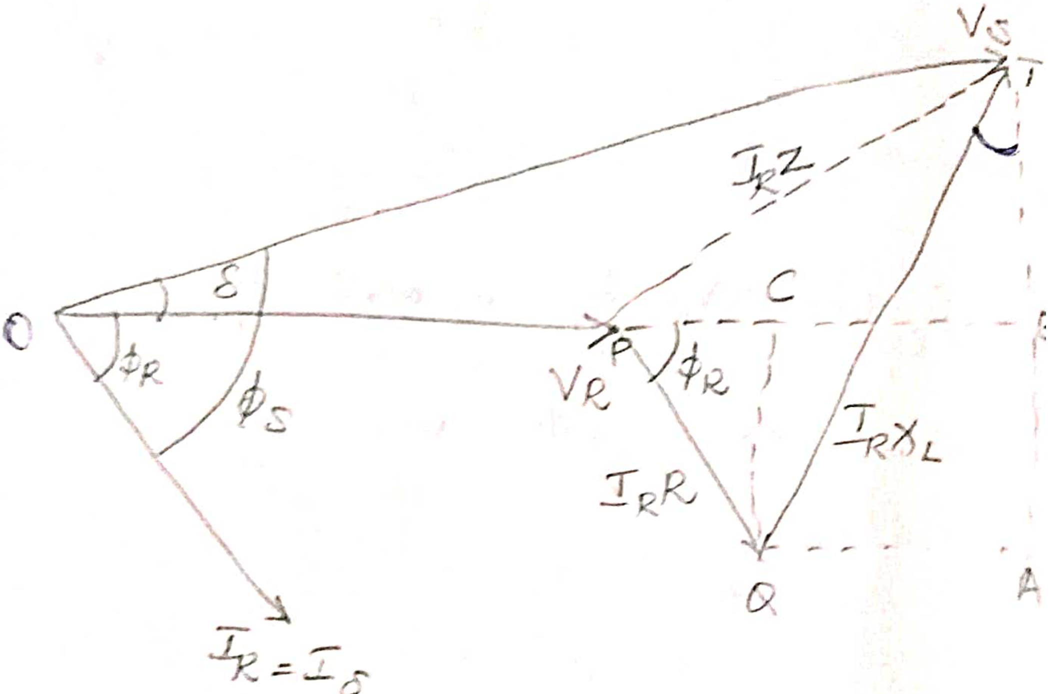
Performance Analysis of short Tr. line for lagging power factor load.



Lagging power factor load is considered to find the tr. efficiency and regulation of the short tr. line.

From ΔPQC, $\sin\phi_R = \dfrac{QC}{PQ}$

$QC = PQ \sin\phi_R$

$= I_R R \sin\phi_R$

$QC = AB$

$\cos\phi_R = \dfrac{PC}{PQ}$

$PC = PQ \cos\phi_R = I_R R \cos\phi_R$

From ΔQTA, $\sin\phi_R = \frac{QA}{QT}$

$QA = QT \sin\phi_R$

$QA = I_R X_L \sin\phi_R$

$QA = CB$

$\cos\phi_R = \frac{TA}{QT}$

$TA = \cos\phi_R \, QT$

$= I_R X_L \cos\phi_R$

From the phasor diagram.

$OT^2 = OB^2 + BT^2$

$OT^2 = (OP + PC + CB)^2 + (TA - AB)^2.$

$V_S^2 = (V_R + I_R R \cos\phi_R + I_R X_L \sin\phi_R)^2 +$
$(I_R X_L \cos\phi_R - I_R R \sin\phi_R)^2.$

$V_S = \sqrt{(V_R + I_R R \cos\phi_R + I_R X_L \sin\phi_R)^2 + (I_R X_L \cos\phi_R - I_R R \sin\phi_R)^2}$

When compared to V_R, $I_R R$ & $I_R X_L$ are small.

$\therefore |V_S| = V_R + I_R R \cos\phi_R + I_R X_L \sin\phi_R$ — (3)

% Voltage regulation $= \frac{|V_S| - |V_R|}{|V_R|}$ — (4)

Sub (3) in (4) we get

$$\% \, VR = \frac{I_R R \cos\phi_R + I_R X_L \sin\phi_R}{V_R} \times 100$$

for lagging power factor.

For leading power factor.

$$\% \text{ Voltage regulation} = \frac{I_R R \cos\phi_R - I_R X_L \sin\phi_R}{V_R} \times 100$$

When pf is leading, regulation will be zero

$$I_R R \cos\phi_R = I_R X_L \sin\phi_R$$

$$\frac{\sin\phi_R}{\cos\phi_R} = \frac{I_R R}{I_R X_L}$$

$$\tan\phi_R = \frac{R}{X_L}$$

Receiving end power $= V_R I_R \cos\phi_R$

Line losses $= I^2 R$

Sending end power = Receiving end power + losses.

$$= V_R I_R \cos\phi_R + I^2 R$$

% Tr. efficiency = $\frac{\text{Receiving end}}{\text{Sending end}} \times 100$

$$\%\eta = \frac{V_R I_R \cos\phi_R}{V_R I_R \cos\phi_R + I^2 R} \times 100 \, \%$$