Tutorial 3

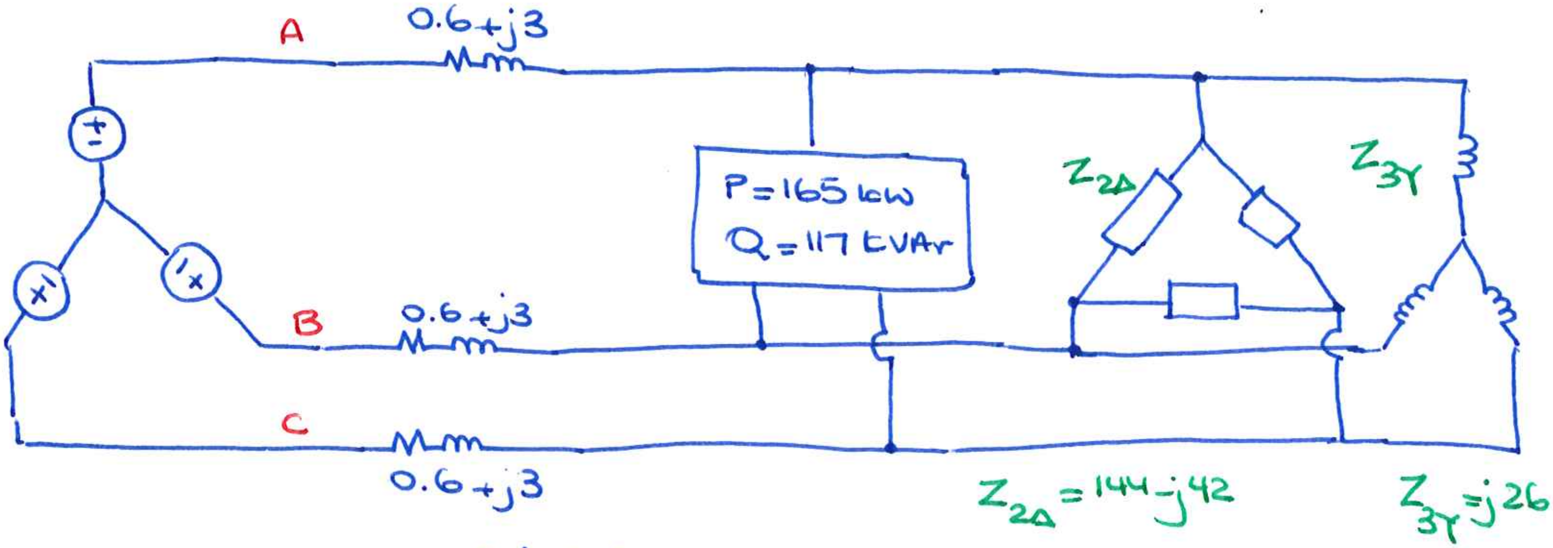
A transmission line with impedance of 0.6+j3 Ω per phase connects a Y-connected generator to 3 loads in parallel: ← provides a predictable voltage level for all loads

- Load 1 draws 165 kW and 117 kVAr (or 202.3 kVA and 0.81 lagging power factor)
- Load 2: delta-connected, Z = 144-j42 Ω
- Load 3: Y-connected, Z = j26 Ω

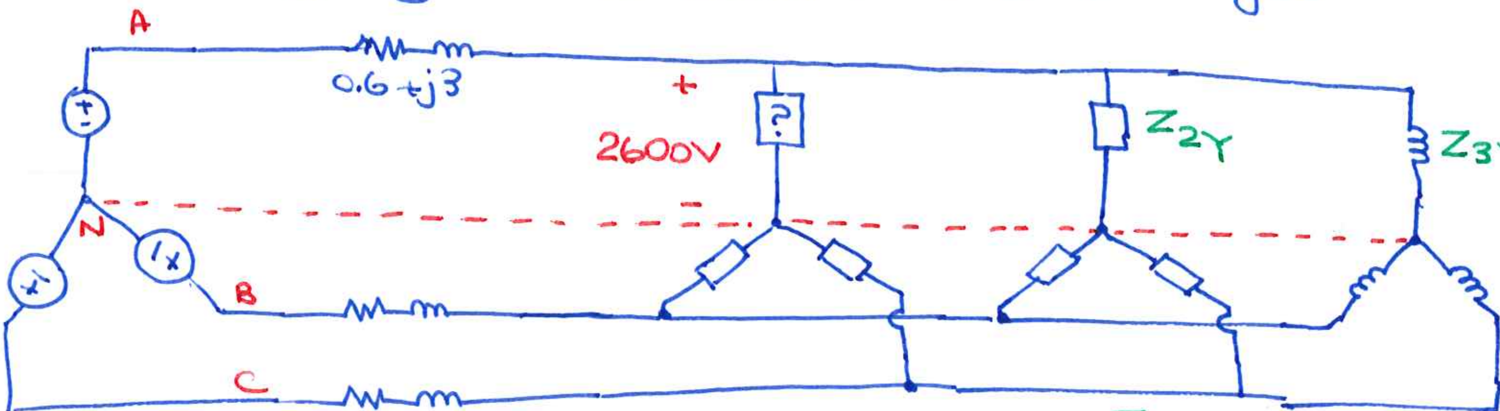
Line-to-neutral voltage at the load end is 2600 V. Find:

