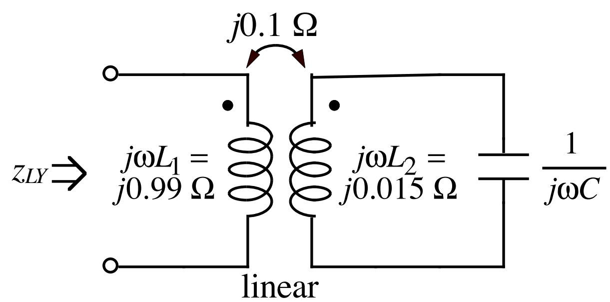
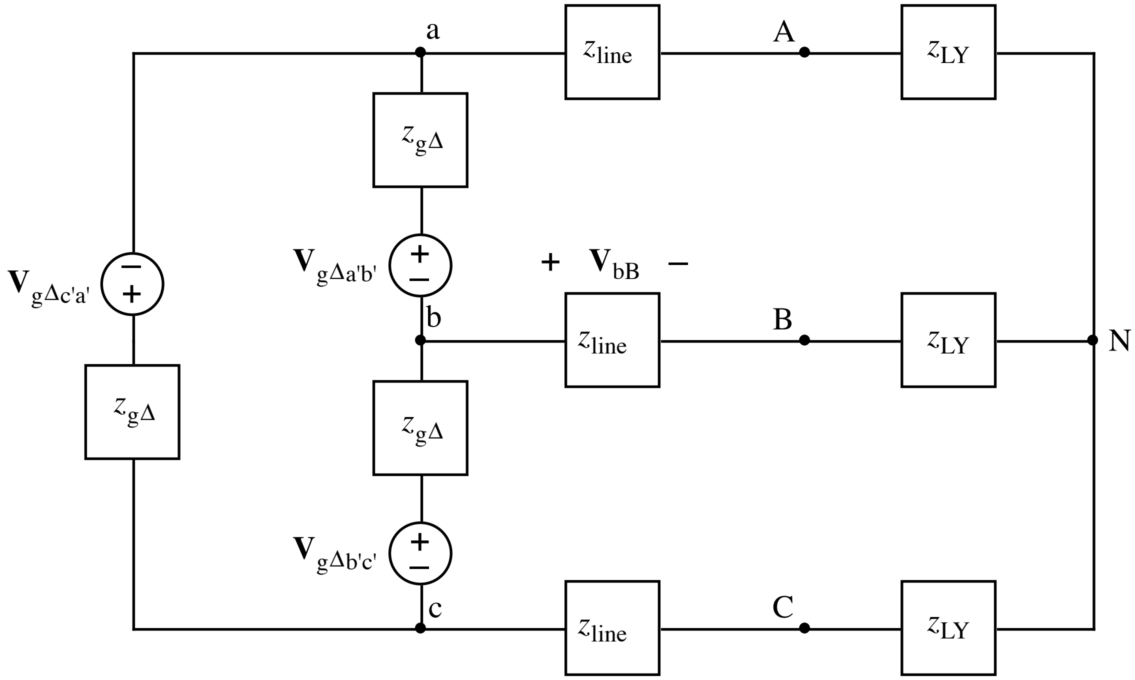
HOMEWORK #10 probs 3, 4, and 5 solution

Ex:



a) Given $\omega = 1\text{M rad/s}$, find the value of C that makes $z_{LY} = -j1.01\ \Omega$. Note that z_{LY} is the equivalent impedance of the entire circuit.



$V_{g\Delta a'b'} = 168\angle 0°$ V $z_{g\Delta} =$ $j0.9\ \Omega$

$V_{g\Delta b'c'} = 168\angle -120°$ V $z_{line} =$ $j1.68\ \Omega$

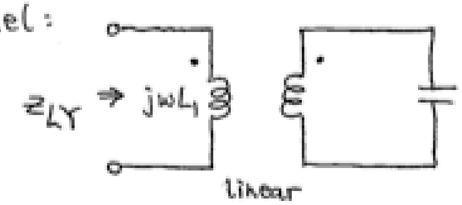
$V_{g\Delta c'a'} = 168\angle +120°$ V $z_{LY} =$ $-j1.01\ \Omega$

