KFUPM-EE DEPT.
EE205: Circuits II-082
HW # 1 : Solution

Problem 1:

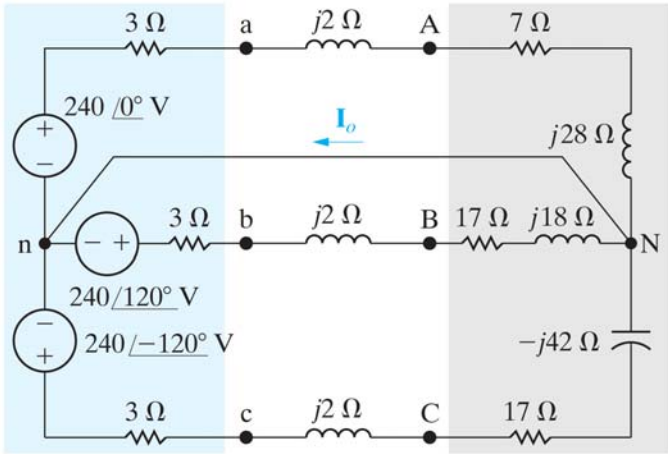


Figure: 11-22-01P11.05

a) For the circuit in the above figure, is it a balanced or unbalanced three-phase system? Explain why.
b) Find $\mathbf{I}_0$

[a] The circuit is unbalanced, because the impedance in each phase of the load is not the same.

[b] $$\mathbf{I}_{aA} = \frac{240\angle 0^\circ}{10 + j30} = 2.4 - j7.2\,\text{A}$$

$$\mathbf{I}_{bB} = \frac{240\angle 120^\circ}{20 + j20} = 2.2 + j8.2\,\text{A}$$

$$\mathbf{I}_{cC} = \frac{240\angle -120^\circ}{20 - j40} = 2.96 - j4.48\,\text{A}$$

$$\mathbf{I}_o = \mathbf{I}_{aA} + \mathbf{I}_{bB} + \mathbf{I}_{cC} = 7.55 - j3.48 = 8.32\angle -24.75^\circ\,\text{A}$$

Problem 2:

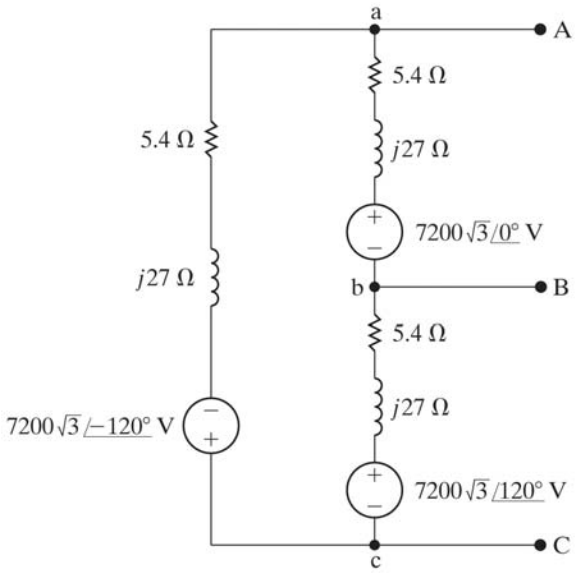


Figure: 11-22-04P11.17

The above figure shows a balanced three-phase Δ-connected source.

a) Find the Y-connected equivalent circuit.
b) Show that the Y-connected equivalent circuit delivers the same open-circuit voltage as the original Δ-connected source.
c) Apply an external short circuit to the terminals A, B, and C. Use the Δ-connected source to find the three line currents $\mathbf{I}_{aA}$, $\mathbf{I}_{bB}$, and $\mathbf{I}_{cC}$.
d) Repeat (c) but use the Y-equivalent source to find the three line currents.

