## 12.7 "Dengeli" Bir Sistemde Güç:

Y-bağlantılı yükte: ($V_p$ rms)

$$v_{AN} = \sqrt{2} V_p \cos(\omega t) \qquad v_{BN} = \sqrt{2} V_p \cos(\omega t - 120^\circ)$$

$$v_{CN} = \sqrt{2} V_p \cos(\omega t + 120^\circ)$$

$$Z_Y = Z \angle \theta$$

$$i_a = \sqrt{2} I_p \cos(\omega t - \theta) \qquad i_b = \sqrt{2} I_p \cos(\omega t - 120^\circ - \theta)$$

$$i_c = \sqrt{2} I_p \cos(\omega t + 120^\circ - \theta)$$

$$P = P_a + P_b + P_c = v_{AN} i_a + v_{BN} i_b + v_{CN} i_c$$

$$= 2 V_p I_p \cos(\omega t)\cos(\omega t - \theta) + 2 V_p I_p \cos(\omega t - 120)\cos(\omega t - 120 - \theta)$$
$$+ 2 V_p I_p \cos(\omega t + 120^\circ)\cos(\omega t + 120 - \theta)$$

$$= V_p I_p \left[ \cos(2\omega t - \theta) + \cos\theta + \cos(2\omega t - 240 - \theta) + \cos\theta + \cos(2\omega t + 240^\circ - \theta) + \cos\theta \right]$$

Toplamları sıfır.

$p = V_p I_p \, 3\cos\theta \longrightarrow$ Üç fazlı bir sistemde anlık güç zamandan bağımsız, yani sabittir. Bu, üç faz kullanmanın avantajlarından biridir.

$$\bar{S}_A = \bar{V}_{AN} \bar{I}_a^* = V_p I_p \angle \theta = \bar{S}_B = \bar{S}_C$$

$$P = P_A + P_B + P_C = 3 V_p I_p \cos\theta$$

$$Q = Q_A + Q_B + Q_C = 3 V_p I_p \sin\theta$$

Y-bağlantılı yük için: $V_L = \sqrt{3} V_p$ $\qquad I_L = I_p$

$V_L$: hat gerilimi, $V_p$: faz g., $I_L$: hat akımı, $I_p$: faz akımı

$P = 3V_p I_p \cos\theta = \sqrt{3} V_L I_L \cos\theta$

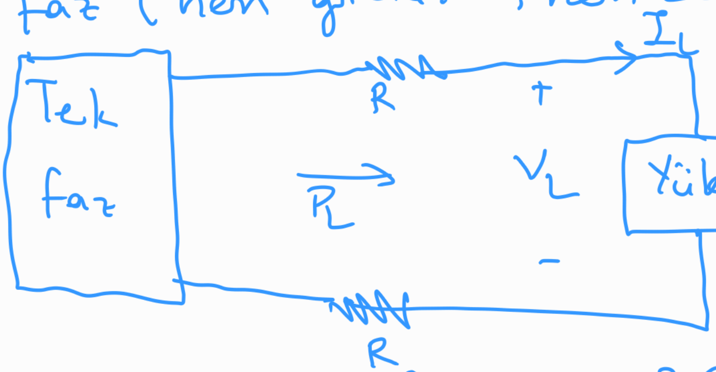
$\Delta$-bağlantılı yük için: $V_L = V_p$ $\quad I_L = \sqrt{3} I_p$

$P = 3V_p I_p \cos\theta = \sqrt{3} V_L I_L \cos\theta$

AYNI!

