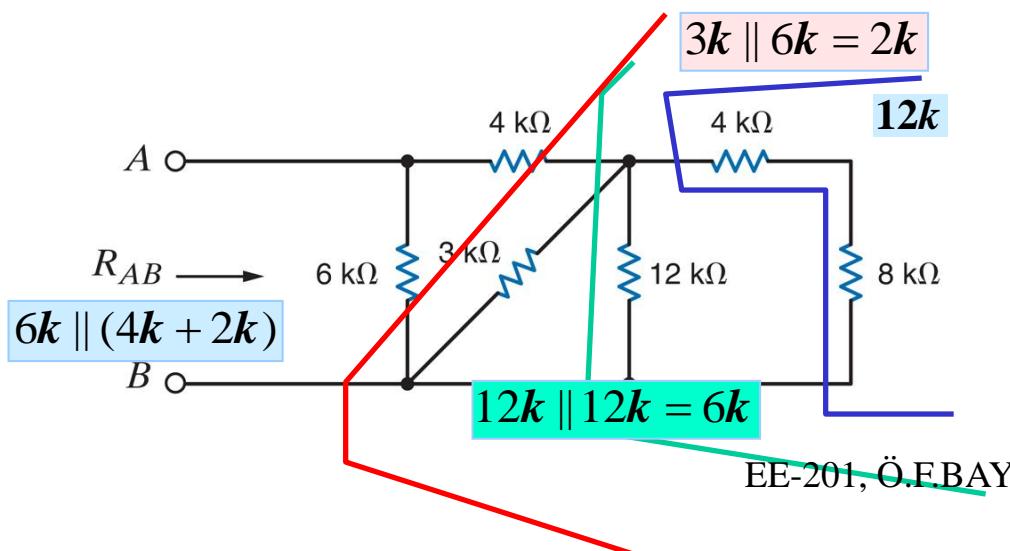
When trying to determine the equivalent resistance at a pair of terminals of a network composed of an interconnection of numerous resistors, it is recommended that the analysis begin at the end of the network opposite the terminals. Two or more resistors are combined to form a single resistor, thus simplifying the network by reducing the number of components as the analysis continues in a steady progression toward the terminals. The simplification involves the following:

## SIMPLIFYING RESISTOR COMBINATIONS

- STEP 1.** **Resistors in series.** Resistors  $R_1$  and  $R_2$  are in series if they are connected end to end with one common node and carry exactly the same current. They can then be combined into a single resistor  $R_S$ , where  $R_S = R_1 + R_2$ .

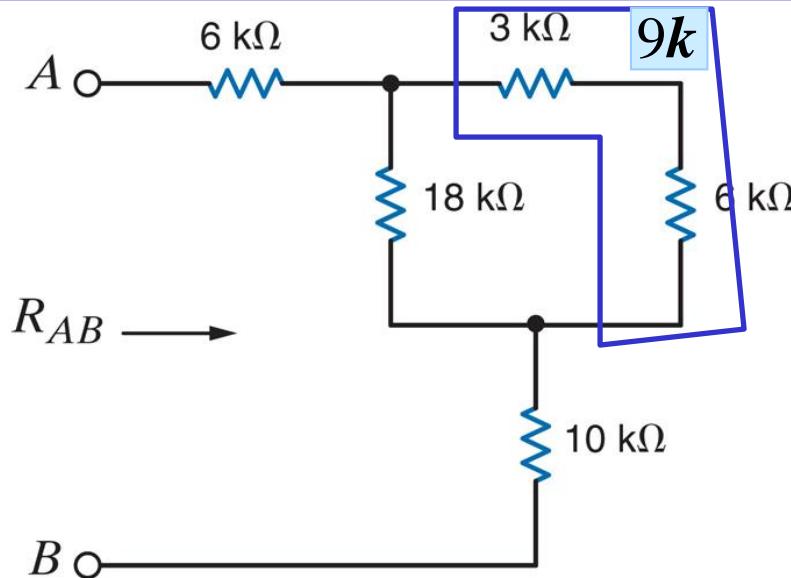
**STEP 2.** **Resistors in parallel.** Resistors  $R_1$  and  $R_2$  are in parallel if they are connected to the same two nodes and have exactly the same voltage across their terminals. They can then be combined into a single resistor  $R_P$ , where  $R_P = R_1R_2/(R_1 + R_2)$ .

These two combinations are used repeatedly, as needed, to reduce the network to a single resistor at the pair of terminals.

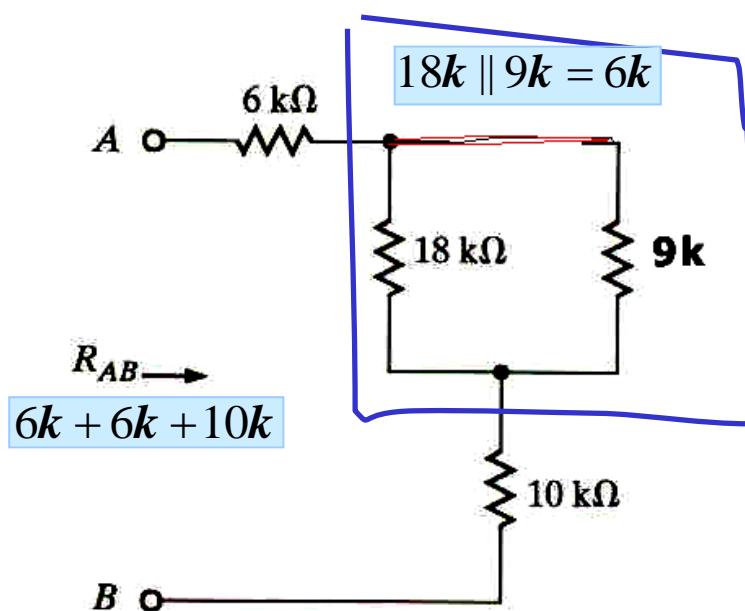


**İşler kafa karıştırıcı  
gelirse...**

## ÖRNEKLER: SERİ-PARALEL BİRLEŞTİRMEMLER



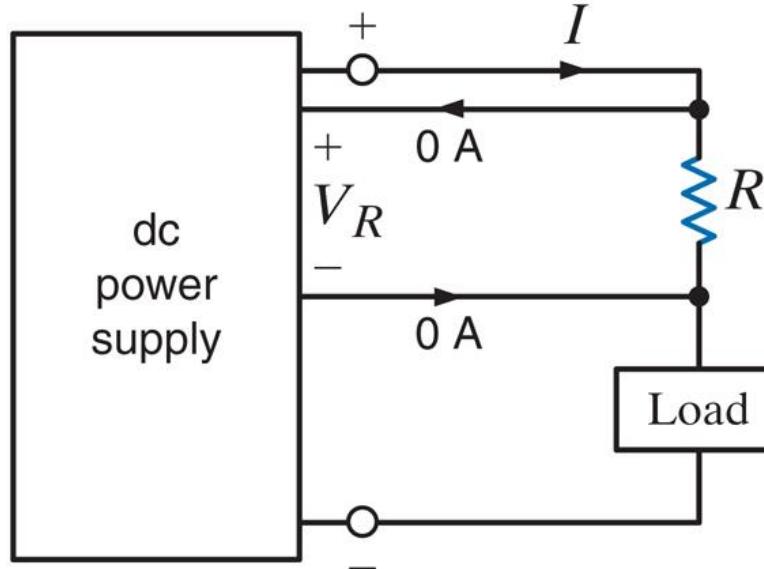
Çizim kafa karıştırıcı olursa ...  
Sadeleştirilmiş devreyi yeniden  
çizip tekrar başlayın