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

sol'n: a) We replace the secondary with reflected impedance, Z_r:

$$Z_r = \frac{(\omega M)^2}{Z_{\text{secondary tot}}} = \frac{(0.1)^2}{j0.015 + \frac{1}{j\omega C}}$$

model:



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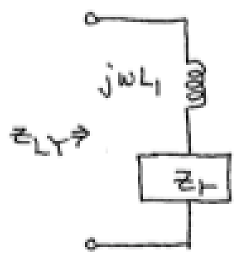


Thus, $Z_{LY} = \underset{j0.99\Omega}{j\omega L_1} + Z_r = -j1.01\Omega$

or $\quad Z_r = -j2\Omega$

or $$\frac{(0.1)^2}{j0.015 + \frac{1}{j\omega C}} = -j2\Omega$$

or $$\frac{1}{j0.015 + \frac{1}{j\omega C}} = -j200\Omega$$

or $$j0.015 + \frac{1}{j\omega C} = \frac{1}{-j200\Omega}$$

or $$0.015 + -\frac{1}{\omega C} = \frac{1}{200\Omega}$$

or $$-\frac{1}{\omega C} = 0.005 - 0.015 = -0.01$$

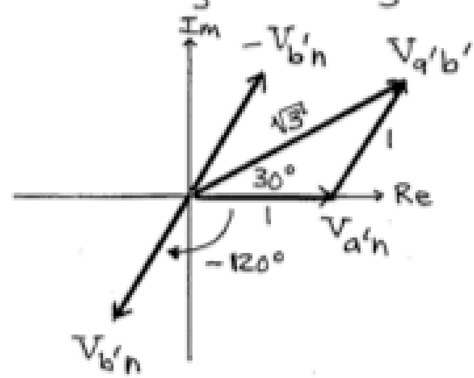
or
$$\omega C = 100$$

or
$$C = \frac{100}{\omega} = \frac{100}{1\,Mr/s}$$

or
$$C = 100\,\mu F$$

b) We first transform the delta generator to a Y configuration.

$$z_{gY} = \frac{z_{g\Delta}}{3} = j\frac{0.9}{3}\,\Omega = j0.3\,\Omega$$



$$V_{a'b'} = V_{a'n} - V_{b'n} = V_{a'n} - V_{a'n}\cdot 1\angle -120°$$

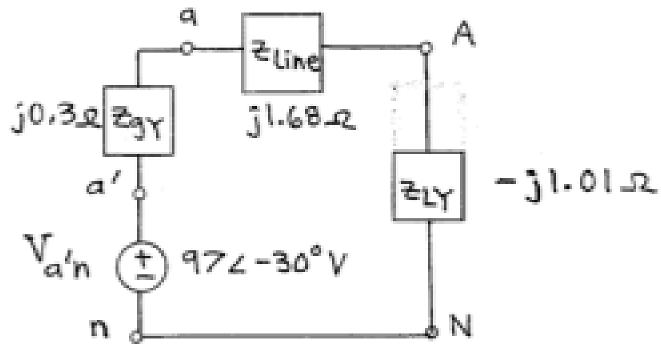
or
$$V_{a'b'} = V_{a'n}\left(1 - 1\angle -120°\right)$$

or
$$V_{a'b'} = V_{a'n}\,\sqrt{3}\angle 30° \quad \text{(from diagram)}$$

or
$$V_{a'n} = V_{a'b'}\,\frac{1}{\sqrt{3}}\angle -30° = \frac{168}{\sqrt{3}}\angle -30°$$

$$V_{a'n} = 97\angle -30°\ V$$

single-phase model:



We find V_{bB} by shifting V_{aA} by -120°.

$$V_{aA} = V_{a'n} \cdot \frac{Z_{line}}{Z_{gY} + Z_{line} + Z_{LY}}$$

or

$$V_{aA} = 97\angle{-30°}\,V \cdot \frac{j\,1.68\,\Omega}{j0.3 + j\,1.68\,\Omega - j\,1.01\,\Omega}$$

or

$$V_{aA} = 97\angle{-30°}\,V \; \frac{1.68}{0.97}$$

or

$$V_{aA} = 100\,(1.68)\,\angle{-30°}\,V$$

$$V_{aA} = 168\angle{-30°}\,V$$

We shift V_{aA} by -120° to obtain V_{bB}:

$$V_{bB} = 168\angle{-150°}\,V$$

(This illustrates that the voltage on the line may be as large as the generator voltage.)