## İletim Hattı Kaybı

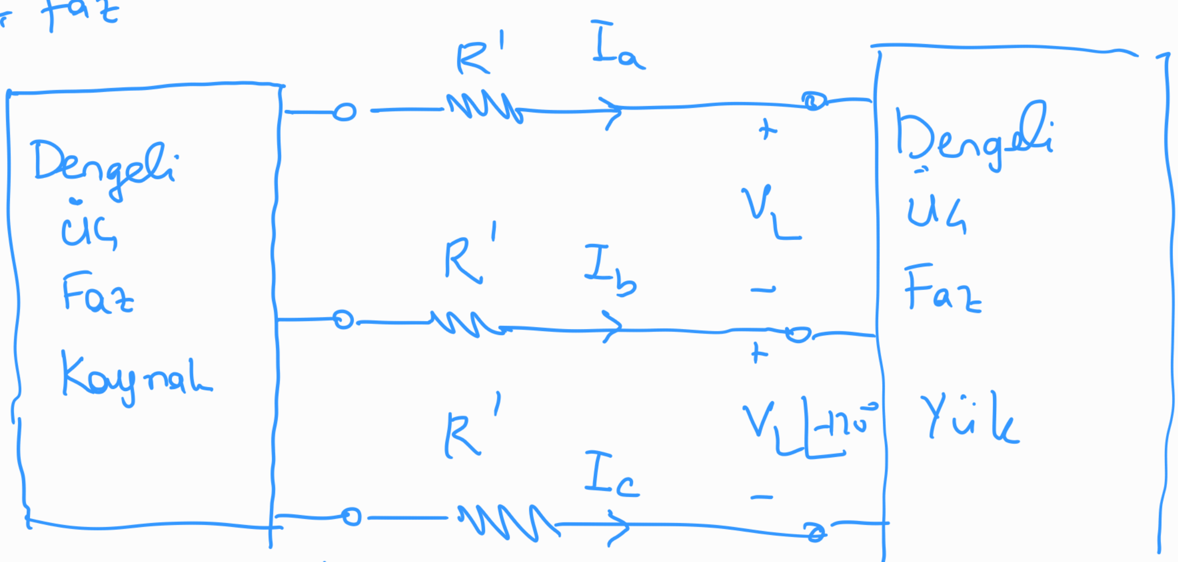
Tek faz (hem gidişte, hem de dönüşte kayıp var)




$P_L = I_L V_L$

$$P_{kayıp} = 2 I_L^2 R = 2R \frac{P_L^2}{V_L^2}$$

Üç faz




$$|I_L'| = |I_a| = |I_b| = |I_c| = \frac{P_L}{\sqrt{3} V_L}$$ hat akımı büyüklükleri

$$P'_{kayıp} = 3 (I_L')^2 R' = 3R' \frac{P_L^2}{3V_L^2} = R' \frac{P_L^2}{V_L^2}$$

Direnç: kesit alanının karesi ile ters orantılı

$$\frac{P_{loss}}{P'_{loss}} = \frac{2R\,\cancel{P_L^2/V_L^2}}{R'\,\cancel{P_L^2/V_L^2}} = \frac{2r'^2}{r^2}$$

iki sistem aynı kayba sahipse $r^2 = 2r'^2$ olur.

$$\frac{\text{Tek faz malzeme}}{\text{Üç faz malzeme}} = \frac{2\pi r^2 l}{3\pi r'^2 l} = \frac{4\pi r'^2 l}{3\pi r'^2 l} = 4/3$$

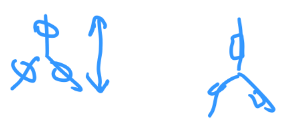
Tek faz %33 daha fazla malzeme gerektirir

Problem 12.6 Prob 12.2'deki Y-Y devresi için kaynak ve yükteki kompleks gücü bulun.

**Practice Problem 12.2**

A Y-connected balanced three-phase generator with an impedance of $0.4 + j0.3\ \Omega$ per phase is connected to a Y-connected balanced load with an impedance of $24 + j19\ \Omega$ per phase. The line joining the generator and the load has an impedance of $0.6 + j0.7\ \Omega$ per phase. Assuming a positive sequence for the source voltages and that $\mathbf{V}_{an} = 120\angle 30^\circ$ V, find: (a) the line voltages, (b) the line currents.

Answer: (a) $207.8\angle 60^\circ$ V, $207.8\angle -60^\circ$ V, $207.8\angle -180^\circ$ V, (b) $3.75\angle -8.66^\circ$ A, $3.75\angle -128.66^\circ$ A, $3.75\angle 111.34^\circ$ A.