Dirençler tam olarak aynı akımı taşıyorsa seri haldedirler

Dirençler aynı iki düğüm arasına bağlandıklarında paraleldirler

# “TERS SERİ PARALEL BİRLEŞTİRMELER”



## BASİT ÖRNEK

$V_R$  600mV olmalı,  $I = 3A$  iken

ELIMIZDE SADECE  $0.1\Omega$  DIRENC BULUNMAKTADIR

$$\text{GEREKLI } R = \frac{0.6V}{3A} = 0.2\Omega \Rightarrow R = 0.1\Omega + 0.1\Omega$$

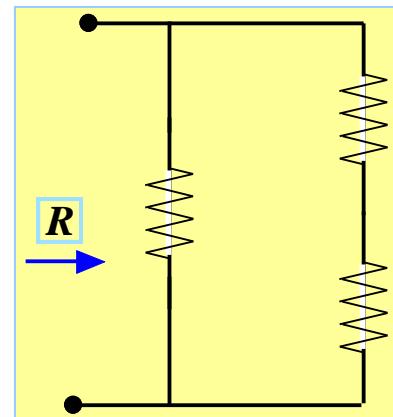
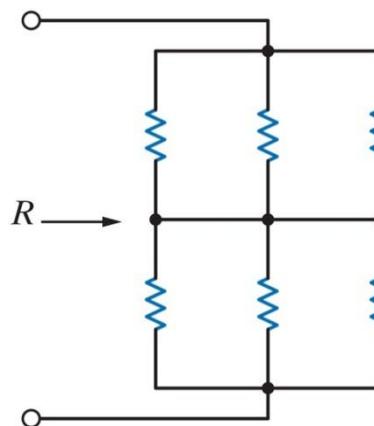
Son değeri göz önüne alarak  
doğru kombinasyonu bulun

## BASİT OLMAYAN ÖRNEK

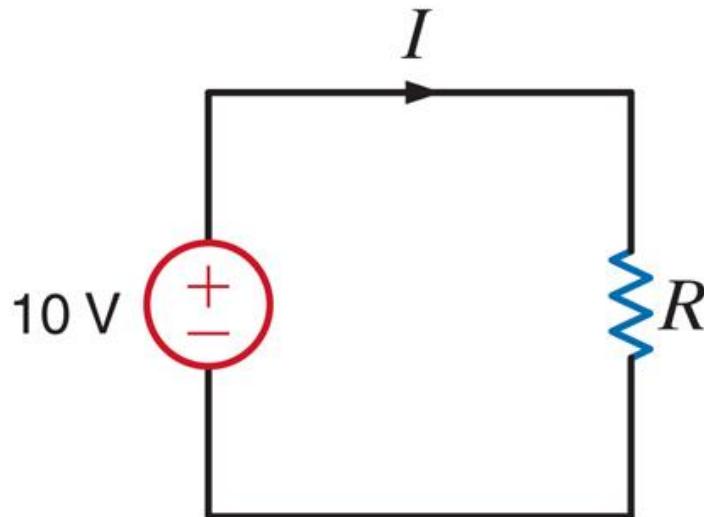
$V_R$  600mV olmalı,  $I = 9A$  iken

SADECE  $0.1\Omega$  DIRENC MEVCUTTUR

$$\text{GEREKLI } R = \frac{0.6V}{9A} = 0.0667\Omega \Rightarrow$$



## DİRENÇ TOLERANSININ ETKİSİ



NORMAL DIRENC DEGERI :  $2.7\text{k}\Omega$   
DIRENC TOLERANSI : 10%

AKIM VE GÜC ARALIKLARI?

$$\text{NORMAL AKIM} : \bar{I} = \frac{10}{2.7k} = 3.704 \text{ mA}$$

$$\text{NORMAL GUC} : P = \frac{(10)^2}{2.7k} = 37.04 \text{ mW}$$

$$\text{MINIMUM AKIM} : I_{\min} = \frac{10}{1.1 \times 2.7k} = 3.367 \text{ mA}$$

$$\text{MAKSIMUM AKIM} : I_{\max} = \frac{10}{0.9 \times 2.7k} = 4.115 \text{ mA}$$

MINIMUM GUC( $V I_{\min}$ ) :  $33.67 \text{ mW}$   
MAKSIMUM GUC :  $41.15 \text{ mW}$

AKIM VE GÜC ARALIKLARI TOLERANSLA BELİRLENİR,  
ANCAK DEĞİŞİM YÜZDESİ TOLERANS YÜZDESİNDEN FARKLI OLABİLİR.  
ARALIKLAR SİMETRİK OLMIYABİLİR

## SERİ-PARALEL DİRENÇ KOMBİNASYONLU DEVRELER

ELEMANLARIN BİRLEŞTİRİLMESİ, BİR DEVRENİN KARMAŞIKLIĞINI AZALTABİLİR VE ŞİMDİYE KADAR GELİŞTİRİLEN TEMEL ARAÇLARI KULLANARAK ANALİZ İÇİN UYGUN HALE GETİRİLEBİLİR.

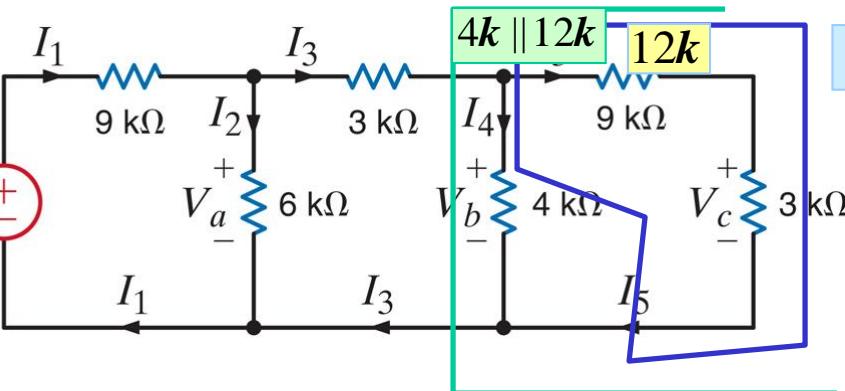
SERİ OLARAK BİRLEŞTİRİLEN DİRENÇLER  
DEVREDEN BİR DÜĞÜMÜ ORTadan KALDIRIR.

PARALEL OLARAK BİRLEŞTİRİLEN DİRENÇLER  
DEVREDEN BİR ÇEVREYİ ORTadan KALDIRIR.

