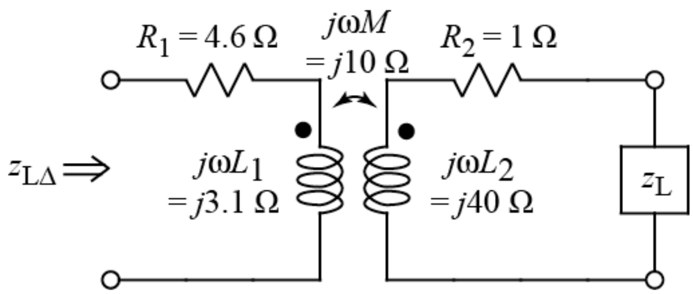
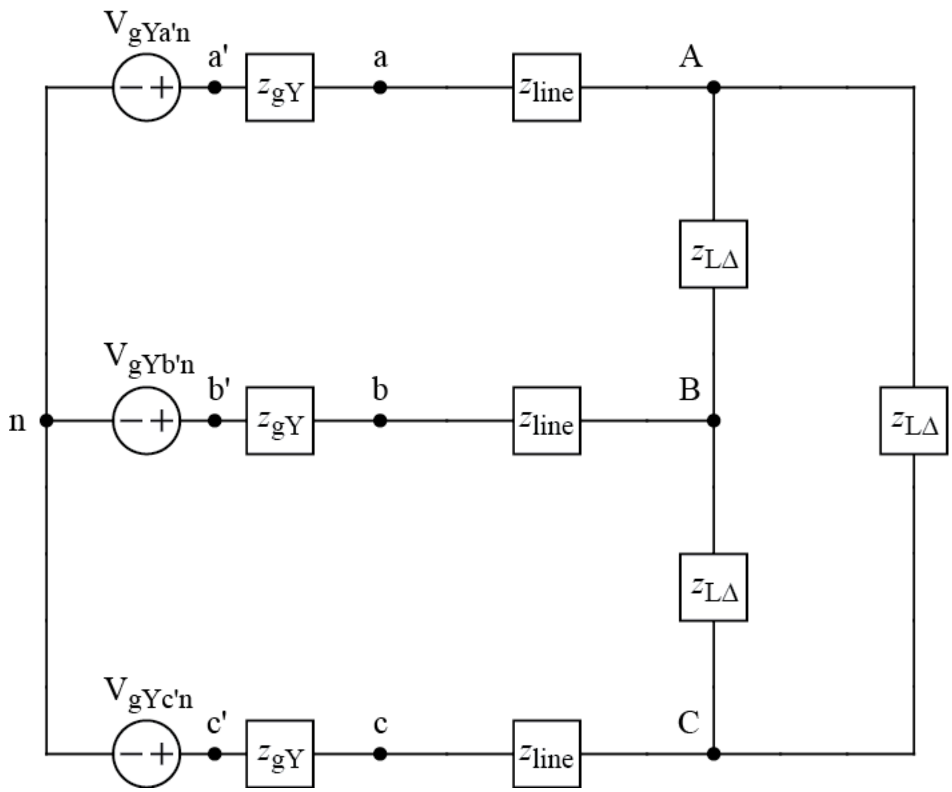
HOMEWORK #10 probs 3, 4, and 5 solution

Ex:



a) Find the value of load impedance, z_L, that makes $z_{L\Delta} = 24.6 - j36.9\ \Omega$. Note that $z_{L\Delta}$ is the equivalent impedance of the entire circuit.



$V_{gYa'n} = 67\angle 0°$ V $\qquad z_{gY} = 11.9 + j19.7\ \Omega$

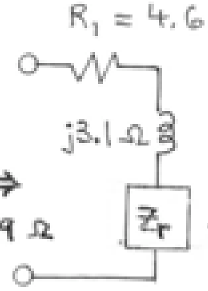
$V_{gYb'n} = 67\angle{-120°}$ V $\qquad z_{line} = j6\ \Omega$

$V_{gYc'n} = 67\angle{+120°}$ V $\qquad z_{L\Delta} = 24.6 - j36.9\ \Omega$

b) For the above 3-phase balanced circuit, find the numerical value of the phasor current $\mathbf{I}_{CA}$.

c) For the above 3-phase balanced circuit, find the numerical value of the phasor voltage $\mathbf{V}_{b'a'}$.

b) We replace the secondary with reflected impedance z_r in the primary.