$\sqrt{3}V_L I_L \cos\theta + j\sqrt{3}V_L I_L \sin\theta$

$\tan^{-1}\frac{19}{24} = 38.66^\circ$

**Yük:** $S = \sqrt{3} \times \underbrace{207.8}_{V_L} \times \underbrace{3.75}_{I_L} \angle 38.66^\circ \rightarrow \theta$

$= 1058.2 + j837.81$ VA ✓

**Kaynak:** $\sqrt{3}\,V_L I_L \cos\theta$

$3 \times \underbrace{120\angle 30^\circ \times I_a^*}_{a} = 3 \times 120\angle 30^\circ \times 3.75\angle 8.66$

$= \cancel{1054 + j\,843.34}$ VA


$\boxed{\text{Aslında } -1054 - j843.34 \text{ VA}}$ ✓

## Example 12.7

A three-phase motor can be regarded as a balanced Y-load. A three-phase motor draws 5.6 kW when the line voltage is 220 V and the line current is 18.2 A. Determine the power factor of the motor.

$$P = \underset{5600}{P} = \sqrt{3}\, \underset{220}{V_L}\, \underset{18.2}{I_L}\, \underbrace{\cos\theta}_{?}$$

$\cos\theta \cong 0.8$

$\boxed{\text{g.f } 0.8}$

## Practice Problem 12.7

Calculate the line current required for a 30-kW three-phase motor having a power factor of 0.85 lagging if it is connected to a balanced source with a line voltage of 550 V.

**Answer:** 37.05 A.

$$P = \sqrt{3}\, V_L I_L \cos\theta$$

$$30000 = \sqrt{3} \times 550 \times \overbrace{I_L}^{?} \times 0.85$$

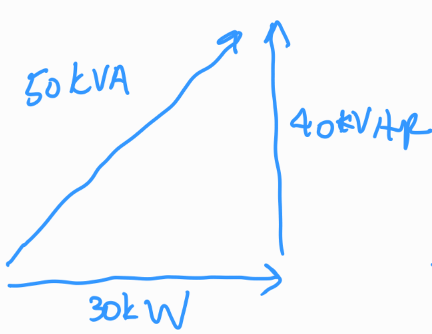
$$\boxed{I_L = 37.05\,A}$$

## Example 12.8

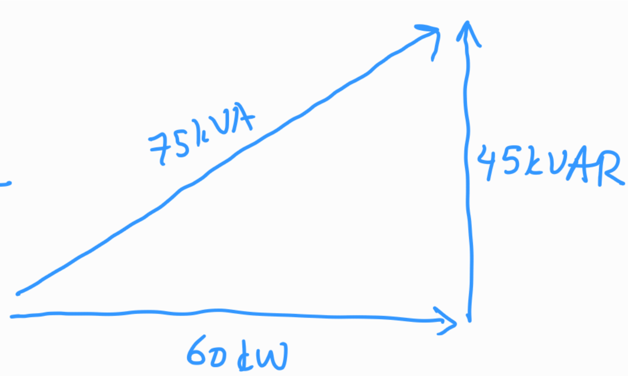
Two balanced loads are connected to a 240-kV rms 60-Hz line, as shown in Fig. 12.22(a). Load 1 draws 30 kW at a power factor of 0.6 lagging, while load 2 draws 45 kVAR at a power factor of 0.8 lagging. Assuming the *abc* sequence, determine: (a) the complex, real, and reactive powers absorbed by the combined load, (b) the line currents, and (c) the kVAR rating of the three capacitors Δ-connected in parallel with the load that will raise the power factor to 0.9 lagging and the capacitance of each capacitor.

$V_L = 240\,kV$

a)




1. yük




2. yük.

Gün toplanır. Birleşik yük: $\bar{S} = 90\,kW + j\,85\,kVAR$

$\underset{\substack{\downarrow \\ \simeq 124\,kVA}}{S} = \sqrt{3}\, \underset{\substack{\downarrow \\ 240\,kV}}{V_L}\, \overset{?}{I_L} \rightarrow I_L \cong \underline{0.3\ A} \rightarrow$ a, b, c fazları için.

$\rightarrow \bar{S} = 124 \angle 43.36^\circ = \sqrt{3}\, \bar{V}_L\, \bar{I}_L^{*}$

