BEEE100

Basic Electrical Engineering

Module – 02: AC Circuits

Tutorial

Tutorial

Problem

A Y-connected balanced 3-phase generator load with the phase voltage of 220 V is connected to a balanced Y-connected load with an impedance per phase of 10+j5 Ω. Calculate the (i) line voltages, (ii) phase currents, (iii) line currents and (iv) complex power at the source and load.

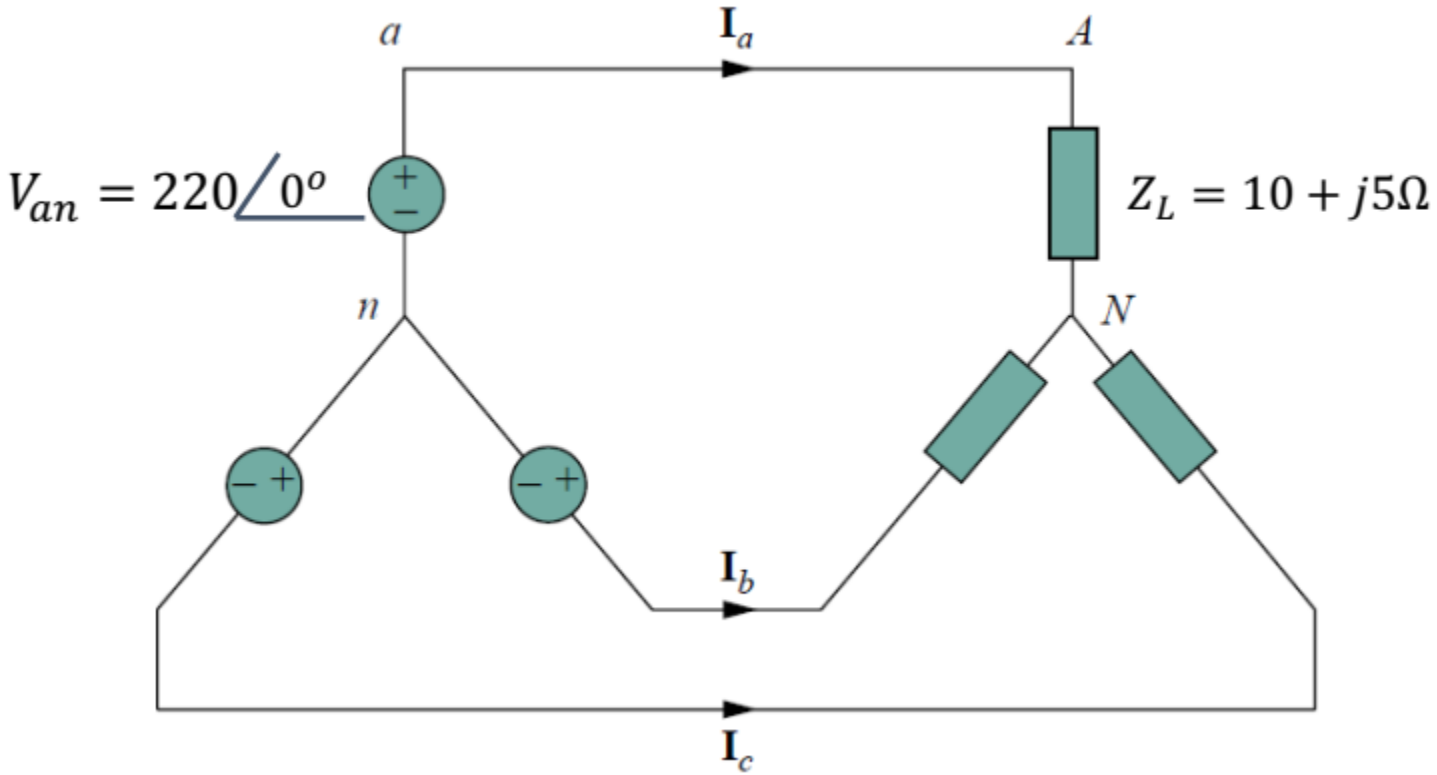
One line voltage of a balanced Y-connected source is $180\angle -20^o$. If the source is connected to a balanced Δ-connected load of $20\angle 40^o$. Calculate the (i) phase voltages, (ii) phase currents, (ii) line currents and (iii) complex power at the source and load.

A balanced Y-connected load with a phase resistance of 40Ω and a reactance of 25Ω is supplied by a balanced Δ-connected source with a line voltage of 210 V. Calculate the (i) phase voltages, (ii) phase currents, (ii) line currents and (iii) complex power at the source and load.