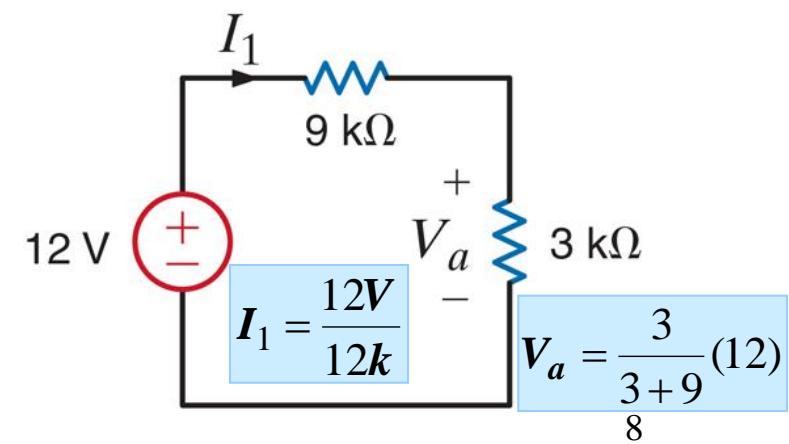
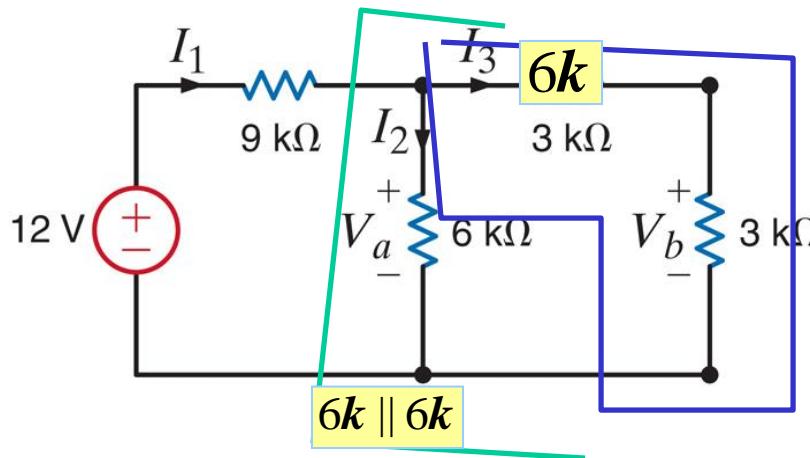
### GENEL STRATEJİ:

- DEVRENİN ANALİZ EDİLEBİLMESİ İÇİN YETERİNCE BASIT HALE GELİNCEYE KADAR KARMAŞIKLIĞINI AZALTIN.
- ORİJİNAL DEVREDEKİ İSTENEN DEĞİŞKENLERİ HESAPLAMAK İÇİN BASİTLEŞTİRİLMİŞ DEVREDEKİ VERİLERİ KULLANIN
- BU NEDENLE DEĞİŞKENLER ARASINDAKİ HERHANGİ BİR İLİŞKİYİ TAKİP ETMENİZ GEREKİR.

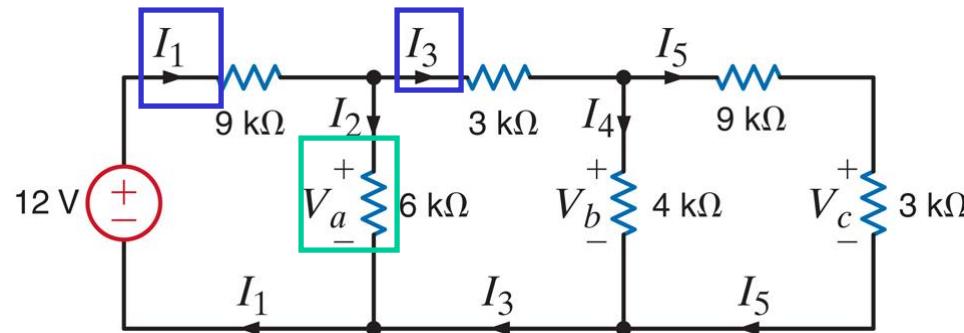
AŞAĞIDAKİ DEVREDE ETİKETLENMİŞ BÜTÜN AKIM VE GERİLİMLERİ BULMAK İSTİRORUZ



Önce onu tek gözlü bir devreye indirgeyin



Sonra: OHM KANUNU, KGK VE KAK KULLANIN



$$\text{OHM KANUNU : } I_2 = \frac{V_a}{6k}$$

$$\text{KAK : } I_1 - I_2 - I_3 = 0$$

$$\text{OHM KANUNU : } V_{3k} = 3k * I_3$$

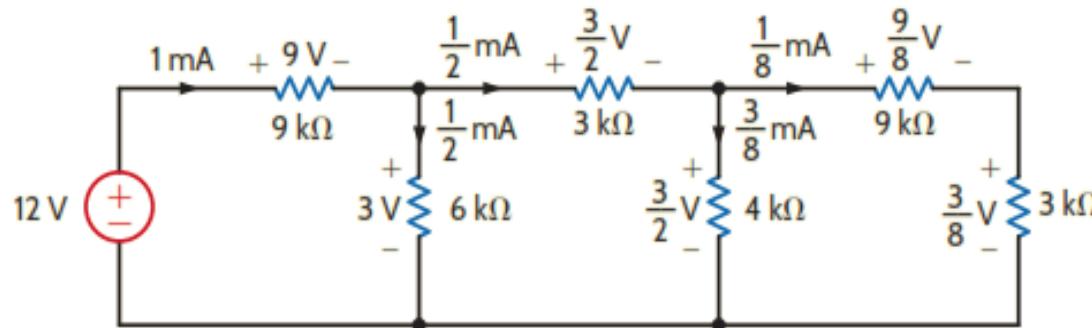
...DİĞER OPSİYONLAR...

