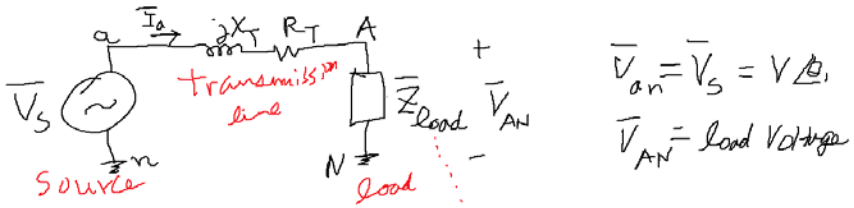
**Pre-Lab 5 Phase angle and Voltage Drop between a sender and a receiver**

As studied in Pre-Lab4, voltage at the load/receiver side can be expressed power from a source to a load can be described by the following diagram and equations thereof:




$$\bar{Z}_L = R_L + jX_L = Z_L\angle\theta_L$$

$$\bar{Z} = \bar{Z}_T + \bar{Z}_{load} = R_T + jX_T + R_L + jX_L$$

$$= (R_T + R_L) + j(X_T + X_L) = Z\angle\theta_z$$

Then,

$$\bar{I}_a = \frac{\bar{V}_S}{\bar{Z}} = \frac{V\angle 0^\circ}{Z\angle\theta_z} = \frac{V}{Z}\angle -\theta_z$$

Therefore

$$\bar{V}_L = \bar{Z}_L \cdot \bar{I}_a = Z_L\angle\theta_L \cdot \frac{V}{Z}\angle -\theta_z$$

$$= \frac{Z_L}{Z} V\angle\theta_L - \theta_z$$

Now we focus more on the phase angle difference between the source voltage and the load voltage. If we assume the source voltage is our reference with phase angle 0, then the phase angle difference between the source voltage and the load voltage can be obtained from the above calculation. Also, we can calculate the power flow from source to load by calculating complex power at the source side and that at the receiver side. Calculations are illustrated below.

$$\bar{I}_S = \bar{I}_a$$

$$\bar{S}_S = \bar{V}_S \bar{I}_S^*$$

$$= V\angle\theta_S \left(\frac{V}{Z}\right)\angle -\theta_z)^* = \frac{V^2}{Z}\angle\theta_S + \theta_z = P_S + jQ_S$$

$$\bar{S}_L = \bar{V}_L \bar{I}_a^* = \frac{V \cdot Z_L}{Z}\angle\theta_L - \theta_z \cdot \frac{V}{Z}\angle\theta_z = \frac{V^2 \cdot Z_L}{Z^2}\angle\theta_L$$

$$= P_L + jQ_L$$

The last step to consider is that, since the above formulation is based on a phase, for 3-phase system, $\mathbf{S}_S$ and $\mathbf{S}_L$ must be multiplied by 3.

1. A balanced 3-phase source with phase voltage Vrms=10000 V is supplying a balanced 3-phase load with $\mathbf{Z_L}=R_L+jX_L$ ($R_L=100$, $X_L=100$) at each phase through a 3-phase transmission line which has $\mathbf{Z_T}=R_T+jX_T$ ($R_T=10$, $X_T=100$) at each phase. Calculate (a) the load voltage $\mathbf{V_{AN}}$ and (b) phase angle difference between the source voltage and the load voltage, and (c) Calculate the complex power at the source and at the load.

2. A balanced 3-phase source with phase voltage Vrms=10000 V is supplying a balanced 3-phase load with $\mathbf{Z_L}=R_L+jX_L$ ($R_L=100$, $X_L=0$) at each phase through a 3-phase transmission line which has $\mathbf{Z_T}=R_T+jX_T$ ($R_T=0$, $X_T=100$) at each phase. Calculate (a) the load voltage $\mathbf{V_{AN}}$ and (b) phase angle difference between the source voltage and the load voltage, and (c) Calculate the complex power at the source and at the load.

2. A balanced 3-phase source with phase voltage Vrms=10000 V is supplying a balanced 3-phase load with $\mathbf{Z_L}=R_L+jX_L$ ($R_L=100$, $X_L=-100$) at each phase through a 3-phase transmission line which has $\mathbf{Z_T}=R_T+jX_T$ ($R_T=0$, $X_T=100$) at each phase. Calculate (a) the load voltage $\mathbf{V_{AN}}$ and (b) phase angle difference between the source voltage and the load voltage, and (c) Calculate the complex power at the source and at the load.