EX:
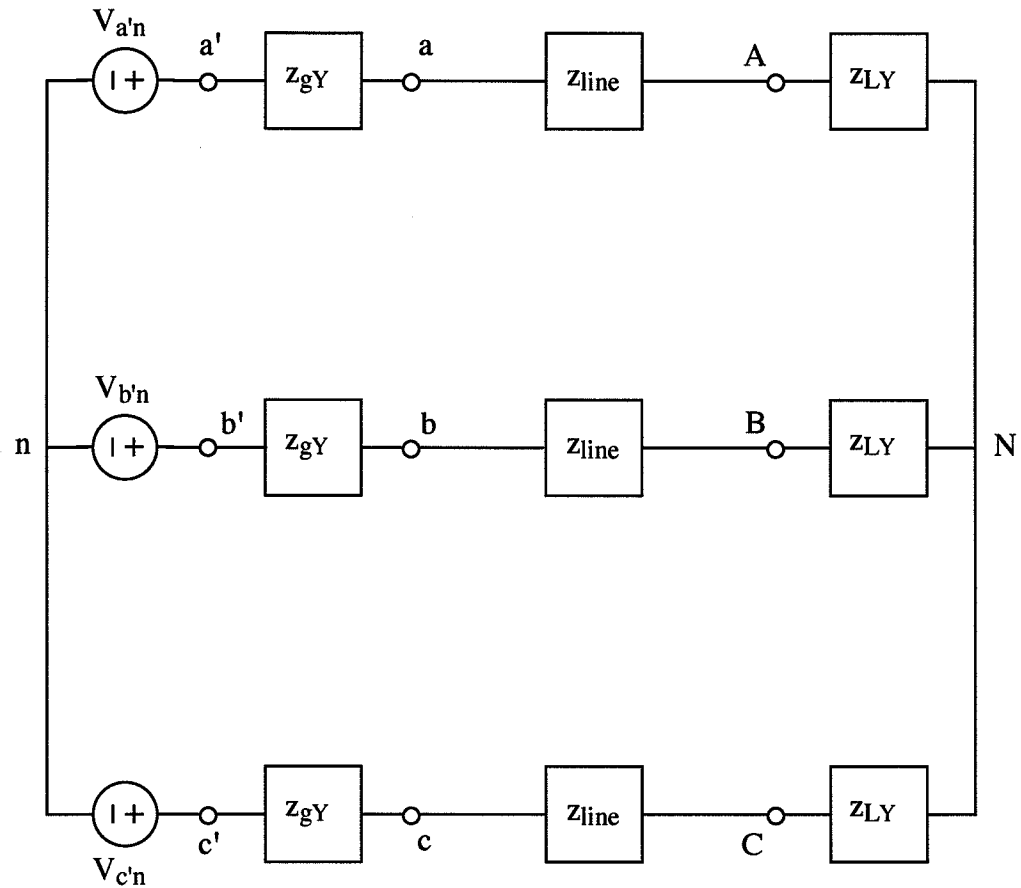

$V_{a'n} = 82\angle 0° \text{ V}$ $z_{gY} = 0.1 \ \Omega$

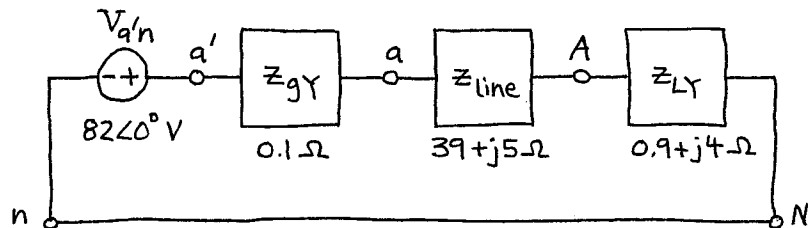$V_{b'n} = 82\angle 120° \text{ V}$ $z_{line} = 39 + j5 \ \Omega$

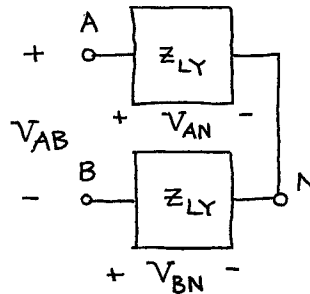$V_{c'n} = 82\angle -120° \text{ V}$ $z_{LY} = 0.9 + j4 \ \Omega$

a)   Draw a single-phase equivalent circuit.

b)   Calculate V_{AB}.

Sol'n: a) Since this circuit is already a Y-Y configuration, we obtain the single-phase equivalent circuit by adding a wire from n to N (which carries no current) and drawing only the A phase.

b) We find V_{AB} from V_{AN} and a phasor diagram that shows how V_{AN} and V_{AB} are related.
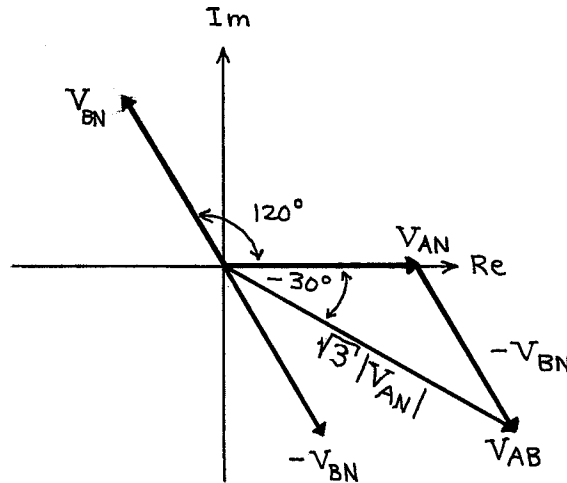
We have $V_{AB} = V_{AN} - V_{BN}$:

From symmetry and the phase angle shift of $+120°$ from $V_{a'n}$ to $V_{b'n}$, we know $V_{BN} = V_{AN} \cdot 1 \angle +120°$.

$$\therefore \quad V_{AB} = V_{AN} - V_{AN} \cdot 1 \angle +120°$$

We use a phasor diagram for the subtraction.

Note: We translate the $-V_{BN}$ vector so it starts where V_{AN} ends. This allows us to add V_{AN} and $-V_{BN}$ graphically.

Note: We always draw the diagram by starting with the shorter vector, V_{AN}, on the real axis. Then we perform the subtraction of the two shorter vectors, V_{AN} and V_{BN}, to get the longer vector V_{AB}. Thus, the diagram indicates how V_{AN} and V_{AB} are <u>related</u> by magnitude and phase rather than the actual phase of either V_{AN} or V_{AB}.

From the diagram, we have the following relationship between V_{AN} and V_{AB}:

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

Now we find V_{AN} from the single-phase model.

We use a voltage-divider eq'n to find V_{AN}:

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

$$= 82\angle 0° V \cdot \frac{0.9 + j4 \; \Omega}{0.1 + 39 + j5 + 0.9 + j4 \; \Omega}$$

$$= 82\angle 0° V \cdot \frac{0.9 + j4}{40 + j9}$$

$$= 82\angle 0° V \cdot \frac{4.1 \angle 77.3°}{41 \angle 12.7°}$$

$$= 8.2 \angle (0° + 77.3° - 12.7°) \, V$$

$$V_{AN} = 8.2 \angle 64.6° \, V$$

Using our eq'n from earlier

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

$$= 8.2 \angle 64.6° V \cdot \sqrt{3} \angle -30°$$

$$V_{AB} = 14.2 \angle 34.6° \, V$$

or $V_{AB} \doteq 11.7 + j8.1 \quad V$