Announcements

Syllabus : chapters 10, 11, 12 + 16 — ①

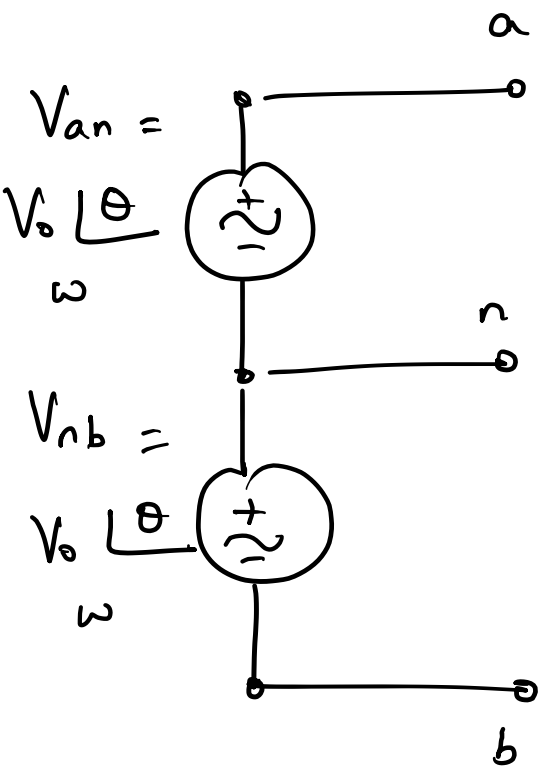
② Tuesday 4:30 pm – 6:30 pm make up Quiz 1 + 2