Tutorial

Problem

- A Y-connected balanced 3-phase generator load with the phase voltage of 220 V is connected to a balanced Y-connected load with an impedance per phase of 10+j5 Ω. Calculate the (i) line voltages, (ii) phase currents, (iii) line currents and (iv) complex power at the source and load.



Tutorial

Problem

At Source (Y)

Given

$$V_P = 220\angle 0^o \text{ V}$$

Relationship between phase and line, voltage and current in Y connection

$$V_L = \sqrt{3}V_P \angle 30^o$$
$$I_L = I_P$$

(i) line voltage

$$V_L = \sqrt{3}(220)\angle 0^o \angle 30^o$$

$$V_L = 381.05\angle 30^o \text{ V}$$

At Load (Y)

Given

$$Z = 10 + j5\ \Omega$$

Relationship between phase and line, voltage and current in Y connection

$$V_L = \sqrt{3}V_P \angle 30^o$$
$$I_L = I_P$$

(i) line voltage

Line voltage of load is equal to line voltage of the source

$$V_{AB} = V_{ab} \qquad V_L = 381.05\lfloor 30^o \text{ V}$$

(ii) Phase current

$$I_P = \frac{V_P}{Z_L} = \frac{220}{10 + j5\Omega} = \frac{220}{11.18\lfloor 26.56}$$

$$= 19.678\lfloor -26.56 \text{ A}$$

Tutorial

Problem

At Source (Y)

(iii) line current

Line current of source is equal to line current of the load

$$I_L = 19.678\lfloor -26.56 \text{ A}$$

(ii) Phase current

$$I_L = I_P = 19.678\lfloor -26.56 \text{ A}$$

(iii) Complex power

$$S = -(P + jQ)$$

$$S = -(3V_P I_P \cos(\theta_V - \theta_i) + j3V_P I_P \sin(\theta_V - \theta_i))$$

$$= -\big(3(220)(19.678)\cos(0^o + 26.56^o) + j3(220)(19.678)\sin(0^o + 26.56^o)\big)$$

$$S = -(11616.86 + j5807.15) \text{ VA}$$

Source power should be negative

At Load (Y)