Answer P2:

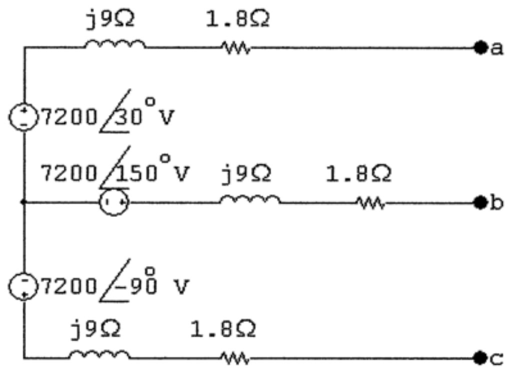
[a] Since the phase sequence is acb (negative) we have:

$$\mathbf{V}_{an} = 7200\underline{/30^\circ}\,\text{V}$$

$$\mathbf{V}_{bn} = 7200\underline{/150^\circ}\,\text{V}$$

$$\mathbf{V}_{cn} = 7200\underline{/-90^\circ}\,\text{V}$$

$$Z_Y = \frac{1}{3}Z_\Delta = 1.8 + j9.0\,\Omega/\phi$$

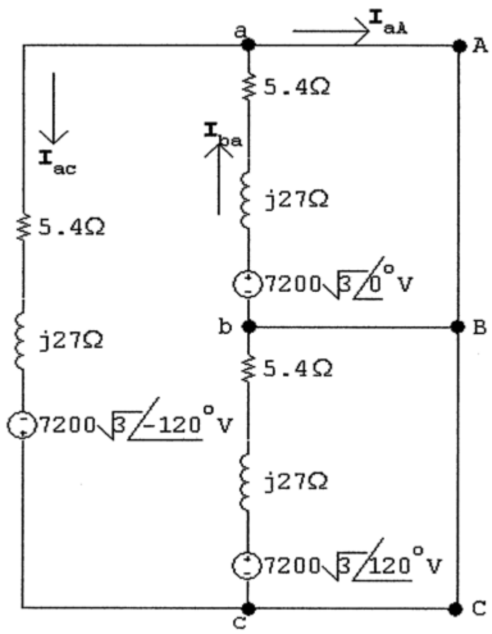


[b] $\mathbf{V}_{ab} = 7200\underline{/30^\circ} - 7200\underline{/150^\circ} = 7200\sqrt{3}\underline{/0^\circ}\,\text{V}$

Since the phase sequence is negative, it follows that

$$\mathbf{V}_{bc} = 7200\sqrt{3}\underline{/120^\circ}\,\text{V}$$

[c]



$$\mathbf{I}_{ba} = \frac{7200\sqrt{3}}{5.4 + j27} = 452.91\underline{/-78.69^\circ}\,\text{A}$$

$$\mathbf{I}_{\rm ac} = \frac{7200\sqrt{3}\underline{/-120^\circ}}{5.4 + j27} = 452.91\underline{/-198.69^\circ}\,\text{A}$$

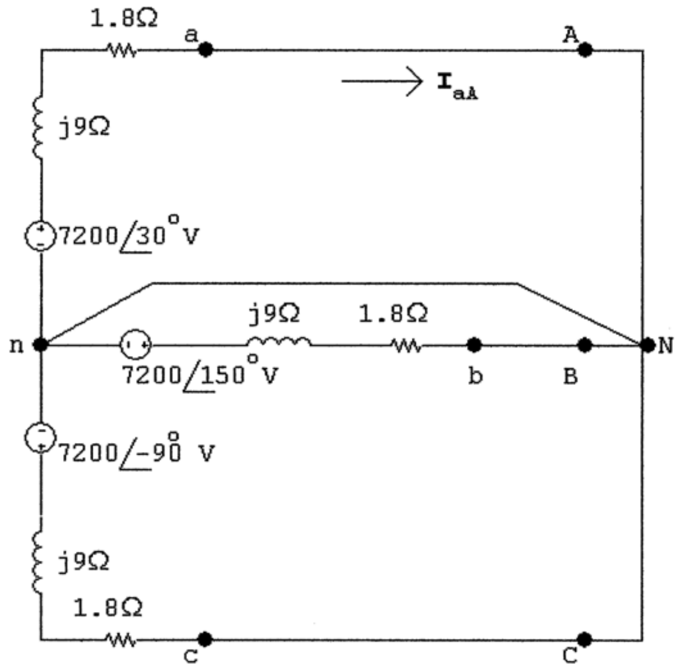
$$\mathbf{I}_{\rm aA} = \mathbf{I}_{\rm ba} - \mathbf{I}_{\rm ac} = 784.46\underline{/-48.69^\circ}\,\text{A}$$