③ Tentative Tuesday 11:00 am – 12:30 pm

④ cheat sheet handwritten, 2 A4 pages / calculator

Review

Single Phase Differential / Two phase / Single Phase Three wire



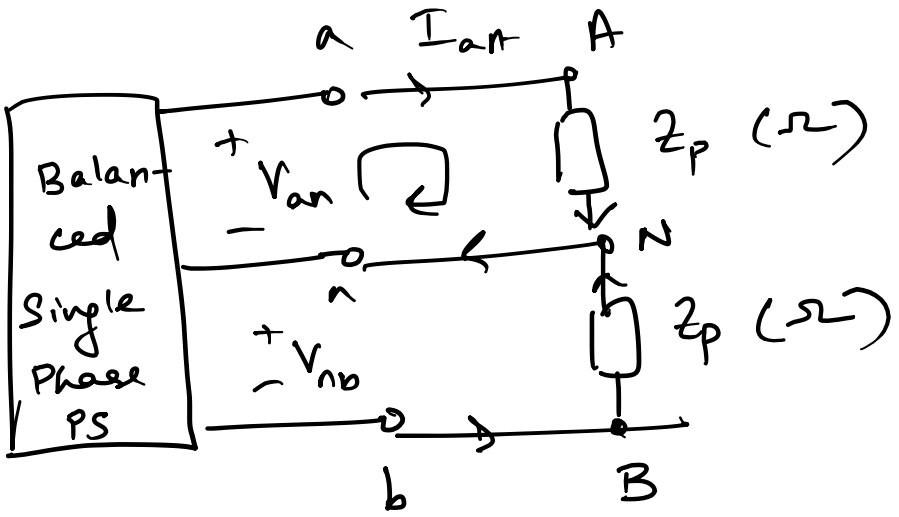
$v_{an} = V_0 \cos(\omega t + \theta)$

$v_{bn} = V_0 \cos(\omega t + \theta - 180^\circ)$

Balanced power supply

$V_{bn} = -V_{nb} = V_0 \angle \theta - 180^\circ$

$V_{an} + V_{bn} = 0$

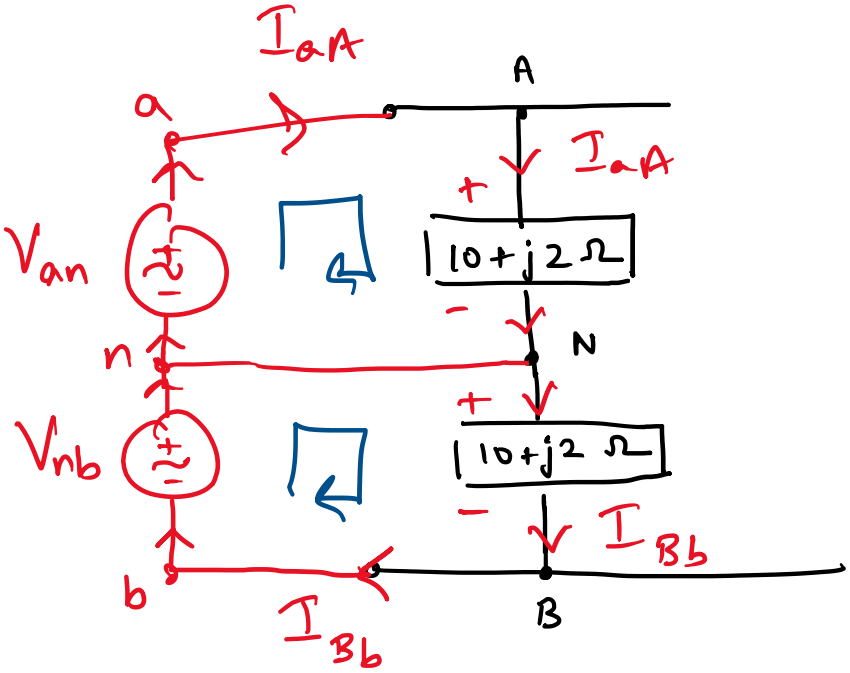


When you have balanced supply $\equiv$ balanced load

$$I_{Nn} = 0 \quad A$$

$$|I_{aA}| = |I_{bB}|$$

4. Consider the balanced load represented in the figure, if it is connected to a three-wire balanced source operating at 50 Hz such that V_{an} = 115 V, (a) Determine the power factor of the load if the capacitor is omitted; (b) Determine the value of capacitance C that will achieve a unity power factor for the total load.



$$\omega = 2\pi f = 2 \times \pi \times 50 = 100\pi \text{ rad/s}$$

$$V_{an} = 115 \angle 0 \quad , \quad V_{nb} = 115 \angle 0$$

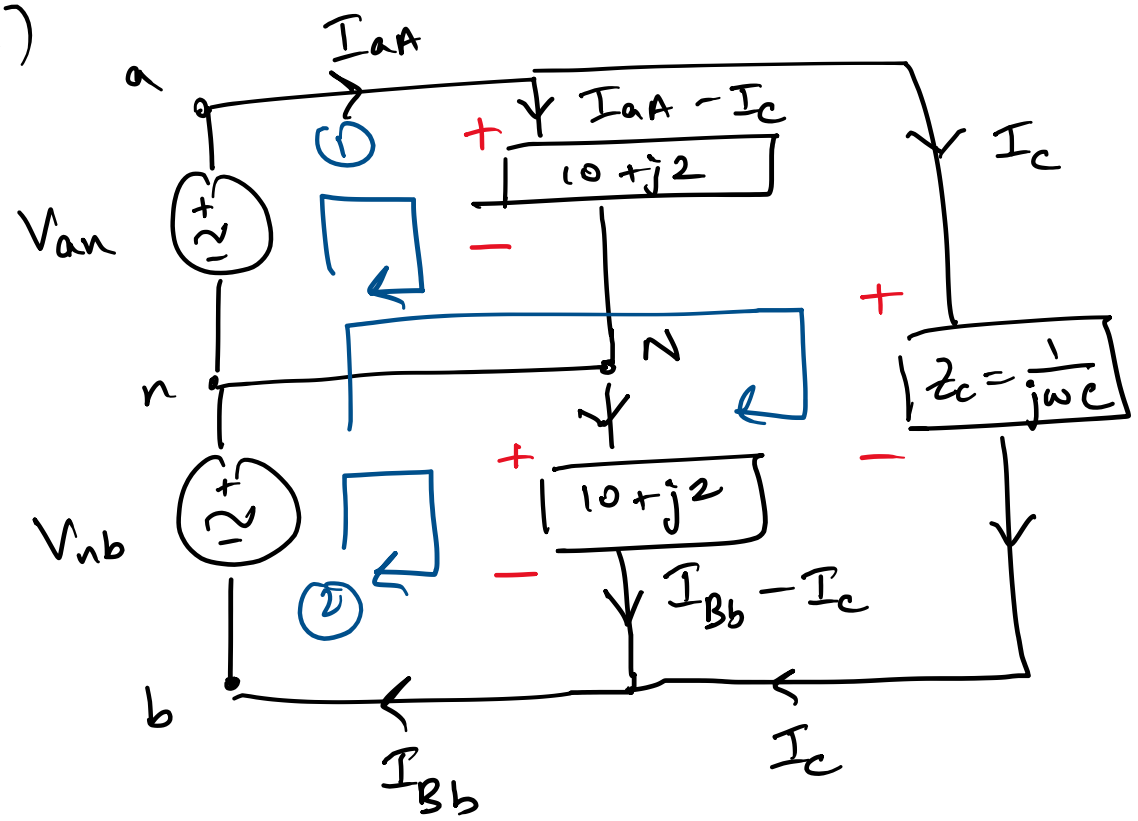
$$+ V_{an} - I_{aA} \times (10 + j2) = 0$$

