# PU

in general, the impedance of a generator, motor or transformer is given in PU or percentage based on the machines ratings.

to convert a PU impedance from an old base to a new base, we use the following equation

$$(Z_{PU})_{NEW} = (Z_{PU})_{OLD} \frac{(V_b)^2_{OLD}}{(V_b)^2_{NEW}} \cdot \frac{[(MVA)_b]_{NEW}}{[(MVA)_b]_{OLD}}$$

EX: A transformer is rated at 100 kV/25kV, 100 MVA and has a reactance of 10%. Choose a base voltage of 110 kV on the primary side of the transformer and a base MVA of 50 MVA.

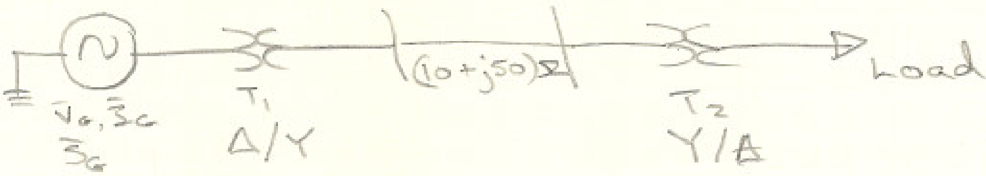
find the PU impedance of the transformer.

SOL:

$$(Z_{PU})_{NEW} = j0.1 \cdot \left(\frac{100}{110}\right)^2 \frac{50}{100}$$

$$= j0.041322 \text{ PU}$$

EX: Solve the system shown below for $\bar{I}_G$, $\bar{V}_G$ and $\bar{S}_G$, using the PU concept.




$T_1$: 100 MVA, 13.8/138 kV, z = j0.1 PU.

$T_2$: 75 MVA, 138/14 kV, z = j0.1 PU.

Load: 50 MVA, 13.5 kV, Y connected, 0.8 PF lag.

SOL: let us choose a base voltage on the high voltage side. of $T_1$

$$(V_b)_{HVS} = 138\text{ kV}$$
$$(V_b)_{LVS} = 13.8\text{ kV}$$
} for $T_1$

$$(V_b)_{LOAD} = 14\text{ kV}$$

now choose a convienient base for MVA.

$$(MVA)_b = 100\text{ MVA}$$

$$\therefore (Z_b)_{HVS} = \frac{138^2}{100} = 190.4\ \Omega$$

$$(Z_{LINE})_{PU} = \frac{10+50j}{190.4} = 0.0525 + j0.2626$$

$$(Z_{T1})_{PU} = \text{remains the same} = 0.1j\text{ PU.}$$

$$(Z_{T2})_{PU} = j0.1 * \left(\frac{138}{138}\right)^2 * \frac{100}{75} = j0.13333.$$

$$(V_{LOAD})_{PU} = \frac{13.5}{14} = 0.964\text{ PU}$$

$$|\bar{S}_{LOAD}| = \frac{50}{100} = 0.5$$

$$(\bar{S}_{LOAD})_{PU} = 0.5(0.8 + j0.6)$$

$$(\bar{I}_G)_{PU} = \frac{(\bar{S}_G^*)_{PU}}{(\bar{V}_G^*)_{PU}} = \frac{0.5(0.8+j0.6)}{0.964}$$

$$= 0.415 - j0.311$$

$$(\bar{V}_G)_{PU} = \underset{\text{ref.}}{0.964\angle 0^\circ} + (0.415 - j0.311)(0.0525 + j0.2626 + j0.1 + j0.13333)$$

$= 1.14 + j\,0.189$

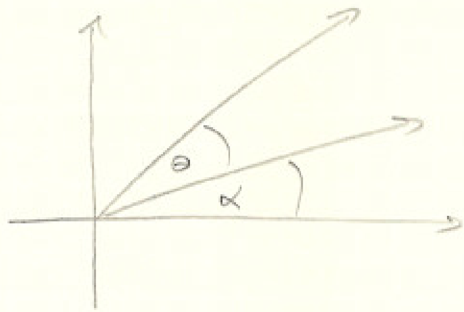
$= 1.156 \underline{/9.4^\circ}$ PU

Line Voltage in P.U.

$(V_G)_{LL} = (13.8)(1.156) = 15.95\,kV$

Actual.

HWK:



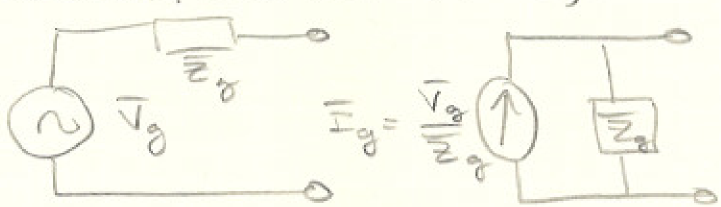

$\bar{V} = |\bar{V}| e^{j\alpha}$

$\bar{I} = |\bar{I}| e^{j(\alpha+\theta)}$

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

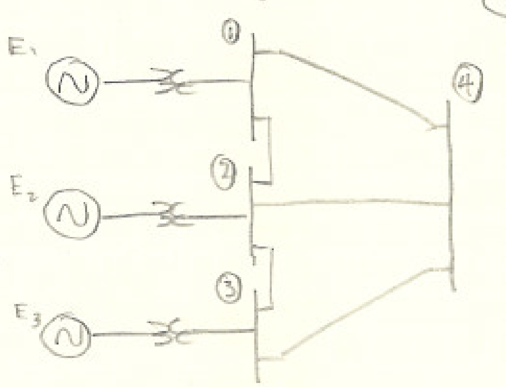
NETWORK CALCULATIONS.

Thevenin / Norton transformation

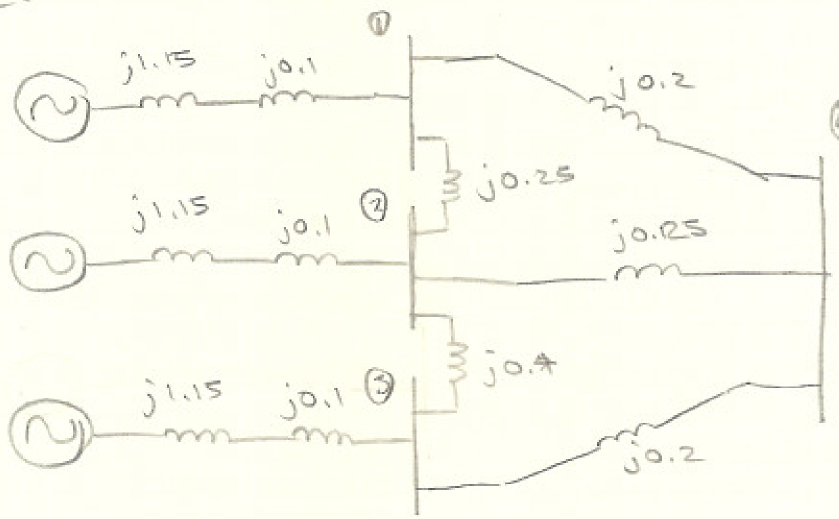



Nodal Equations

consider the following system.



Let the PU impedance diagram for the above have:




we may easilly write the nodal equation by first converting voltage sources to current sources as follows.