(iii) line current

$$I_L = I_P = 19.678\lfloor -26.56 \text{ A}$$

(iii) Complex power

$$S = P + jQ$$

$$S = 3V_P I_P \cos(\theta_V - \theta_i) + j3V_P I_P \sin(\theta_V - \theta_i)$$

$$= 3(220)(19.678)\cos(0^o + 26.56^o) + j3(220)(19.678)\sin(0^o + 26.56^o)$$

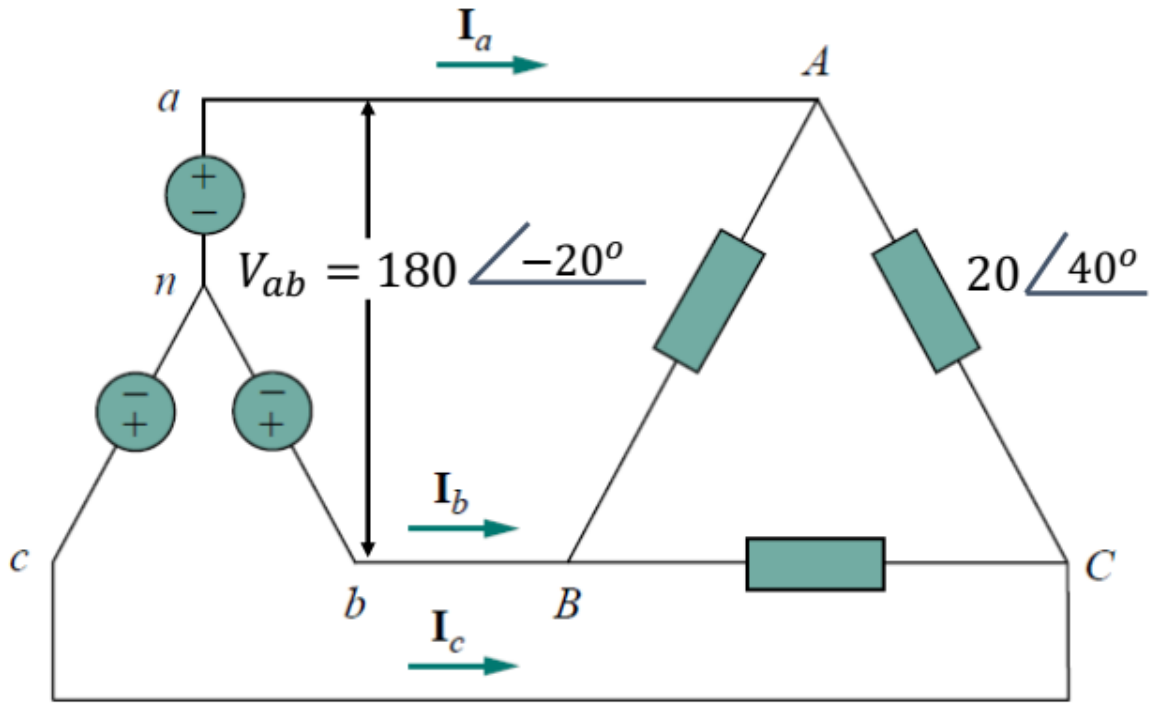
$$S = 11616.86 + j5807.15 \text{ VA}$$

Load power should be positive

Tutorial

Problem

One line voltage of a balanced Y-connected source is $180\angle -20^o$. If the source is connected to a balanced Δ-connected load of $20\angle 40^o$. Calculate the (i) phase voltages, (ii) phase currents, (ii) line currents and (iii) complex power at the source and load.



Tutorial

Problem

At Source (Y)

Given

$$V_L = 180 \angle -20^o \text{ V}$$

Relationship between phase and line, voltage and current in Y connection

$$V_L = \sqrt{3} V_P \angle 30^o$$
$$I_L = I_P$$

(i) phase voltage

$$V_P = \frac{V_L}{\sqrt{3} \lfloor 30^0}$$

$$V_P = \frac{180 \lfloor -20^o}{\sqrt{3} \lfloor 30^o}$$

$$V_P = 103.92 \angle -30^o \text{ V}$$

At Load (Δ)

Given

$$Z_L = 20 \angle 40^o \ \Omega$$

Relationship between phase and line, voltage and current in Δ connection

$$I_L = \sqrt{3} V_P \angle -30^o$$
$$V_L = V_P$$

(i) line voltage

Line voltage of load is equal to line voltage of the source

$$V_{AB} = V_{ab} \qquad V_L = 180 \angle -20^o \text{ V}$$

(ii) phase voltage

$$V_P = V_L = 180 \angle -20^o \text{ V}$$

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Problem

At Source (Y)

(iii) line current

Line current of source is equal to line current of the load

$$I_L = 15.58\angle -90^o \text{ A}$$

(ii) Phase current

$$I_P = I_L = 15.58\angle -90^o \text{ A}$$

(iii) Complex power

$$S = -(P + jQ)$$

$$S = -(3V_P I_P \cos(\theta_V - \theta_i) + j3V_P I_P \sin(\theta_V - \theta_i))$$

$$= -\big(3(103.92)(15.58)\cos(-50^0 + 90^o) + j3(103.92)(15.58)\sin(-50^o + 90^o)\big)$$

$$S = -(3720.847 + j3122.16) \text{ VA}$$

At Load (Δ)