$Z_{L\Delta} \Rightarrow$
$= 24.6 - j36.9\ \Omega$

$$Z_r = \frac{(\omega M)^2}{Z_{sec\ tot}}$$

$$\cancel{4.6+j3.1} + \left(Z_r = \frac{(10\ \Omega)^2}{j40 + 1\Omega + Z_L} \right) = \begin{array}{r} 24.6 - j\,36.9\ \Omega \\ \underline{-4.6 - j\,3.1\ \Omega} \\ 20 - j\,40\ \Omega \end{array}$$

Inverting both sides, we have the following:

$$\frac{j40 + 1\Omega + Z_L}{100\ \ \Omega^2} = \frac{1}{20 - j40\ \Omega}$$

$$Z_L = \frac{100\ \ \Omega^2}{20 - j\,40\ \Omega} - (1 + j\,40)\ \Omega$$

$$= 1 + 2i - 1 - j\,40\ \Omega$$

$$Z_L = -j\,38\ \Omega$$

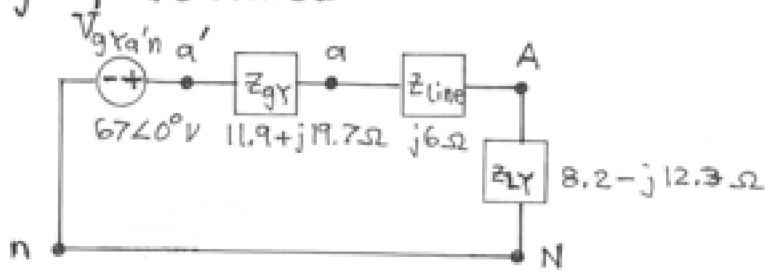
sol'n: a) We use a single-phase model to find V_{AN}. From V_{AN} we can find V_{AB}, then V_{CA}, and then I_{CA}.

We only need to convert $Z_{L\Delta}$ to Z_{LY}:

$$Z_{LY} = \frac{Z_{L\Delta}}{3} = \frac{24.6 - j\,36.9}{3}\ \Omega$$

$$Z_{LY} = 8.2 - j\,12.3\ \Omega$$

Single-phase model:



$$V_{AN} = V_{gYa'n} \cdot \frac{Z_{LY}}{Z_{gY}+Z_{line}+Z_{LY}}$$

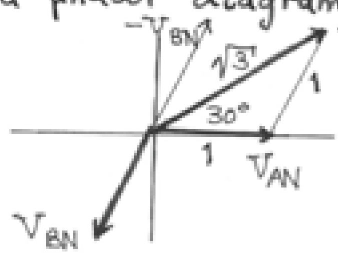
$$= 67\angle 0° V \; \frac{8.2-j12.3\,\Omega}{11.9+j19.7+j6+8.2-j12.3\,\Omega}$$

$$= 67\angle 0° V \; \frac{8.2-j12.3\,\Omega}{20.1+j13.4\,\Omega}$$

$$\doteq 67\angle 0° V \cdot 0.612\angle -90°$$

$$V_{AN} = 41\angle -90° V$$

We use a phasor diagram to find V_{AB}.



$$V_{AB} = V_{AN} - V_{BN}$$
$$= V_{AN} \cdot \sqrt{3}\angle 30°$$

$$V_{AB} = 41\angle -90° V \cdot \sqrt{3}\angle 30°$$

$$V_{AB} \doteq 71\angle -60° V$$

We shift $+120°$ to get V_{CA}:

$V_{CA} = V_{AB} \cdot 1\angle 120°$

$V_{CA} \doteq 71\angle 60°$ V

Using $Z_{L\Delta}$ and V_{CA}, we find I_{CA}:

$$I_{CA} = \frac{V_{CA}}{Z_{L\Delta}} \doteq \frac{71\angle 60° \text{ V}}{24.6 - j36.9\ \Omega}$$

$$\doteq \frac{71\angle 60° \text{ V}}{44.35\angle -56.3°\ \Omega}$$

$I_{CA} \doteq 1.6\angle 116.3°$ A

c) Since $V_{AB} = V_{AN}\sqrt{3}\angle 30°$, we have the same relationship for the generator side:

$$V_{a'b'} = V_{a'n}\sqrt{3}\angle 30°$$

or

$$V_{a'b'} = 67\angle 0° \cdot \sqrt{3}\angle 30° \doteq 116\angle 30°$$

Reversing the indices to b'a' means changing the sign, which is equivalent to adding or subtracting 180°.

$$V_{b'a'} \doteq 116\angle 210° = 116\angle -150°$$