$$I_{aA} = \frac{V_{an}}{10 + j2} = \frac{115 \angle 0}{\sqrt{104} \angle 11.3^\circ}$$

$$\therefore I_{aA} = 11.27 \angle 0 - 11.3^\circ \text{ A}$$

pf = cos (11.3°) lagging

(b) (4)



Loop 1

$$+V_{an} - (I_{aA} - I_c) \times Z_p = 0$$

$$I_{aA} - I_c = \frac{V_{an}}{Z_p} \quad \text{— (1)}$$

Loop 2

$$+V_{nb} - (I_{Bb} - I_c) \times Z_p = 0$$

$$I_{Bb} - I_c = \frac{V_{nb}}{Z_p} \quad \text{— (2)}$$

Loop 3

$$V_{an} + V_{nb} = I_c \times Z_c$$

$$\therefore I_c = \frac{V_{ab}}{Z_c} \quad \text{— (3)}$$

$$pf = 1 = \cos(\theta - \varphi) =$$

$$\varphi = \theta$$

$$pf = 1 = \frac{Re\{S\}}{\|S\|} \Rightarrow \text{when}$$

$$Im\{S\} = 0$$

S = complex power of load

$$= \frac{1}{2} \times V_{an} (I_{an} - I_c)^* + \frac{1}{2} V_{nb} (I_{Bb} - I_c)^*$$

$$+ \frac{1}{2} V_{ab} (I_c)^*$$

$$= \frac{1}{2} V_{an} \times \left(\frac{V_{an}}{Z_p}\right)^* + \frac{1}{2} V_{nb} \times \left(\frac{V_{nb}}{Z_p}\right)^* + \frac{1}{2} V_{ab} \times \left(\frac{V_{ab}}{Z_c}\right)^*$$

↑ loop 1 ↑ loop 2 ↑ loop 3

$$= \frac{1}{2} \frac{|V_{an}|^2}{Z_p^*} + \frac{1}{2} \frac{|V_{nb}|^2}{Z_p^*} + \frac{1}{2} \frac{|V_{ab}|^2}{Z_c^*}$$

$$= \frac{|V_{an}|^2}{Z_p^*} \times \frac{Z_p}{Z_p} + \frac{1}{2} \frac{|V_{ab}|^2}{Z_c^*} \times \frac{Z_c}{Z_c}$$

$$= \frac{|V_{an}|^2}{|Z_p|^2} \times Z_p + \frac{1}{2} \frac{|V_{ab}|^2}{|Z_c|^2} \times Z_c$$

$$= \frac{(115)^2}{104} \times (10 + j2) + \frac{1}{2} \times \frac{(230)^2}{\left(\frac{1}{\omega^2 C^2}\right)} \times \frac{1}{j\omega C}$$

$$= \frac{(115)^2}{104} (10 + j2) + \frac{1}{2} \times (230)^2 \times -j\omega C$$