(iii) phase current

$$I_P = \frac{V_P}{Z} = \frac{180\lfloor -20^0}{20\lfloor 40^o}$$

$$= 9\lfloor -60^o \text{ A}$$

(iii) line current

$$I_L = \sqrt{3} I_P \angle -30^o$$

$$I_L = \sqrt{3}(9)\angle -60^o \angle -30^o$$

$$I_L = 15.58\angle -90^o \text{ A}$$

(iii) Complex power

$$S = P + jQ$$

$$S = 3V_P I_P \cos(\theta_V - \theta_i) + j3V_P I_P \sin(\theta_V - \theta_i)$$

$$= 3(180)(9)\cos(-20^0 + 60^o) + j3(180)(9)\sin(-20^o + 60^o)$$

$$S = 3722.98 + j3123.95 \text{ VA}$$

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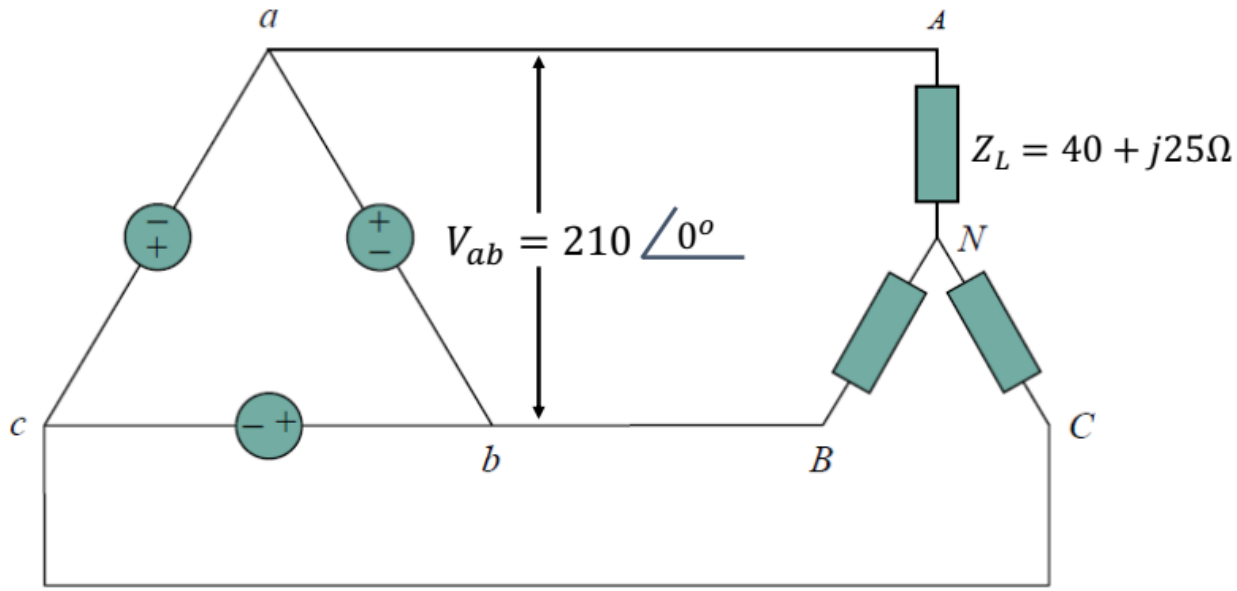
A balanced Y-connected load with a phase resistance of 40Ω and a reactance of 25Ω is supplied by a balanced Δ-connected source with a line voltage of 210 V. Calculate the (i) phase voltages, (ii) phase currents, (ii) line currents and (iii) complex power at the source and load.



Tutorial

Problem

At Source (Δ)

Given

$$V_L = 210 \angle 0^o \text{ V}$$

Relationship between phase and line, voltage and current in Δ connection

$$I_L = \sqrt{3} V_P \angle -30^o$$
$$V_L = V_P$$

(i) phase voltage

$$V_P = V_L = 210 \angle 0^o \text{ V}$$

At Load (Y)

Given

$$Z = 40 + j25\ \Omega \quad Z_L = 47.17 \angle 32.005^o$$

Relationship between phase and line, voltage and current in Y connection

$$V_L = \sqrt{3} V_P \angle 30^o$$
$$I_L = I_P$$

(i) line voltage

Line voltage of load is equal to line voltage of the source

$$V_{AB} = V_{ab} \quad V_L = 210 \angle 0^o \text{ V}$$

(ii) phase voltage

$$V_P = \frac{V_L}{\sqrt{3} \angle 30^0}$$

$$V_P = 121.24 \angle -30^o \text{ V}$$

Tutorial

Problem

At Source (Δ)

(iii) line current

Line current of source is equal to line current of the load

$$I_L = 2.57\angle -62.005^o \text{ A}$$

(ii) Phase current

$$I_P = I_L/(\sqrt{3}\angle -30^o)$$

$$I_P = (2.57)/\sqrt{3})\angle -62.005^o \angle 30^o$$

$$I_P = 1.483\angle -32.005^o \text{ A}$$

(iii) Complex power

$$S = -(P + jQ)$$

$$S = -(3V_P I_P \cos(\theta_V - \theta_i) + j3V_P I_P \sin(\theta_V - \theta_i))$$

$$= -\big(3(210)(1.483)\cos(0^0 + 32.005^o) + j3(210)(1.483)\sin(0^0 + 32.005^o)\big)$$

$$S = -(792.28 + j495.17) \text{ VA}$$

At Load (Y)

(iii) phase current

$$I_P = \frac{V_P}{Z_L} = \frac{121.24\lfloor -30^0}{47.17\lfloor 32.005^o}$$

$$= 2.57\lfloor -62.005^o \text{ A}$$

(iii) line current

$$I_P = I_L = 2.57\angle -62.005^o \text{ A}$$

(iii) Complex power

$$S = P + jQ$$

$$S = 3V_P I_P \cos(\theta_V - \theta_i) + j3V_P I_P \sin(\theta_V - \theta_i)$$

$$= 3(121.24)(2.57)\cos(-30^0 + 62.005^o) + j3(121.24)(2.57)\sin(-30^o + 62.005^o)$$

$$S = 792.68 + j495.42 \text{ VA}$$

Thank You!