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(a) $E_a = V_t - j\bar{I}_a X_s$, $V_L = 415V$, $S = 25kVA = 25000VA$

$V_t = \frac{V_L}{\sqrt{3}} = \frac{415}{\sqrt{3}} = 239.6V$

$X_s = 1.5\Omega$, $P_F = 0.8$ lagging $\therefore \theta = \cos^{-1}(0.8) = 143.13$

$I_a = \frac{S}{V_L\sqrt{3}} = \frac{25000}{415\sqrt{3}} = 34.78A \angle 143.13°$

$\therefore E_a = 239.6 - j[(34.78A \angle 143.13°)(1.5)]$

$= 270.70 + j41.74$

$= 274.098V \angle 8.76°$

(b) 20% increase $= 1 + 0.2 = 1.2$

$\delta = 8.76°$, $E_a' = 1.2 \times 274.098 = 328.92V$

$\frac{V_t E_a \sin\delta}{X_s} = \frac{V_t E_a' \sin\delta'}{X_s}$

$\therefore \sin\delta' = \frac{E_a \sin\delta}{E_a'}$

$= \frac{274.098}{328.92} \times \sin 8.76°$

$\sin\delta' = 0.1269$

$\delta' = \sin^{-1}(0.1269)$

$= 7.29°$

$\bar{I}_A' = \frac{\bar{E}_a' - V_t}{jX_s} = \frac{328.92\angle 7.29° - 239.6\angle 0}{j1.5}$

$= 27.82 - j57.77$

$\bar{I}_a' = 64.13A \angle -64.28°$

(i) Power Factor $= \cos(-64.28°)$

$= 0.434$ Lagging

(ii) $Q = 3V_t I_a \sin\theta = 3 \times 239.6 \times 64.13 \times \sin(64.28)$

$= 41529.65$ VAR

(c) At max power, $\delta = 70^\circ$

$$P_{max} = \frac{3E_a V_t}{X_s} = \frac{3 \times 274.098 \times 239.6}{1.5}$$

$$= 131347.76\ W$$

$$I_{max} = \frac{E_a \angle -V_t}{jX_s} = \frac{274.098 \angle 70^\circ - 239.6 \angle 0}{j1.5}$$

$$= 242.71 A \angle 41.16^\circ$$

Power factor $= \cos(41.16^\circ)$

$= 0.7529$ leading

$$Q_{max} = 3 V_t I_{amax} \sin\theta = 3 \times 239.6 \times 242.71 \times \sin(41.16^\circ)$$

$$= 114827.54\ VAR$$