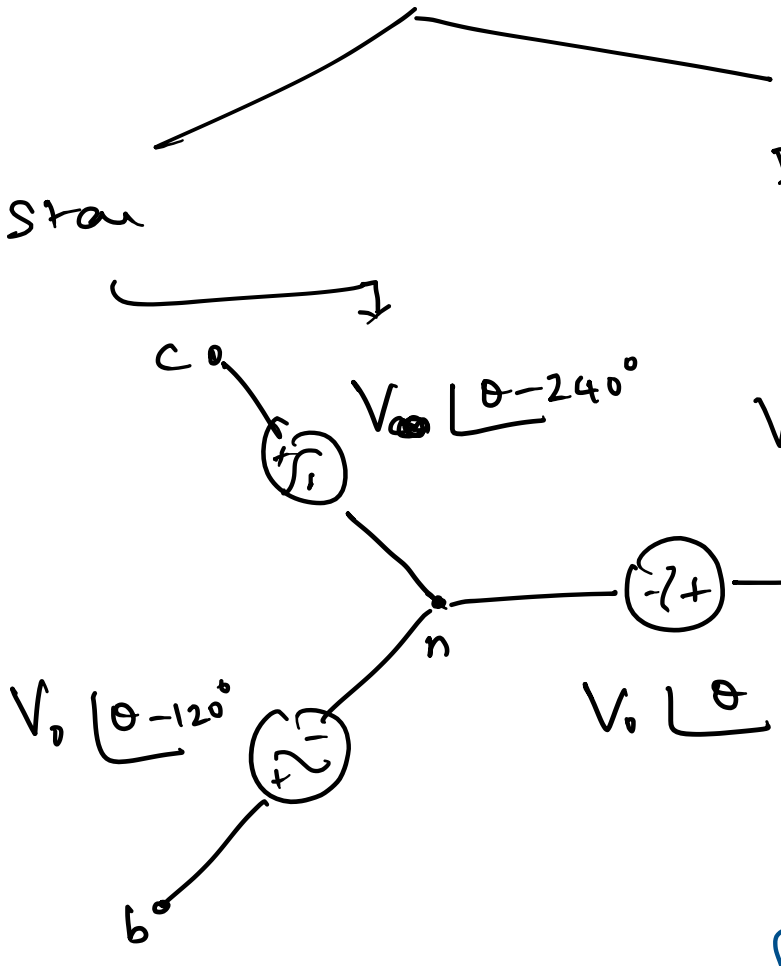
$$Im\{S\} = 0$$

$$\frac{115^2}{104} \times j2 + j\omega C \times \frac{1}{2} \times (230)^2 = 0$$

$$\Rightarrow \frac{\omega C}{2} \times (230)^2 = \frac{2 \times (115)^2}{104}$$

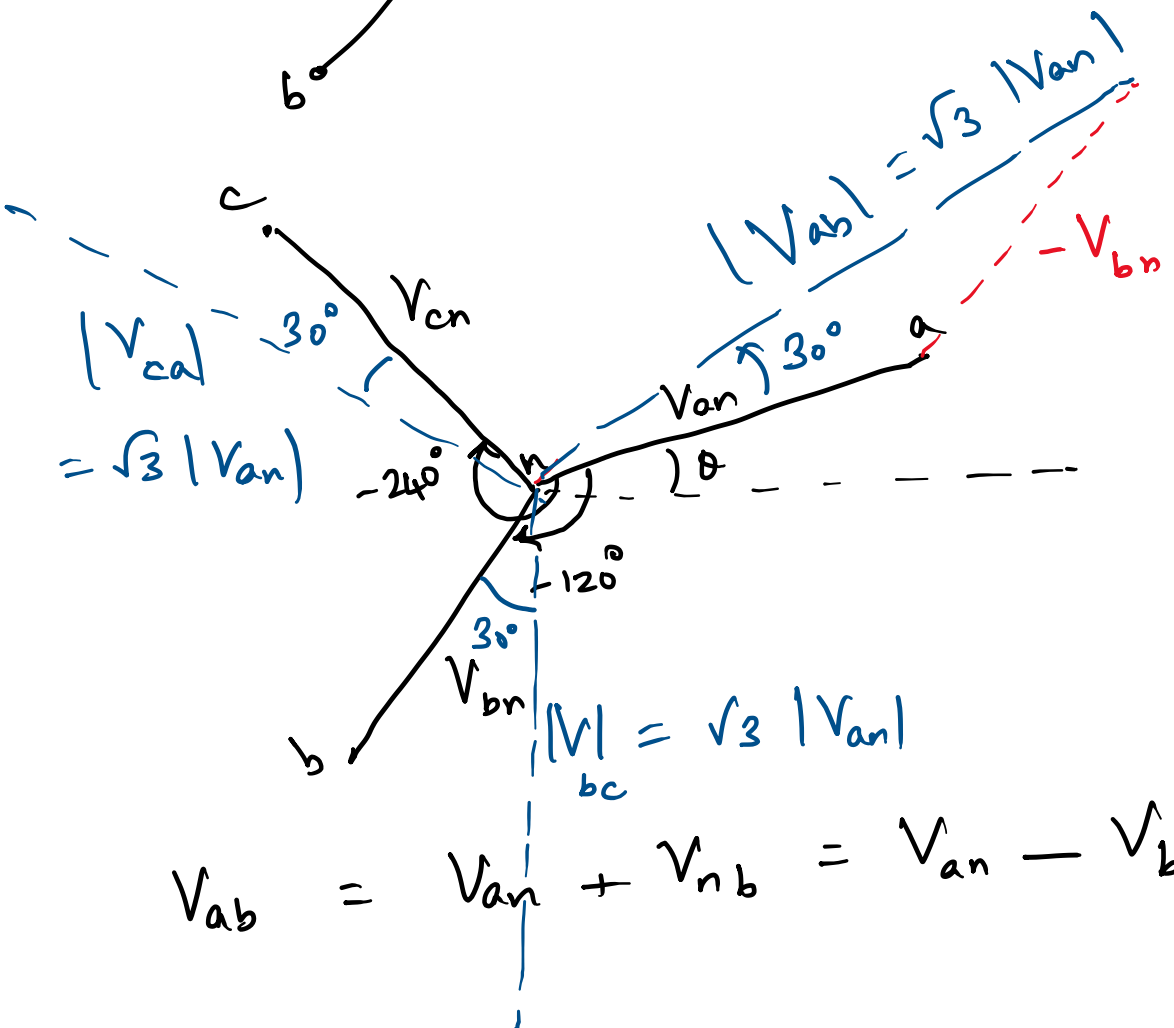
$$\Rightarrow C = \frac{2 \times 2 \times (115)^2}{\omega \times (230)^2 \times 104} = 30\ \mu F$$