a) Phase current of the source
b) Line-to-line voltage at the source
c) $V_{an}(t)$ in Load 3
d) Instantaneous phase current in Load 2
e) Power absorbed by Load 3

Tutorial 3

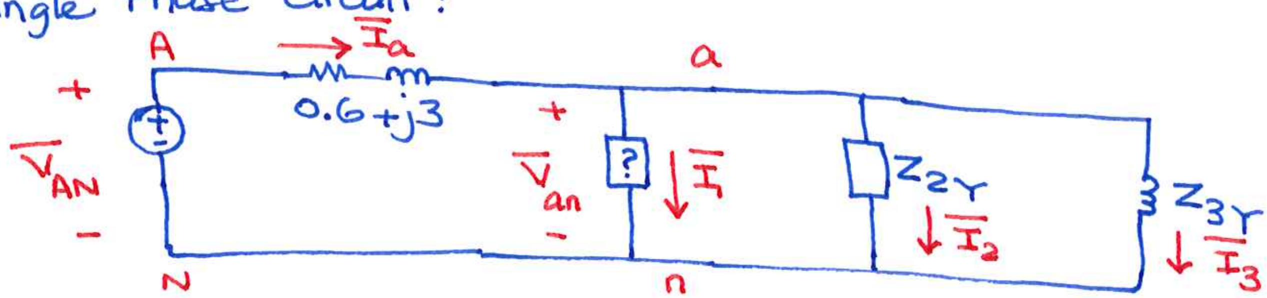


Convert everything to equivalent Y connection for single ϕ analysis



$$Z_{2Y} = \frac{Z_{2\Delta}}{3} = 48 - j14$$

Single Phase circuit:



$$\overline{V}_{an} = 2600 \angle 0^\circ$$

given arbitrarily assigned

a) Need to find $\overline{I_a}$.

To find $\overline{I_1}$:

$$\overline{S_{1\phi}} = \overline{V_{an}} \cdot \overline{I_1}^* \quad \therefore \quad \overline{I_1} = \frac{\overline{S_{1\phi}}^*}{\overline{V_{an}}^*}$$

$$\overline{S_{1\phi}} = \frac{1}{3} \cdot \overline{S_{3\phi}} = \frac{1}{3}\left(\underbrace{165}_{P} + j\underbrace{117}_{Q}\right) = 67.42 \angle 35.3^\circ \text{ kVA}$$

$$\therefore \overline{I_1} = \frac{67.42 \angle -35.3^\circ \text{ kVA}}{2600 \angle 0^\circ \text{ V}} = 25.93 \angle -35.3^\circ \text{ A}$$

Use Ohm's Law to find $\overline{I_2}$ & $\overline{I_3}$:

$$\overline{I_2} = \frac{\overline{V_{an}}}{Z_{2Y}} = \frac{2600 \angle 0^\circ}{48 - j14} = 49.92 + j\,14.56 \text{ A}$$

$$\overline{I_3} = \frac{\overline{V_{an}}}{Z_{3Y}} = \frac{2600 \angle 0^\circ}{j26} = -j100 \text{ A}$$

From KCL:

$$\overline{I_a} = \overline{I_1} + \overline{I_2} + \overline{I_3} = 123 \angle -54.71^\circ \text{ A}$$

