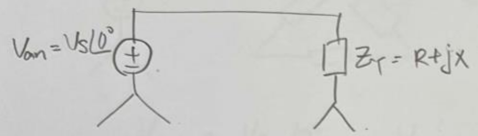
① Y-Y.



$$V_{an} = V_s \angle 0^\circ$$
$$V_{bn} = V_s \angle -120^\circ$$
$$V_{cn} = V_s \angle -240^\circ \text{ or } V_s \angle 120^\circ$$

$$I_p = I_L, \quad I_a = \frac{V_s\angle 0^\circ}{R+jX}, \quad I_b = \frac{V_s \angle -120^\circ}{R+jX}, \quad I_c = \frac{V_s \angle -240^\circ}{R+jX}$$

complex power per phase.

$$S_A = V_{an} \times I_a^* = V_s \angle 0^\circ \times \frac{V_s \angle 0^\circ}{R-jX} = \frac{V_s^2 (R+jX)}{(R-jX)(R+jX)} = \frac{V_s^2 (R+jX)}{R^2+X^2}$$

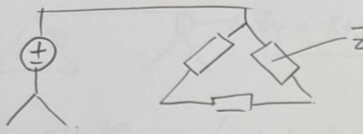
$$S_B = V_{bn} \times I_b^* = V_s \angle -120^\circ \times \frac{V_s \angle 120^\circ}{R-jX} = \frac{V_s^2 (R+jX)}{R^2+X^2}$$

$$S_C = V_{cn} \times I_c^* = \frac{V_s^2 (R+jX)}{R^2+X^2}.$$

total complex power

$$S = S_A+S_B+S_C = \frac{3V_s^2 (R+jX)}{R^2+X^2} \text{ or } \frac{3V_s^2}{R^2+X^2} \sqrt{R^2+X^2} \angle \tan^{-1}\frac{X}{R}$$

② Y−Δ



$Z_\Delta = R+jX \Rightarrow Z_Y = \frac{1}{3}(R+jX)$

$V_{an} = V_s \angle 0°$, $V_{bn} = V_s \angle -120°$, $V_{cn} = V_s \angle -240°$

$I_a = \frac{V_{an}}{Z_Y} = \frac{3V_s \angle 0°}{R+jX}$, $I_b = \frac{3V_s \angle -120°}{R+jX}$, $I_c = \frac{3V_s \angle -240°}{R+jX}$

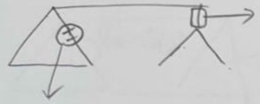
$S_A = V_{an} \times I_a^* = \frac{3V_s^2}{R-jX} = \frac{3V_s^2 (R+jX)}{R^2+X^2}$

$S_B = V_{bn} \times I_b^* = \frac{3V_s^2 (R+jX)}{R^2+X^2}$

$S_C = V_{cn} \times I_c^* = \frac{3V_s^2 (R+jX)}{R^2+X^2}$

total Complex power $= \frac{9V_s^2 (R+jX)}{R^2+X^2}$ or $\frac{9V_s^2 \sqrt{R^2+X^2}}{R^2+X^2} \angle \tan^{-1}\frac{X}{R}$

③ $\Delta - Y$.



$Z_Y = R+jX \Rightarrow Z_\Delta = 3(R+jX)$.

$V_{ab} = V_s \angle 0°$. Line voltage = phase voltage

$V_{bc} = V_s \angle -120°$.

$V_{ca} = V_s \angle -240°$.

phase currents $I_{AB} = \dfrac{V_{ab}}{Z_\Delta} = \dfrac{V_s \angle 0°}{3(R+jX)}$

$I_{BC} = \dfrac{V_{bc}}{Z_\Delta} = \dfrac{V_s \angle -120°}{3(R+jX)}$

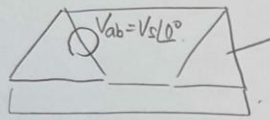
$I_{CA} = \dfrac{V_{ca}}{Z_\Delta} = \dfrac{V_s \angle -240°}{3(R+jX)}$

$S_A = V_{ab} \times I_{AB}^* = V_s \angle 0° \times \dfrac{V_s \angle 0°}{3(R-jX)} = \dfrac{1}{3} V_s^2 \times \dfrac{(R+jX)}{R^2+X^2}$

$S_B = V_{bc} \times I_{BC}^* = \dfrac{1}{3} V_s^2 \dfrac{(R+jX)}{R^2+X^2}$, $S_C = V_{ca} \times I_{CA}^* = \dfrac{1}{3} V_s^2 \dfrac{(R+jX)}{R^2+X^2}$

total complex power $= V_s^2 \dfrac{R+jX}{R^2+X^2}$ or $\dfrac{V_s^2}{R^2+X^2} \sqrt{R^2+X^2} \angle \tan^{-1}\dfrac{X}{R}$

④ $\Delta - \Delta$



Line = phase voltages $V_{ab} = V_s \angle 0^\circ$, $V_{bc} = V_s \angle -120^\circ$, $V_{ca} = V_s \angle -240^\circ$

phase current $I_{AB} = \dfrac{V_s \angle 0^\circ}{R+jX}$, $I_{BC} = \dfrac{V_s \angle -120^\circ}{R+jX}$, $I_{CA} = \dfrac{V_s \angle -240^\circ}{R+jX}$

$$S_A = V_{ab} \times I_{AB}^* = \frac{V_s^2}{R-jX} = \frac{V_s^2 (R+jX)}{R^2+X^2}$$

$$S_B = V_{bc} \times I_{BC}^* = \frac{V_s^2 (R+jX)}{R^2+X^2}$$

$$S_C = V_{ca} \times I_{CA}^* = \frac{V_s^2 (R+jX)}{R^2+X^2}$$

total complex power $S = \dfrac{3 V_s^2 (R+jX)}{R^2+X^2}$ or

$$= \frac{3 V_s^2 \sqrt{R^2+X^2}}{R^2+X^2} \angle \tan^{-1} \frac{X}{R}$$