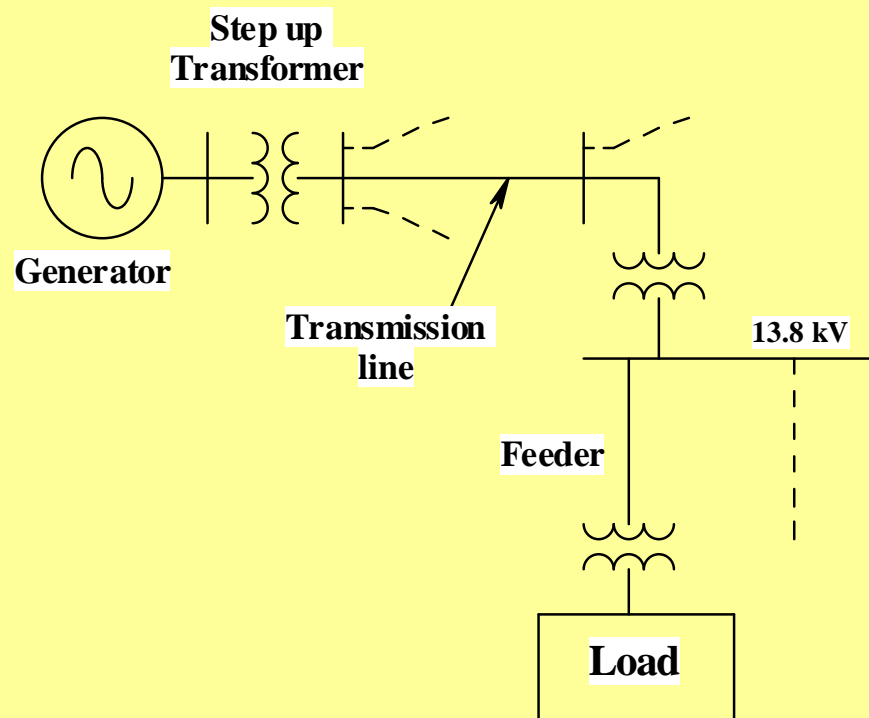


Review of Basic Electric Circuits

- Three-Phase Circuits
 - Per-Phase Analysis
 - Wye-Delta Transformation

Three Phase Circuits (Transmission and Distribution)

- One-line diagram of power systems



Three Phase Circuits

□ Wye-connection

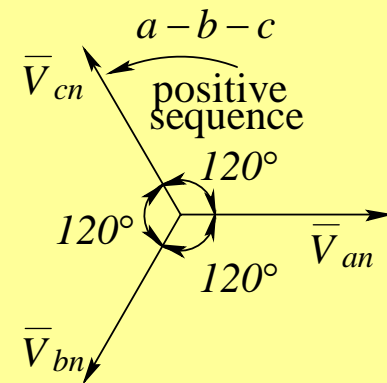
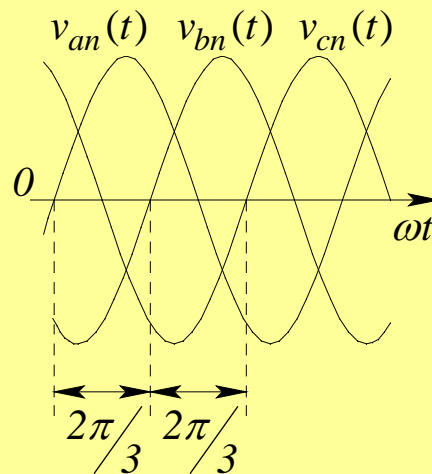
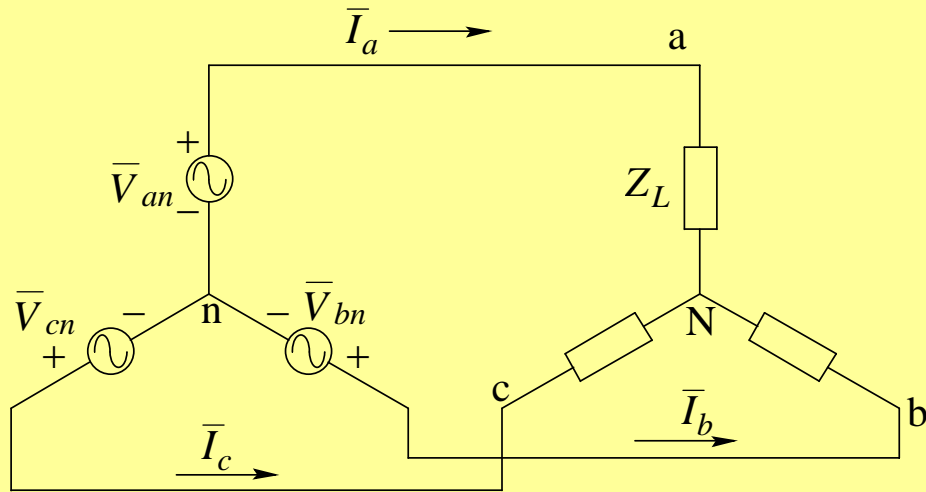
$$\bar{V}_{an} = \hat{V}_s \angle 0^\circ$$