$\sqrt{3}\, V_L I_L \angle \theta_v - \theta_i$ (0) — a fazı için

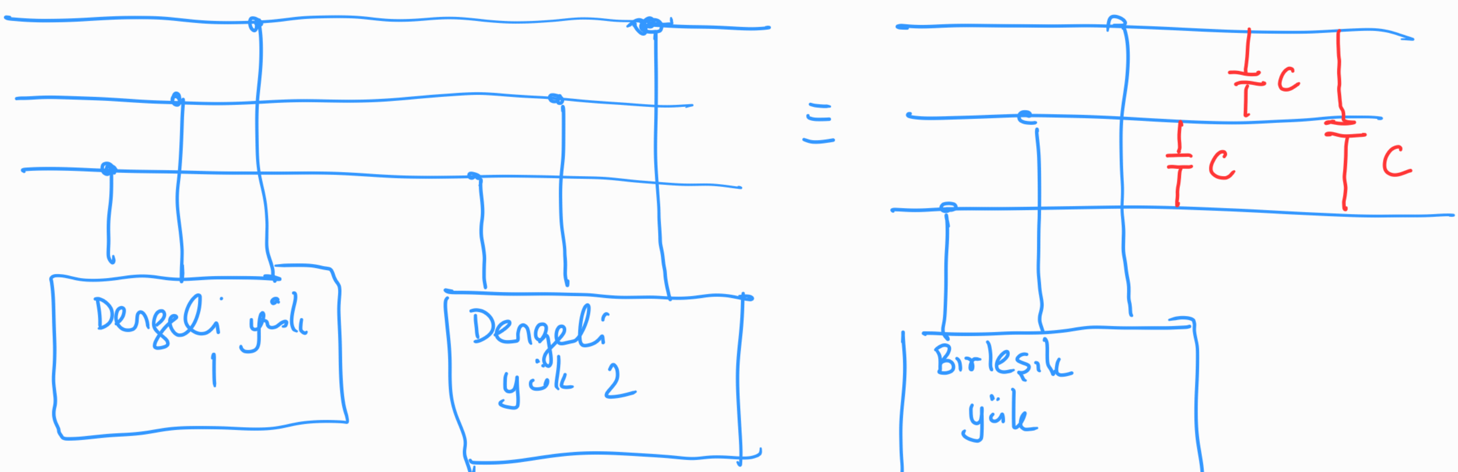
$\theta_v = 0 \rightarrow$ a fazı için

$\theta_i = -43.36^\circ$

$\rightarrow \underline{\underline{\bar{I}_{La} = 0.3 \angle -43.36^\circ\ A}}$

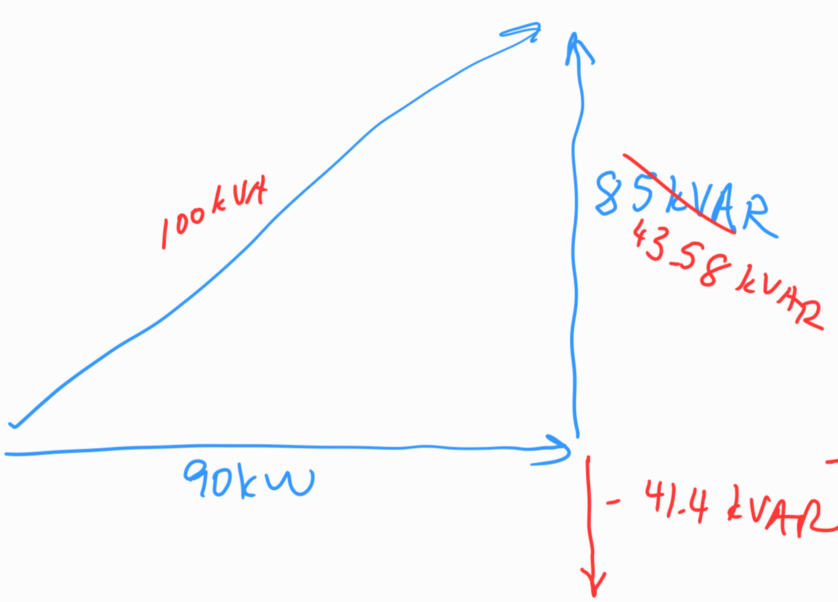
$\bar{I}_{Lb} = 0.3 \angle -163.36^\circ\ A$

$\bar{I}_{Lc} = 0.3 \angle +76.64^\circ\ A$




şu anda g.f. 0.73 (takipeden)

Bunu 0.9 (takip eden) yapmak için C ekliyoruz.