- Source is Y-connected $\therefore$ phase current = line current $= 123 \angle -54.71^\circ$ A

b) $$\overline{V_{AN}} = \overline{V_{an}} + \overline{I_a}(0.6 + j3) \qquad \leftarrow \text{KVL in the } 1\phi \text{ circuit}$$

line-to-neutral voltage at source

$$= 2974 \angle 2.97^\circ \text{ V}$$

$$\overline{V_{AB}} = \overline{V_{AN}} \cdot \sqrt{3} \angle 30^\circ = 5104 \angle 32.97^\circ \text{ V}$$

line-to-line voltage at source

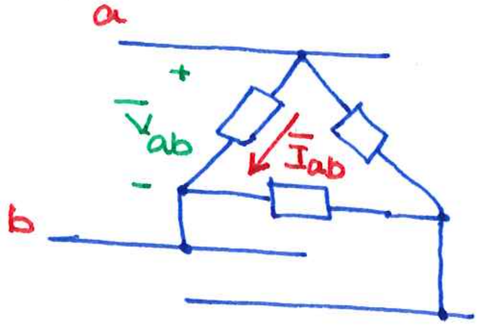
c) $$\overline{V_{an}} = \underbrace{2600}_{\text{RMS}} \angle 0^\circ \longrightarrow V_{an}(t) = \underbrace{2600\sqrt{2}}_{\text{peak}} \cdot \cos(\omega t + 0^\circ)$$

d) Need $\overline{I}_{ab}$ (or $\overline{I}_{bc}$, $\overline{I}_{ca}$) in Δ- connected load 2:

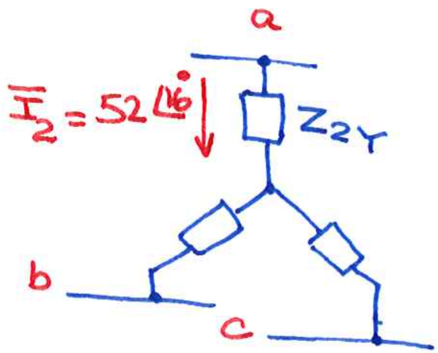
option i

$$\overline{I}_{ab} = \frac{\overline{V}_{ab}}{Z_{2\Delta}} = \frac{\overline{V}_{an} \cdot \sqrt{3}\angle 30^\circ}{Z_{2\Delta}}$$

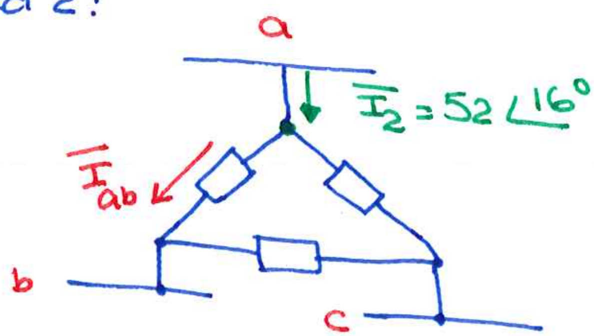
$$= 30\angle 46^\circ \quad A$$



option ii from part a)



actual load 2:

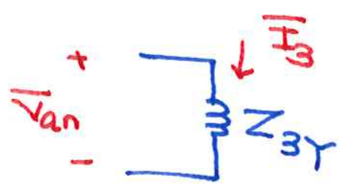


going from line current $\overline{I}_2$ to phase current $\overline{I}_{ab}$ in Δ connection:

$$\underbrace{\overline{I}_{ab}}_{\overline{I}_\phi} = \frac{\overbrace{\overline{I}_2}^{\overline{I}_\ell}}{\sqrt{3}\angle -30^\circ} = 30\angle 46^\circ \quad A$$

For both options, $i_{ab}(t) = 30\sqrt{2}\cos(\omega t + 46^\circ)$

e) $\overline{S}_{3\phi} = 3 \cdot \overline{S}_{1\phi} = 3\left(\overline{V}_{an} \cdot \overline{I}_3{}^*\right)$



$$= 3 \times 2600\angle 0^\circ \times 100\angle +90^\circ$$

$$= 780 \angle 90^\circ \quad kVA$$

$$= 0 + j\,780$$

$P_{3\phi} = 0$ $\qquad$ $Q_{3\phi} = 780$ kVAr