$$\bar{V}_{bn} = \hat{V}_s \angle -120^\circ$$

$$\bar{V}_{cn} = \hat{V}_s \angle -240^\circ$$

$$\bar{V}_{an} + \bar{V}_{bn} + \bar{V}_{cn} = 0$$

$$v_{an}(t) + v_{bn}(t) + v_{cn}(t) = 0$$

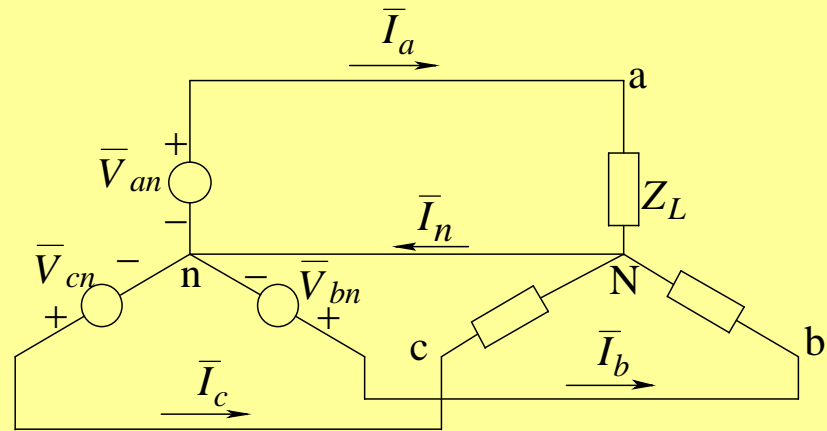


Per phase Analysis of Balanced Three phase Circuits

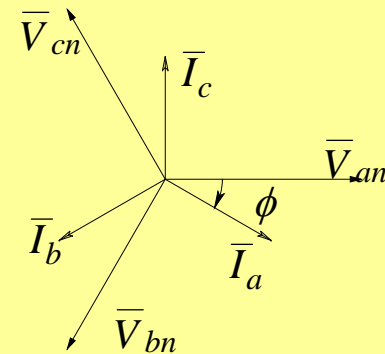
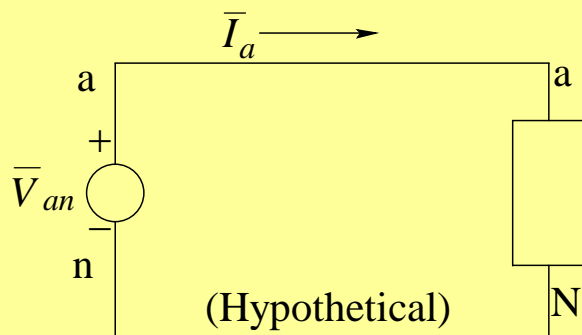
$$\bar{I}_a = \frac{\bar{V}_{an}}{|Z_L|} = \frac{\hat{V}_s}{|Z_L|} \angle -\phi$$

$$\bar{I}_b = \frac{\bar{V}_{bn}}{|Z_L|} = \frac{\hat{V}_s}{|Z_L|} \angle -\frac{2\pi}{3} - \phi$$