Three Phase Power Supply



Balanced

$$V_{an} + V_{bn} + V_{cn} = 0$$



$$V_{ab} = V_{an} + V_{nb} = V_{an} - V_{bn}$$

→ $f = 50\ Hz$

$V_{an} = 230\ V \angle 30^\circ$ rms } Balanced 3 phase supply

phase voltages in time domain
line voltages in time domain

Ans.

$\omega = 2\pi f = 100\pi$ rad/s

$v_{an}(t) = 230\sqrt{2} \cos(100\pi t + 30^\circ)\ V$

$v_{bn}(t) = 230\sqrt{2} \cos(100\pi t - 90^\circ)\ V$

$v_{cn}(t) = 230\sqrt{2} \cos(100\pi t - 210^\circ)\ V$

} phase voltages

$V_{ab} = \sqrt{3}\,|V_{an}| \angle \theta + 30^\circ$

$= \sqrt{3} \times 230 \times \sqrt{2} \angle 30^\circ + 30^\circ$

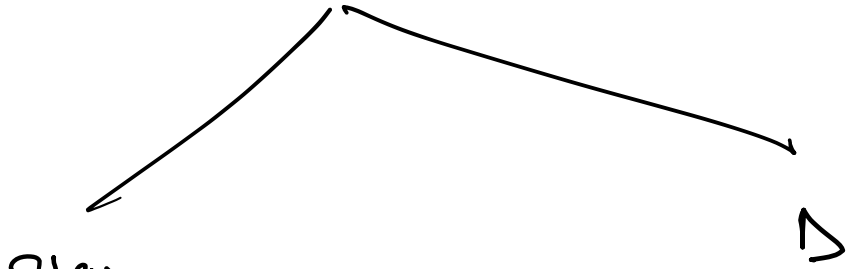
$v_{ab}(t) = 230\sqrt{6} \cos(100\pi t + 60^\circ)\ V$