$$I_4 = \frac{12}{4+12} I_3$$

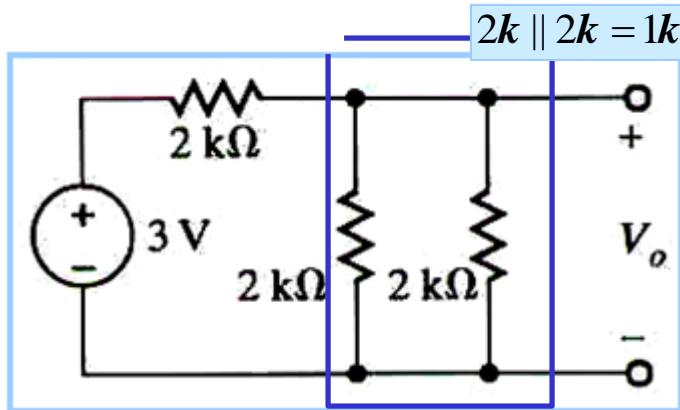
$$V_b = 4k * I_4$$

$$\text{KAK : } I_5 + I_4 - I_3 = 0$$

$$\text{OHM KANUNU : } V_c = 3k * I_5$$



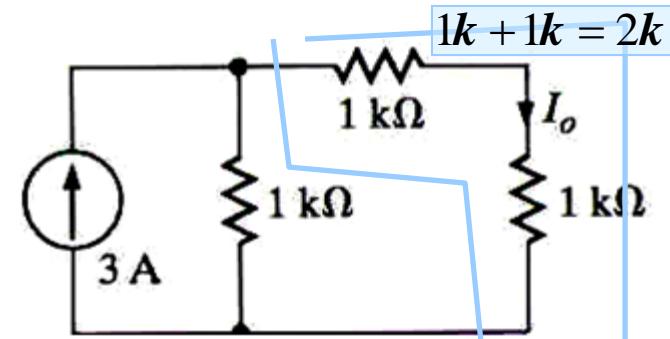
**V<sub>o</sub> değerini bulun**



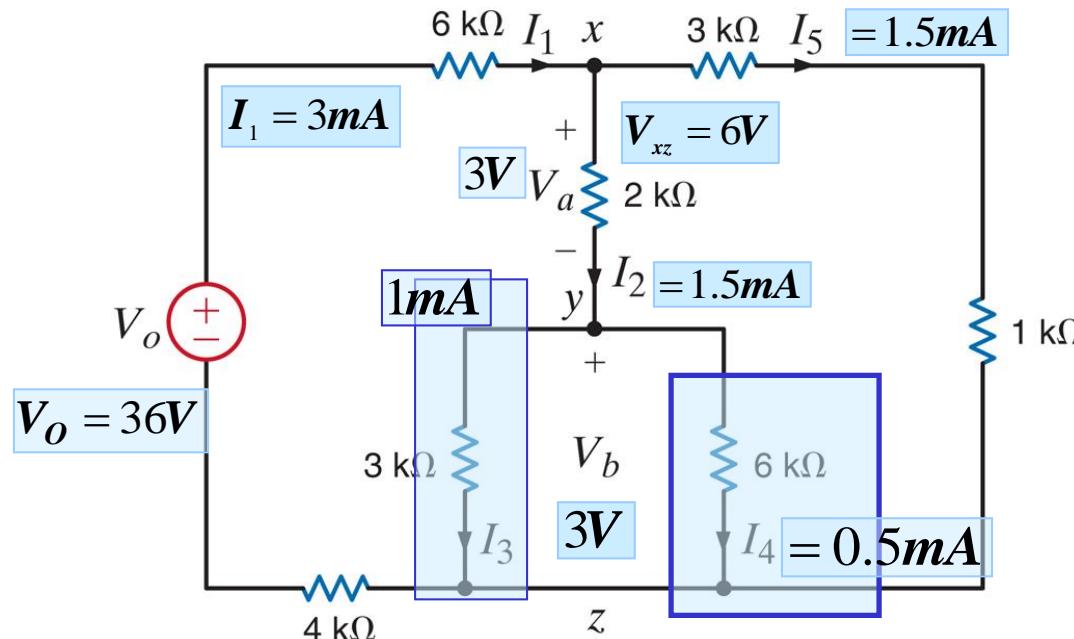
$$\text{GERİLİM BOLUCU : } V_o = \frac{1k}{1k + 2k} (3V) = 1V$$

**YAPARAK ÖĞRENİN**

**I<sub>o</sub> değerini bulun**



$$\text{AKIM BOLUCU : } I_o = \frac{1k}{1k + 2k} (3A) = 1A$$



STRATEJİ. HER ZAMAN SORUN: “BAŞKA NEYİ HESAPLAYABİLİRİM?”