Since we have a balanced three-phase circuit and a negative phase sequence we have:

$$\mathbf{I}_{\rm bB} = 784.46\underline{/71.31^\circ}\,\text{A}$$

$$\mathbf{I}_{\rm cC} = 784.46\underline{/-168.69^\circ}\,\text{A}$$

[d]



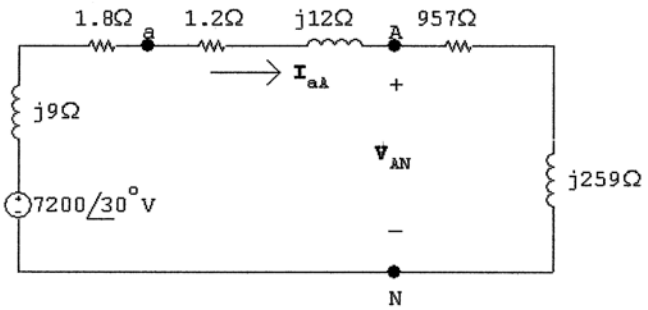
$$\mathbf{I}_{\rm aA} = \frac{7200\underline{/30^\circ}}{1.8 + j9} = 784.46\underline{/-48.69^\circ}\,\text{A}$$

Problem 3:

The Δ-connected source of Problem 2 is connected to a Y-connected load by means of a balanced three-phase distribution line. The load impedance is 957+j259 Ω per phase. And the line impedance is 1.2+j12 Ω per phase.

a) Construct a single-phase equivalent circuit of the system.
b) Determine the magnitude of the line voltage at the terminals of the load.
c) Determine the magnitude of the phase current in the Δ-source.
d) Determine the magnitude of the line voltage at the terminals of the source.

[a]



[b] $\mathbf{I}_{aA} = \dfrac{7200\angle 30^\circ}{960 + j280} = 7.2\angle 13.74^\circ$ A

$\mathbf{V}_{AN} = (957 + j259)(7.2\angle 13.74^\circ) = 7138.28\angle 28.88^\circ$ V

$|\mathbf{V}_{AB}| = \sqrt{3}(7138.28) = 12{,}363.87$ V

[c] $|\mathbf{I}_{ba}| = \dfrac{7.2}{\sqrt{3}} = 4.16$ A

[d] $\mathbf{V}_{an} = (958.2 + j271)(7.20\angle 13.74^\circ) = 7169.65\angle 29.54^\circ$ V

$|\mathbf{V}_{ab}| = \sqrt{3}(7169.65) = 12{,}418.20$ V

Problem 4:

A three-phase positive sequence Y-connected source supplies 14kVA with a power factor of 0.75 lagging to a parallel combination of a Y-connected load and a Δ-connected load. The Y-connected load used 9 kVA at a power factor of 0.6 lagging and has an a-phase current of $10\angle -30^0$ A.
a) Find the complex power per phase of the Δ-connected load.
b) Find the magnitude of the line voltage.

[a] $S_{T\Delta} = 14{,}000\underline{/41.41^\circ} - 9000\underline{/53.13^\circ} = 5.5\underline{/22^\circ}$ kVA

$$S_\Delta = S_{T\Delta}/3 = 1833.46\underline{/22^\circ} \text{ VA}$$

[b] $|\mathbf{V}_{\text{an}}| = \left|\frac{3000\underline{/53.13^\circ}}{10\underline{/-30^\circ}}\right| = 300$ V(rms)

$$|\mathbf{V}_{\text{line}}| = |\mathbf{V}_{\text{ab}}| = \sqrt{3}|\mathbf{V}_{\text{an}}| = 300\sqrt{3} = 519.62 \text{ V(rms)}$$