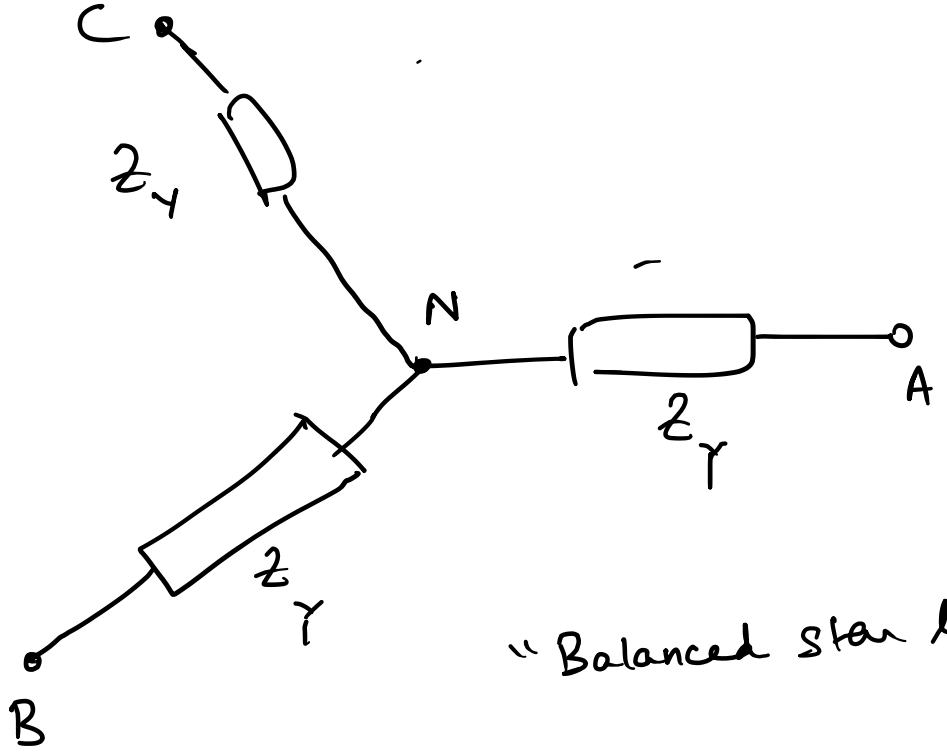
$v_{bc}(t) = 230\sqrt{6} \cos(100\pi t - 60^\circ)\ V$

$v_{ca}(t) = 230\sqrt{6} \cos(100\pi t - 180^\circ)\ V$

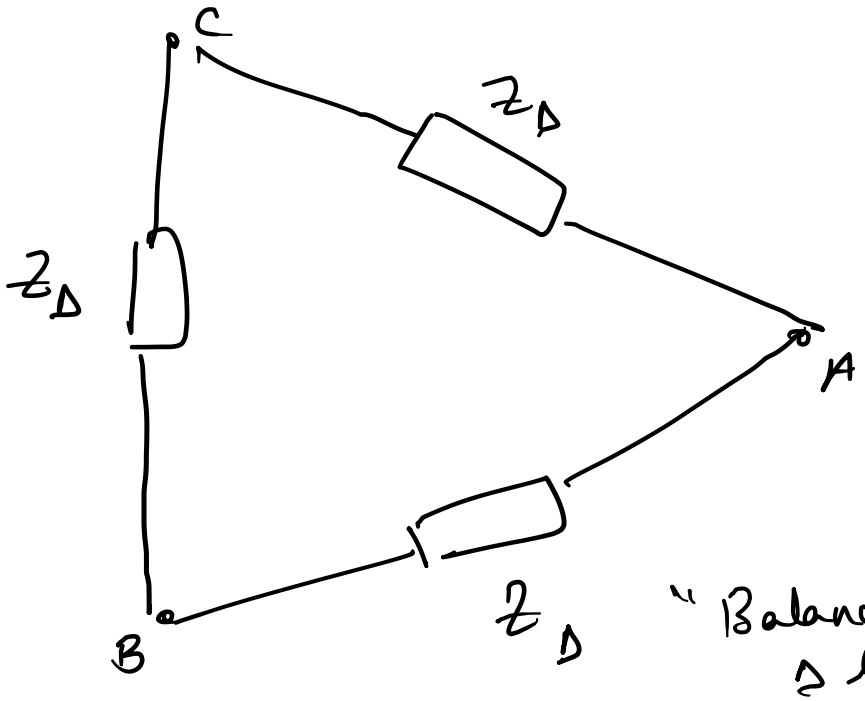
} line voltages

Three Phase Load





"Balanced star load"



"Balanced Δ load"