$$V_b = 6k * I_4$$

$$I_3 = \frac{V_b}{3k}$$

$$I_2 = I_3 + I_4$$

$$V_a = 2k * I_2$$

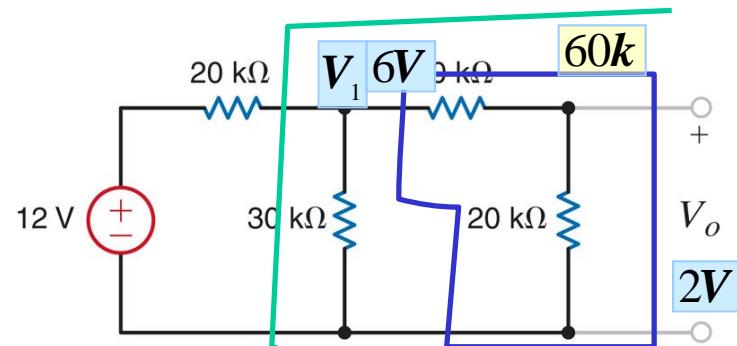
$$V_{xz} = V_a + V_b$$

$$I_5 = \frac{V_{xz}}{4k}$$

$$I_1 = I_2 + I_5$$

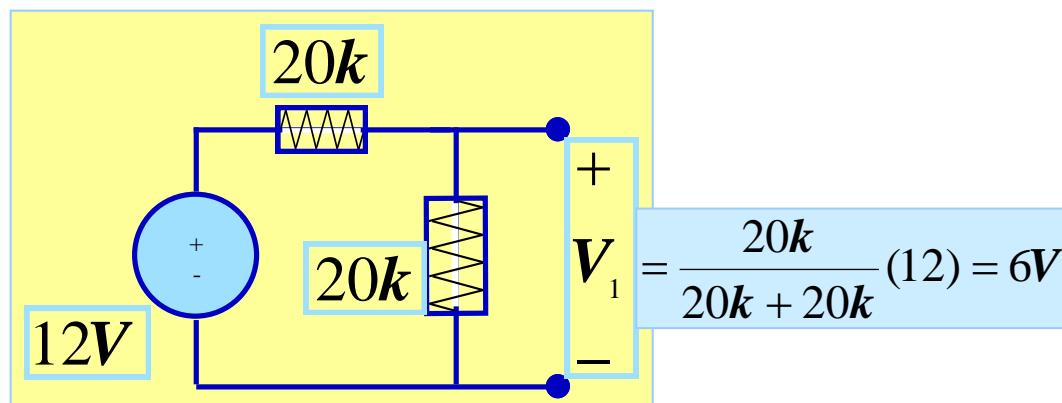
$$V_o = 6k * I_1 + V_{xz} + 4k * I_1$$

$V_o$ 'i bulun



STRATEJİ :  $V_1$ 'i bul  
Gerilim Bolucu kullan

$$30k \parallel 60k = 20k$$

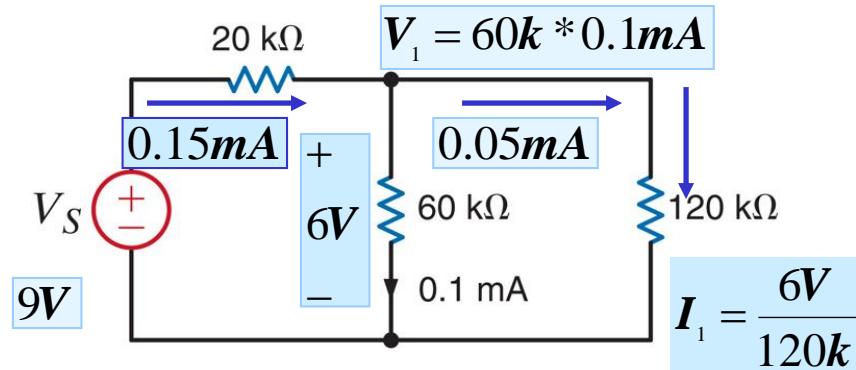


$$V_1 = \frac{20k}{20k + 20k} (12) = 6V$$

GERİLİM BOLUCU

$$V_o = \frac{20k}{20k + 40k} V_1$$

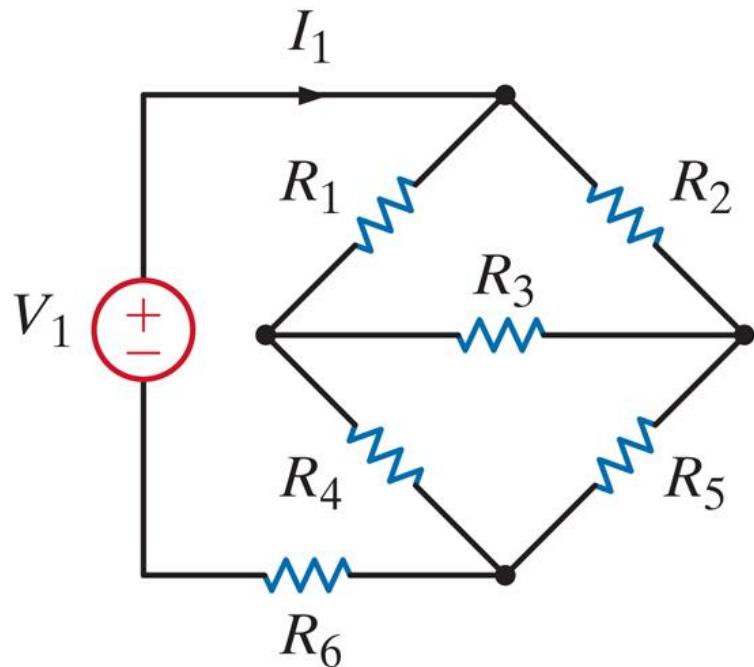
$V_s$  'yi bulun



Bu tersden bir sorudur, ne hesaplanabilir?

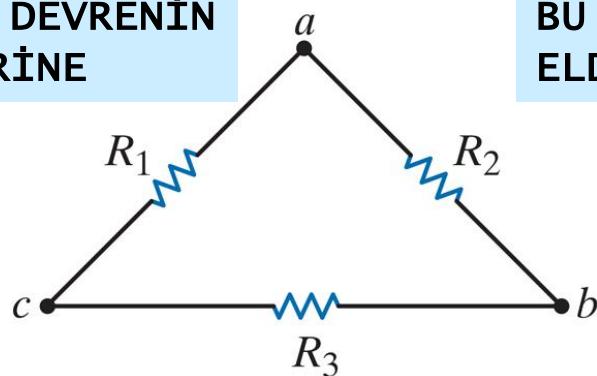
$$V_s = 20k * 0.15mA + 6V$$

## YILDIZ ÜÇGEN DÖNÜŞÜMLERİ



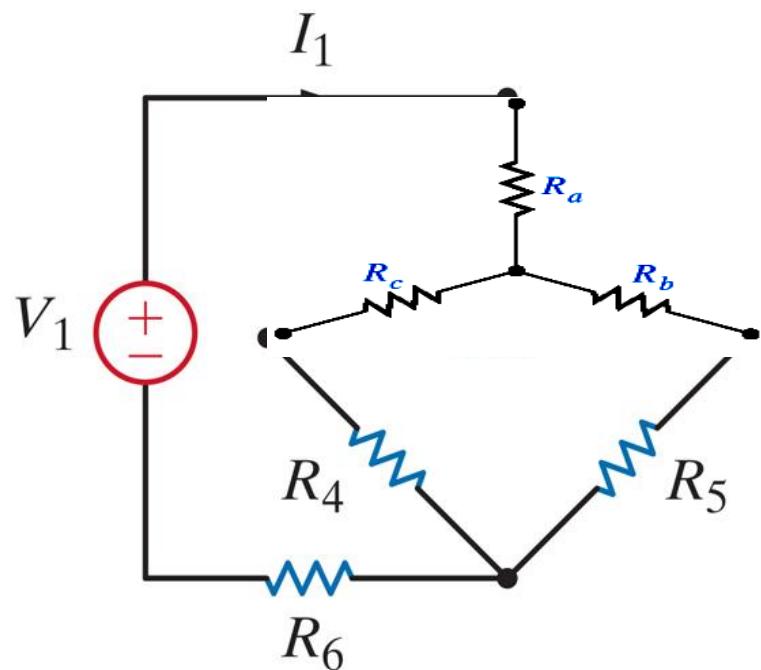
BU DEVRE SERİ YA DA PARALEL  
DİRENÇ İÇERMEMEKTEDİR