bunu 3'e böleriz

$Q_c = -13.8\,kVAR$ rating

$$S' = \frac{90kW}{0.9} = 100\,kVA$$

$$S = \bar{V}\bar{I}^* = \frac{\bar{V}\bar{V}^*}{\bar{Z}^*} = \frac{|V|^2}{Z^*}$$

$$-j\,13800 = \frac{(240000)^2}{1/\omega C}$$

$$13800 = (240000)^2\, 2\pi\, 60\; C$$

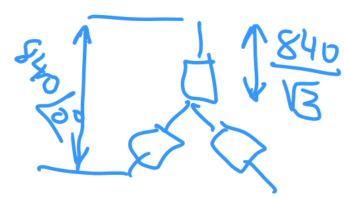
$$= 6.355\times10^{-10} F$$

$$= 635.5\, pF$$

**Practice Problem 12.8**

Assume that the two balanced loads in Fig. 12.22(a) are supplied by an 840-V rms 60-Hz line. Load 1 is Y-connected with $30 + j40\,\Omega$ per phase, while load 2 is a balanced three-phase motor drawing 48 kW at a power factor of 0.8 lagging. Assuming the *abc* sequence, calculate: (a) the complex power absorbed by the combined load, (b) the kVAR rating of each of the three capacitors Δ-connected in parallel with the load to raise the power factor to unity, and (c) the current drawn from the supply at unity power factor condition.

**Answer:** (a) 56.47 + *j*47.29 kVA, (b) 15.76 kVAR, (c) 38.81 A.




Yük 1:

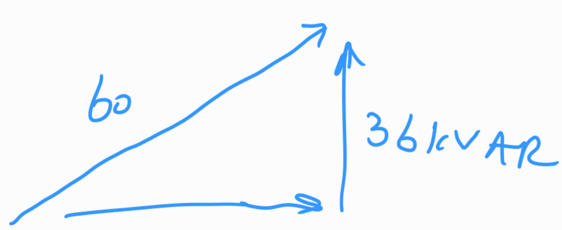
$$S = \sqrt{3}\,\underbrace{V_L}_{840}\,I_L\,\underbrace{\cos\theta}_{0.6} + j\sqrt{3}\,\underbrace{V_L}_{840}\,I_L\,\underbrace{\sin\theta}_{0.8}$$

$$\boxed{I_L = \frac{840}{50\sqrt{3}}}$$

$$= 14112\times0.6 + j\,14112\times0.8$$

$$= 8467 + j\,11290 \;\; VA$$

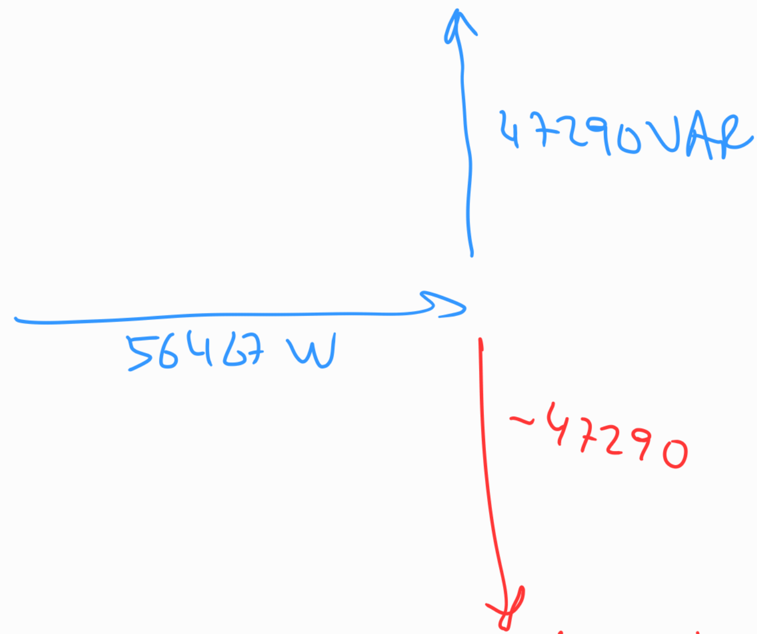
Yük 2:




$$\bar{S}^2 = 48000 + j\,36000 \;\; VA$$

$$\bar{S} = \bar{S}^1 + \bar{S}^2 = 56467 + j\,47290$$

b)




g.f. 1 olacak

O zaman: her bir C'nin kVAR rating'i:

