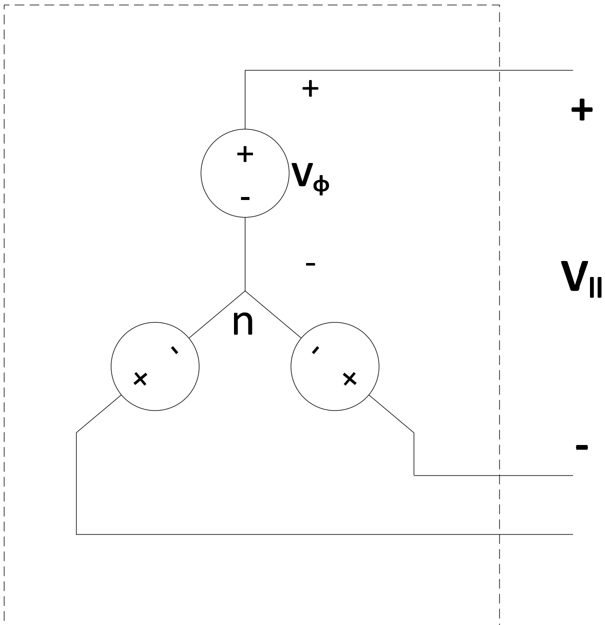
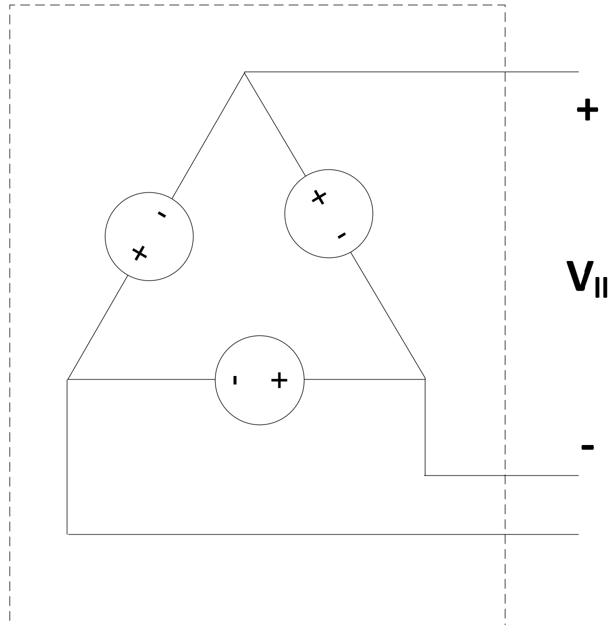
ENEL 487

Delta-Wye transformation

Sources:

For sources to be equivalent, the line-to-line voltage (V_{ll}) produced by one configuration should be identical to V_{ll} produced by the other.





For the Y-connected source to be equivalent to the delta-connected source, the phase (line-to-neutral) voltage in the Y-connected source should be:

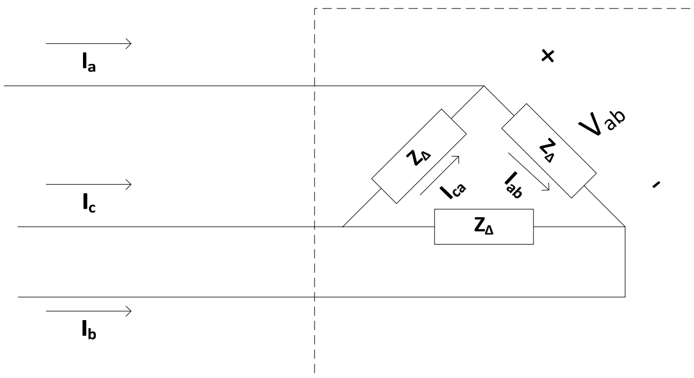
$$\overline{V_\emptyset} = \frac{\overline{V_{ll}}}{\sqrt{3}\angle 30°}$$

For the delta-connected source to be equivalent to the Y-connected source, the phase (line-to-line) voltage in the delta connection should be the same as the line-to-line voltage in the Y connection. We can also express the phase voltage in the delta connection (line-to-line) in terms of the phase voltage in the Y connection (line-to-neutral):

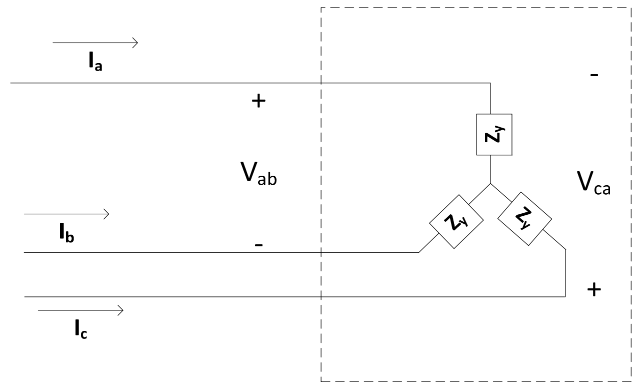
$$\overline{V_{ll}} = \overline{V_\emptyset} \, . \sqrt{3}\angle 30°$$

Loads:

For loads to be equivalent, the line-to-line voltage (V_{ll}) at the load terminals and the line current drawn by the load (I_l) should be identical. To accomplish this, the equivalent loads should be calculated based on the following equations:



$$Z_{\Delta} = 3.Z_y$$



$$Z_y = \frac{Z_{\Delta}}{3}$$

Why?

$$\bar{V}_{ab} = Z_y.\overline{I_a} - Z_y.\overline{I_b} = Z_y.(\overline{I_a} - \overline{I_b}) \qquad [1]$$

$$\bar{V}_{ca} = Z_y.(\overline{I_c} - \overline{I_a}) \qquad [2]$$

For a balanced system,

$$\overline{I_a} + \overline{I_b} + \overline{I_c} = 0 \quad \therefore \quad \overline{I_a} = -\overline{I_b} - \overline{I_c} \qquad [3]$$

Subtract [2] from [1], then plug in [3]

$$\bar{V}_{ab} - \bar{V}_{ca} = Z_y.(\overline{I_a} - \overline{I_b} - \overline{I_c} + \overline{I_a})$$
$$= 3\,Z_y.\overline{I_a}$$

$$\therefore\ 3\,Z_y = \frac{\bar{V}_{ab} - \bar{V}_{ca}}{\overline{I_a}}$$

KCL:

$$\bar{I}_a = \bar{I}_{ab} - \bar{I}_{ca} = \frac{\bar{V}_{ab}}{Z_{\Delta}} - \frac{\bar{V}_{ca}}{Z_{\Delta}}$$

$$\therefore\ Z_{\Delta} = \frac{\bar{V}_{ab} - \bar{V}_{ca}}{\bar{I}_a}$$