BU DEVRENİN  
YERİNE

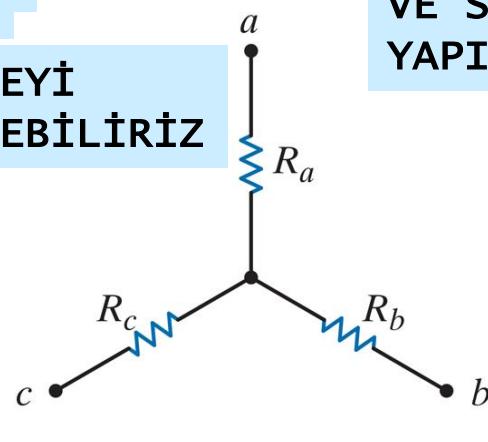


BU DEVREYİ  
ELDE EDEBİLİRİZ

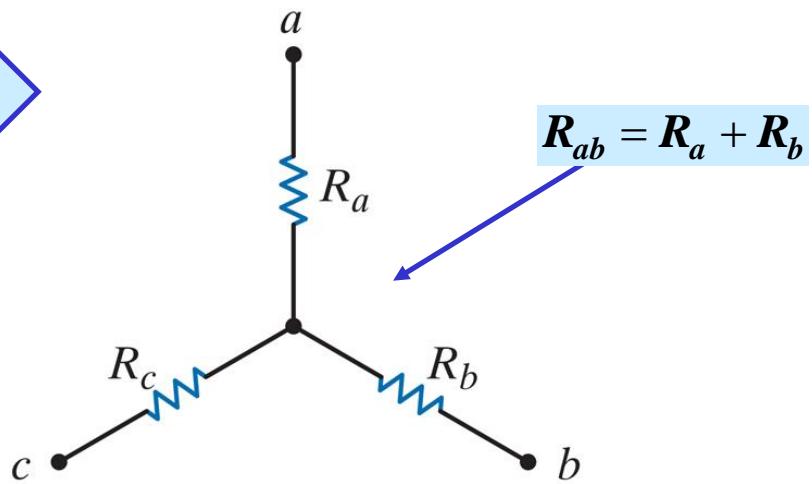
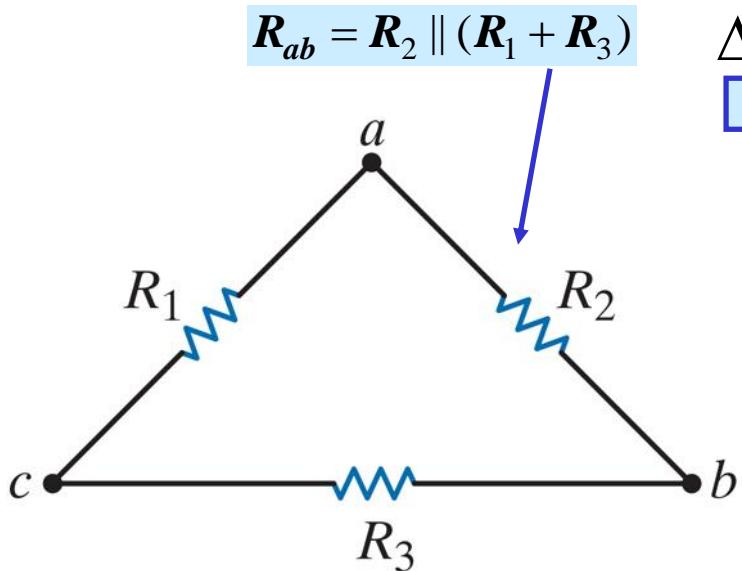
## $Y - \Delta$ DÖNÜŞÜMLERİ



SONRA DEVRE BU HALE GELİR  
VE SERİ PARALEL DÖNÜŞÜMLER  
YAPILABİLİR



# ÜÇGEN YILDIZ DÖNÜŞÜMÜ



$$R_{ab} = R_a + R_b = \frac{R_2(R_1 + R_3)}{R_1 + R_2 + R_3}$$

$$R_{bc} = R_b + R_c = \frac{R_3(R_1 + R_2)}{R_1 + R_2 + R_3}$$

$$R_{ca} = R_c + R_a = \frac{R_1(R_2 + R_3)}{R_1 + R_2 + R_3}$$

$$R_a + R_b + R_c = \frac{R_1R_2 + R_1R_3 + R_2R_3}{R_1 + R_2 + R_3}$$

$$R_a = (R_a + R_b + R_c) - (R_b + R_c)$$

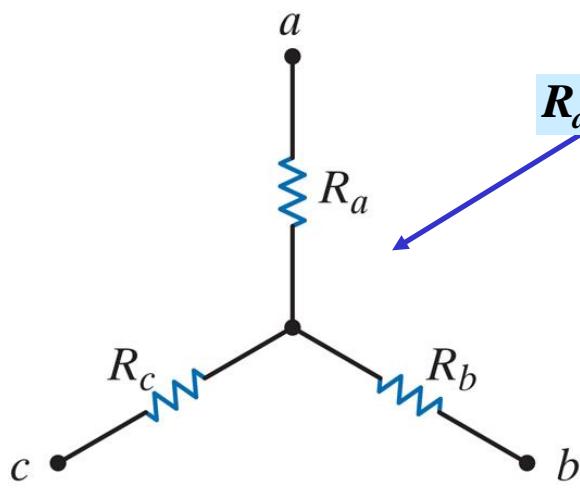
$$R_a = \frac{R_1R_2}{R_1 + R_2 + R_3}$$

$$R_b = \frac{R_2R_3}{R_1 + R_2 + R_3}$$

$$R_c = \frac{R_3R_1}{R_1 + R_2 + R_3}$$

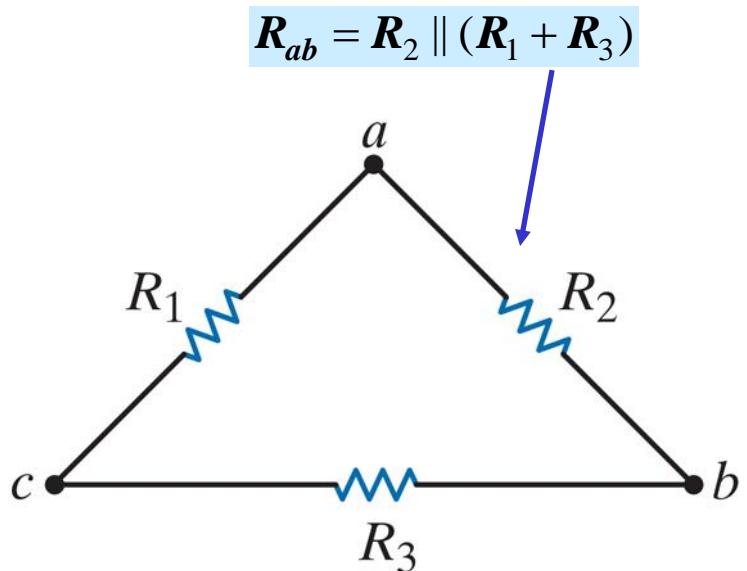
$\Delta \rightarrow Y$

# YILDIZ ÜÇGEN DÖNÜŞÜMÜ



$$\mathbf{R}_{ab} = \mathbf{R}_a + \mathbf{R}_b$$

$Y \rightarrow \Delta$



$$\mathbf{R}_{ab} = \mathbf{R}_2 \parallel (\mathbf{R}_1 + \mathbf{R}_3)$$

$$\mathbf{R}_a = \frac{\mathbf{R}_1 \mathbf{R}_2}{\mathbf{R}_1 + \mathbf{R}_2 + \mathbf{R}_3}$$

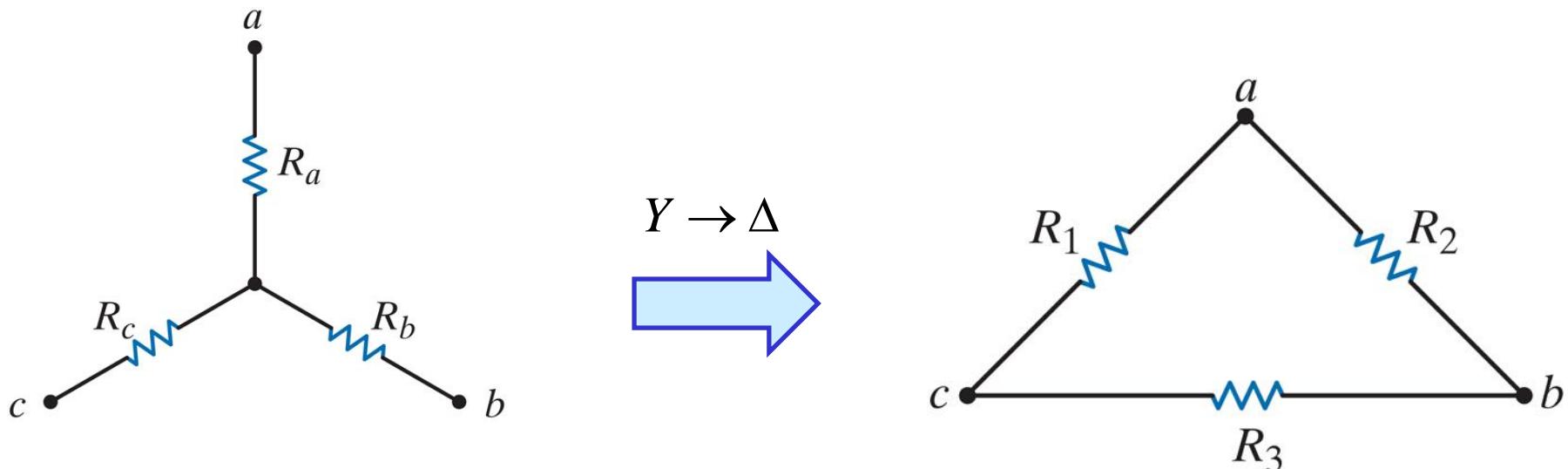
$$\mathbf{R}_b = \frac{\mathbf{R}_2 \mathbf{R}_3}{\mathbf{R}_1 + \mathbf{R}_2 + \mathbf{R}_3}$$