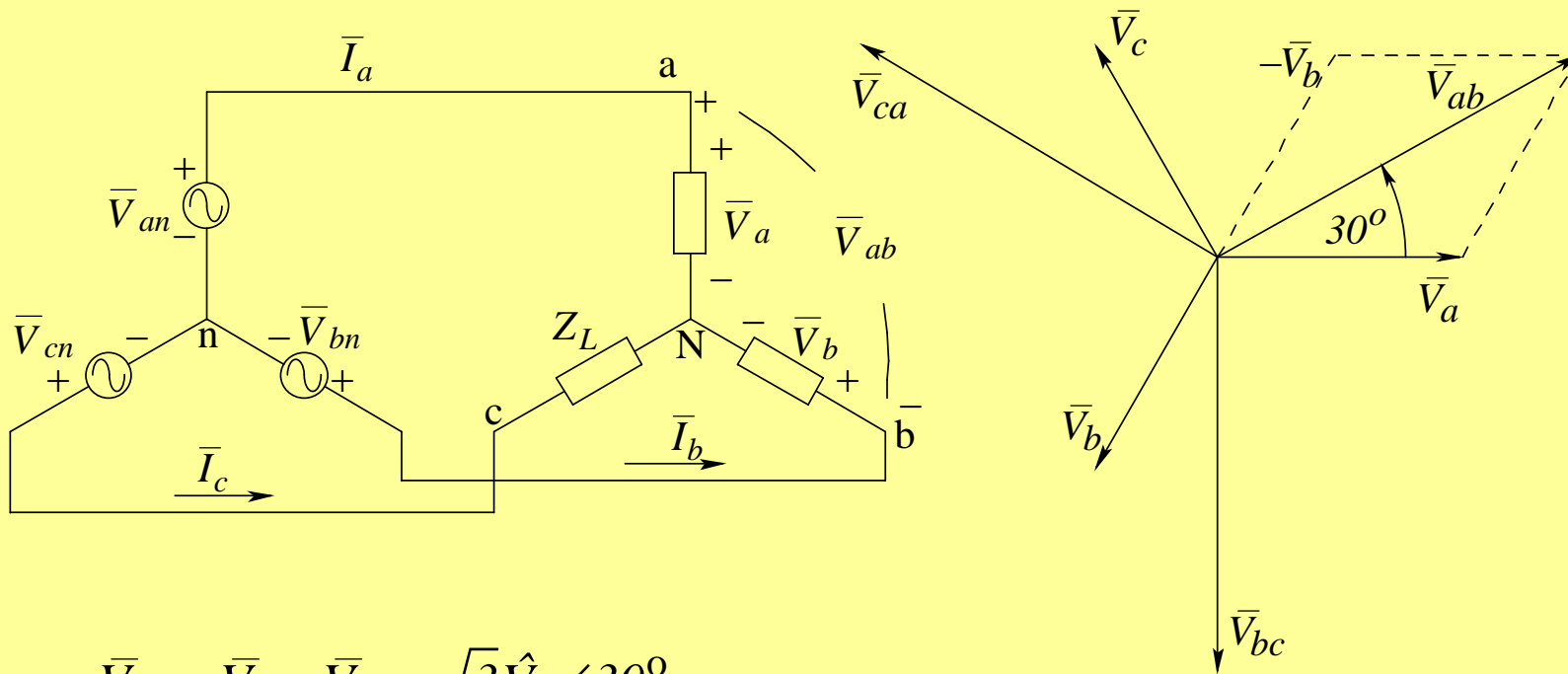
$$\bar{I}_c = \frac{\bar{V}_{cn}}{|Z_L|} = \frac{\hat{V}_s}{|Z_L|} \angle -\frac{4\pi}{3} - \phi$$



$$\bar{I}_n = (\bar{I}_a + \bar{I}_b + \bar{I}_c) = 0 \Rightarrow i_n(t) = [i_a(t) + i_b(t) + i_c(t)] = 0$$