$$\frac{47290}{3} = 15.76\,kVAR$$

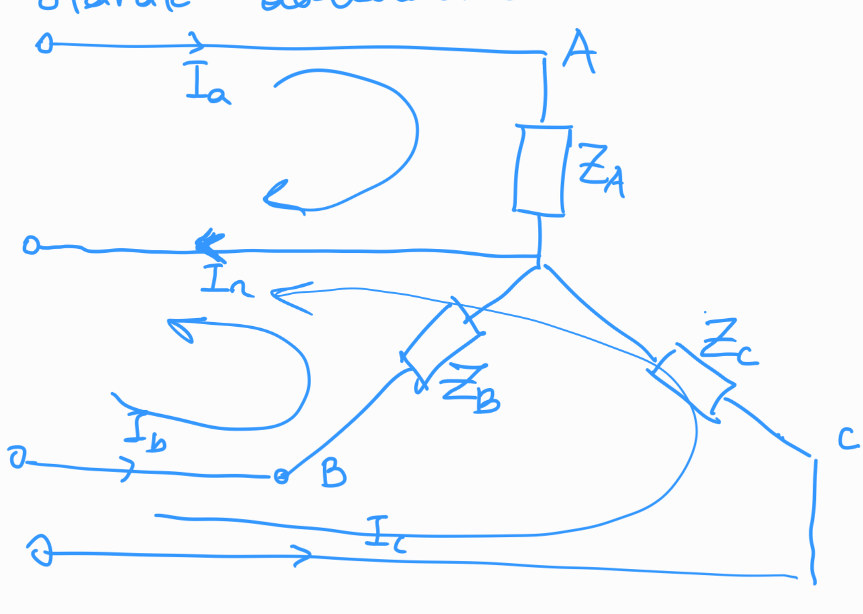
c) Yeni durumda $\bar{S} = 56467$ (resistif)

$$\underset{\downarrow\,56467}{\bar{S}} = \sqrt{3}\, \underset{\downarrow\,840}{V_L}\, I_L \underset{1}{\cancel{\cos\theta}}$$

$$\boxed{I_L = 38.81\ A}$$

## 12.8 Dengesiz Üç Fazlı Sistem:

Yükler eşit olmazsa üç fazlı sistem dengesiz olarak adlandırılır.




$$Z_A \neq Z_B \neq Z_C$$

$$\bar{I}_a = \frac{\bar{V}_{AN}}{Z_A} \qquad \bar{I}_b = \frac{\bar{V}_{BN}}{Z_B} \qquad \bar{I}_c = \frac{\bar{V}_{CN}}{Z_c}$$

$$\boxed{\bar{I}_n = \bar{I}_a + \bar{I}_b + \bar{I}_c}$$

Nötr bağlantısı yoksa, çevre akım yöntemi kullanılabilir.
Benzer analizler Y-Δ, Δ-Y, Δ-Δ için de yapılabilir.
Güç hesabını bütün fazlar için ayrı ayrı yapmak gerekir.

## Practice Problem 12.9

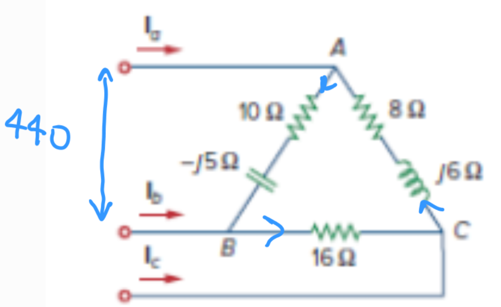



**Figure 12.24**
Unbalanced Δ-load; for Practice Prob. 12.9.

The unbalanced Δ-load of Fig. 12.24 is supplied by balanced line-to-line voltages of 440 V in the positive sequence. Find the line currents. Take $\mathbf{V}_{ab}$ as reference.

**Answer:** 39.71$\angle -41.06°$ A, 64.12$\angle -139.8°$ A, 70.13$\angle 74.27°$ A.

$$V_{AB} = 440$$

$$V_{BC} = 440\angle -120°$$

$$V_{CA} = 440\angle +120°$$

$$\bar{I}_{AB} = \frac{440}{10-j5} \qquad \bar{I}_{BC} = \frac{440\angle -120°}{16} \qquad \bar{I}_{CA} = \frac{440\angle +120}{8+j6}$$

$$\bar{I}_a + \bar{I}_{CA} = \bar{I}_{AB} \Rightarrow \bar{I}_a = \bar{I}_{AB} - \bar{I}_{CA}$$

$$\bar{I}_b + \bar{I}_{AB} = \bar{I}_{BC} \Rightarrow \bar{I}_b = \bar{I}_{BC} - \bar{I}_{AB}$$

$$\bar{I}_c = \bar{I}_{CA} - \bar{I}_{BC}$$