$$\mathbf{R}_c = \frac{\mathbf{R}_3 \mathbf{R}_1}{\mathbf{R}_1 + \mathbf{R}_2 + \mathbf{R}_3}$$

$\Delta \rightarrow Y$

$$R_a R_b + R_b R_c + R_c R_a = \frac{\mathbf{R}_1 \mathbf{R}_2}{\mathbf{R}_1 + \mathbf{R}_2 + \mathbf{R}_3} * \frac{\mathbf{R}_2 \mathbf{R}_3}{\mathbf{R}_1 + \mathbf{R}_2 + \mathbf{R}_3} + \\ \frac{\mathbf{R}_2 \mathbf{R}_3}{\mathbf{R}_1 + \mathbf{R}_2 + \mathbf{R}_3} * \frac{\mathbf{R}_3 \mathbf{R}_1}{\mathbf{R}_1 + \mathbf{R}_2 + \mathbf{R}_3} + \\ \frac{\mathbf{R}_3 \mathbf{R}_1}{\mathbf{R}_1 + \mathbf{R}_2 + \mathbf{R}_3} * \frac{\mathbf{R}_1 \mathbf{R}_2}{\mathbf{R}_1 + \mathbf{R}_2 + \mathbf{R}_3}$$

# YILDIZ ÜÇGEN DÖNÜŞÜMÜ -Devam



$$R_a R_b + R_b R_c + R_c R_a = \frac{R_1 R_2^2 R_3 + R_1 R_2 R_3^2 + R_1^2 R_2 R_3}{(R_1 + R_2 + R_3)^2} = \frac{R_1 R_2 R_3 (R_2 + R_3 + R_1)}{(R_1 + R_2 + R_3)^2}$$

$$R_a R_b + R_b R_c + R_c R_a = \frac{R_1 R_2 R_3}{(R_1 + R_2 + R_3)}$$

$$\frac{R_a R_b + R_b R_c + R_c R_a}{R_b} = \frac{R_1 R_2 R_3}{(R_1 + R_2 + R_3)} / \frac{R_2 R_3}{R_1 + R_2 + R_3}$$

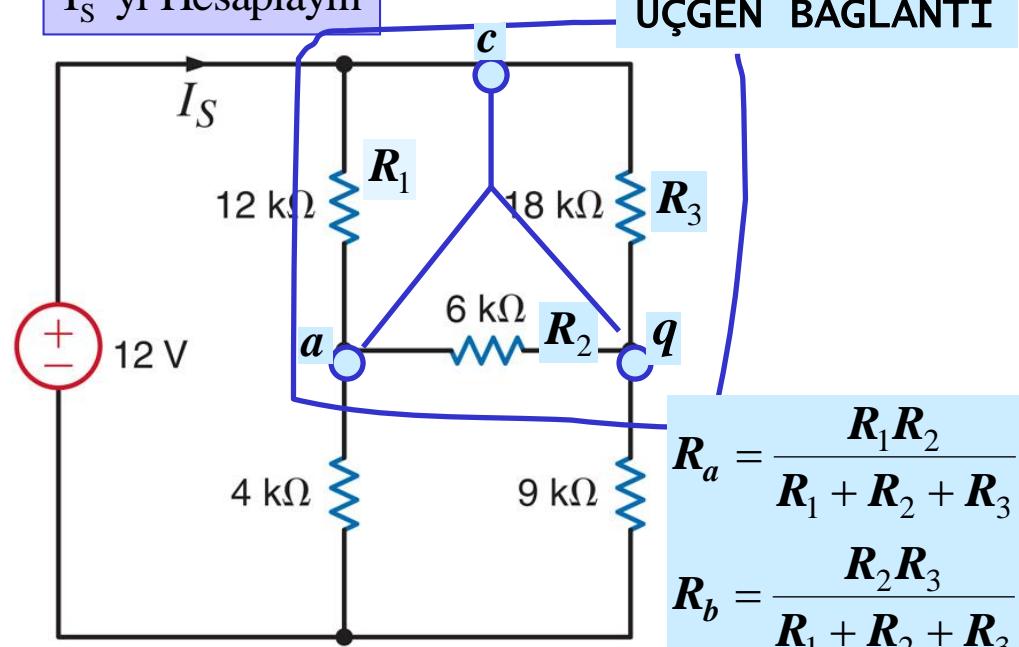
$$R_1 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_b}$$