Line-to-Line Voltages



$$\bar{V}_{ab} = \bar{V}_a - \bar{V}_b = \sqrt{3} \hat{V}_s \angle 30^\circ$$

$$\bar{V}_{bc} = \bar{V}_b - \bar{V}_c = \sqrt{3} \hat{V}_s \angle -90^\circ$$

$$\bar{V}_{ca} = \bar{V}_c - \bar{V}_a = \sqrt{3} \hat{V}_s \angle -210^\circ$$

$$\bar{V}_{LL} = \sqrt{3} \bar{V}_{ph} \angle 30^\circ$$

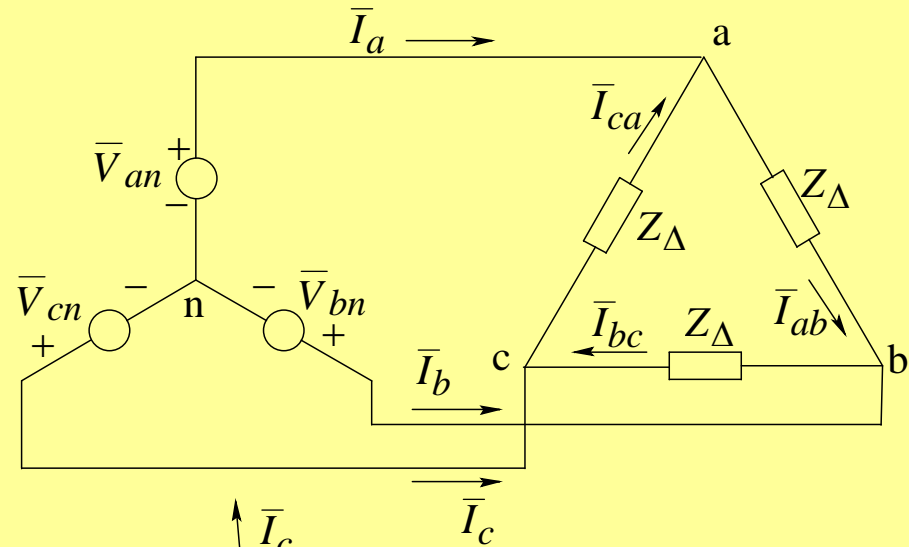
Delta Connection

Phase Currents in Delta Load

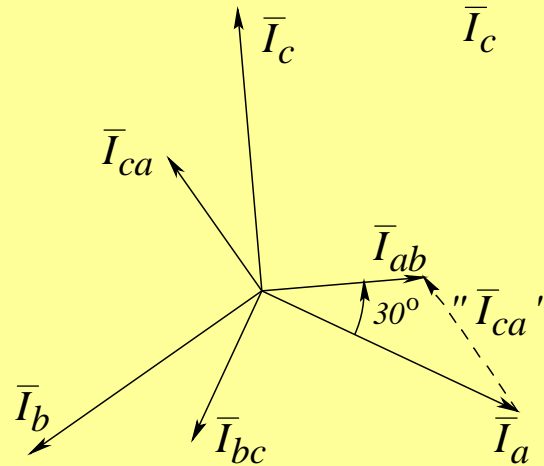
$$\bar{I}_a = \bar{I}_{ab} - \bar{I}_{ca}$$

$$\bar{I}_b = \bar{I}_{bc} - \bar{I}_{ab}$$

$$\bar{I}_c = \bar{I}_{ca} - \bar{I}_{bc}$$

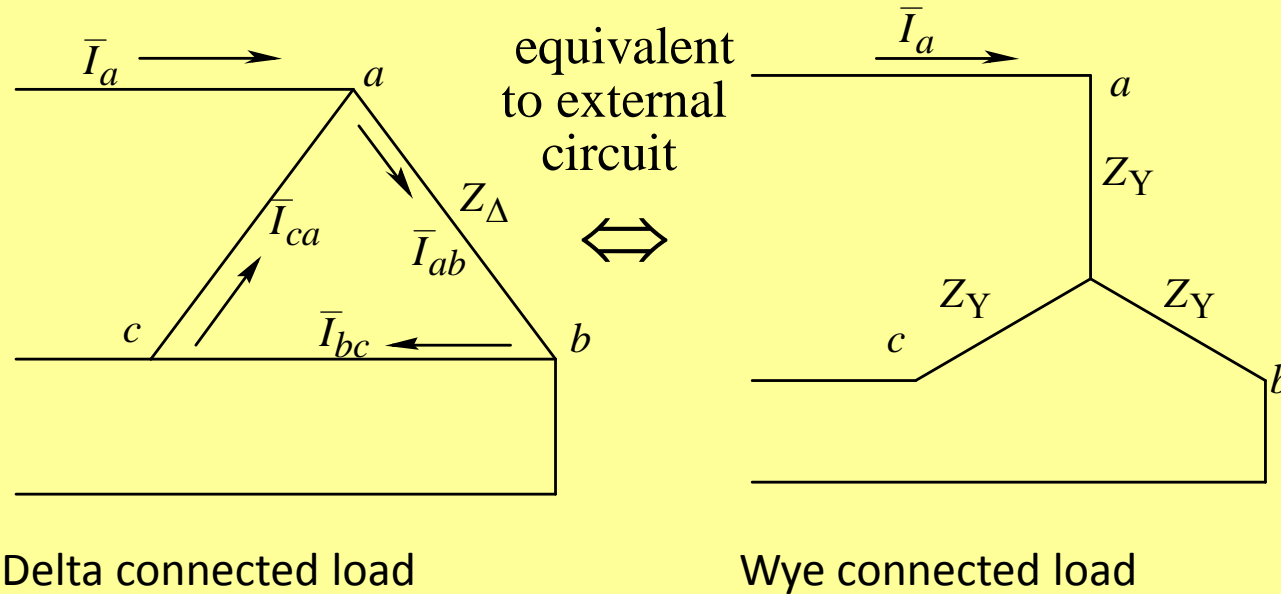


$$\bar{I}_\Delta = \frac{1}{\sqrt{3}} \bar{I}_l \angle 30^\circ$$



$\Delta - Y$ Transformation

- Allows per phase analysis



These circuits are indistinguishable to the external circuit, when

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

Summary

- Three-Phase Circuits
 - Per-Phase Analysis
 - Wye-Delta Transformation