$$R_2 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_c}$$

$$R_3 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_a}$$

## ÖRNEK: YILDIZ-ÜÇGEN DÖNÜŞÜMÜ UYGULAMASI

$I_S$  'yi Hesaplayın

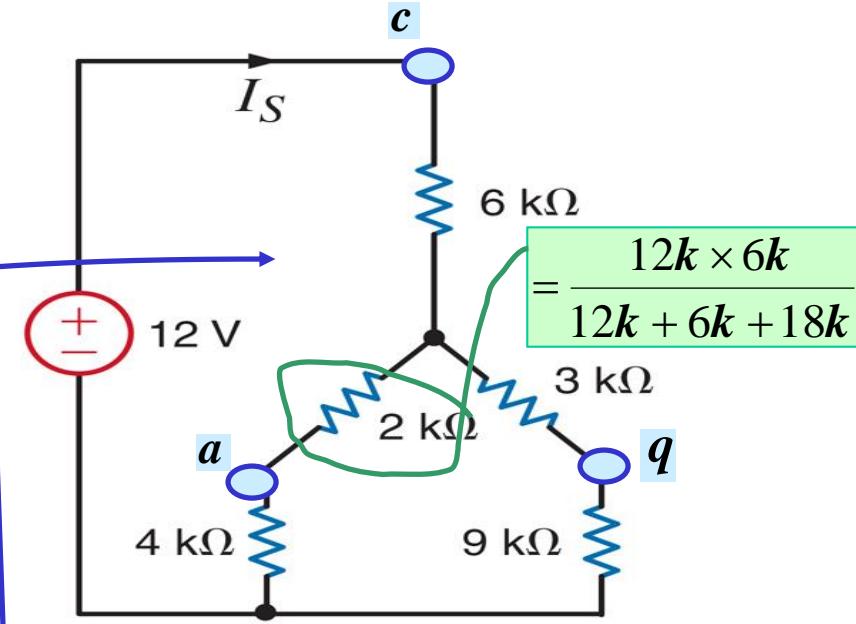


$$R_a = \frac{R_1 R_2}{R_1 + R_2 + R_3}$$

$$R_b = \frac{R_2 R_3}{R_1 + R_2 + R_3}$$

$$R_c = \frac{R_3 R_1}{R_1 + R_2 + R_3}$$

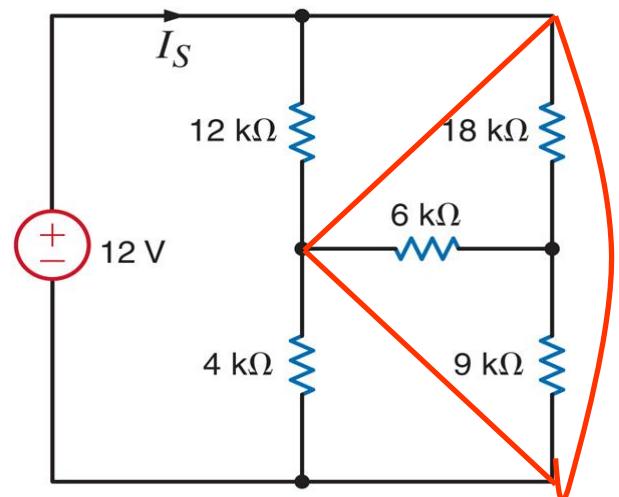
$\Delta \rightarrow Y$



$$R_{EQ} = 6k + (3k + 9k) \parallel (2k + 6k) = 10k$$

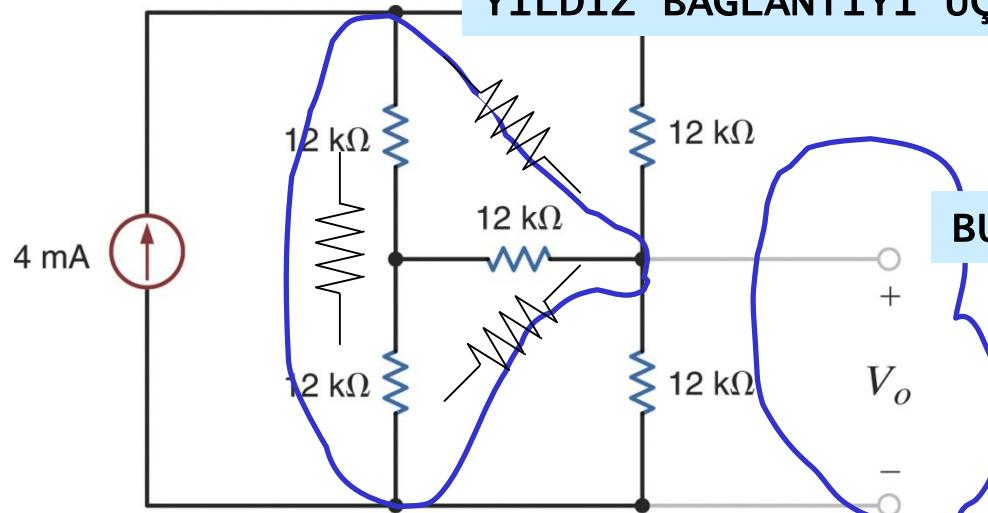
$$I_S = \frac{12V}{10k} = 1.2mA$$

Yıldız-Üçgen dönüşümü de  
kullanılabilirdi ...



## ÖRNEK

YILDIZ BAĞLANTIYI ÜÇGEN BAĞLANTIYA DÖNÜŞTÜRÜN?



BU DÜĞÜMLER KAYBEDİLMEMELİ!

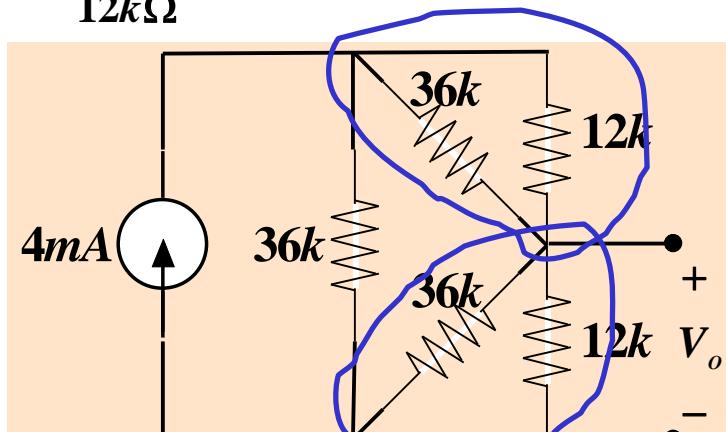
EĞER YILDIZ BAĞLANTIYI ÜÇGEN BAĞLANTIYA DÖNÜŞTÜRÜRSEK,  
SERİ PARALEL SADELEŞTİRMELER OLUR!

$$R_1 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_b} = \frac{3 * 12k\Omega * 12k\Omega}{12k\Omega} = 36k\Omega$$

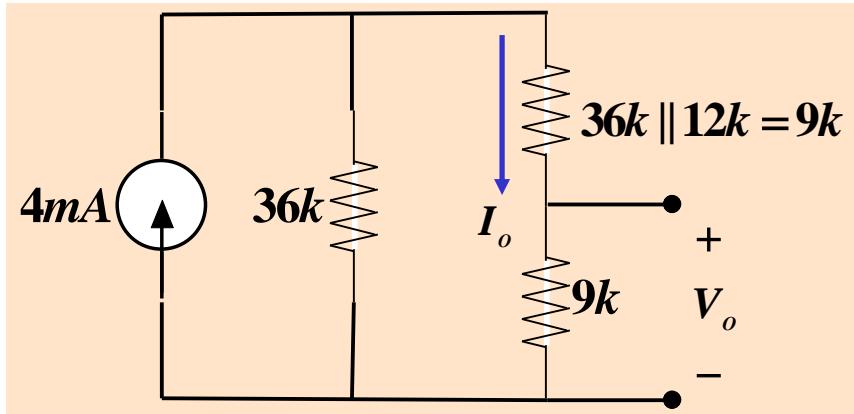
$$R_2 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_c}$$

$$R_3 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_a}$$

$Y - \Delta$



Sonuçtaki devre  
bir akım bölücündür



## PARALEL SADELEŞTİRME SONRASI DEVRE

$$I_o = \frac{36k}{36k + 18k} \times 4mA = \frac{8}{3}mA$$

$$V_o = 9k\Omega \times I_o = 9k\Omega \times \frac{8}{3}mA = 24V$$