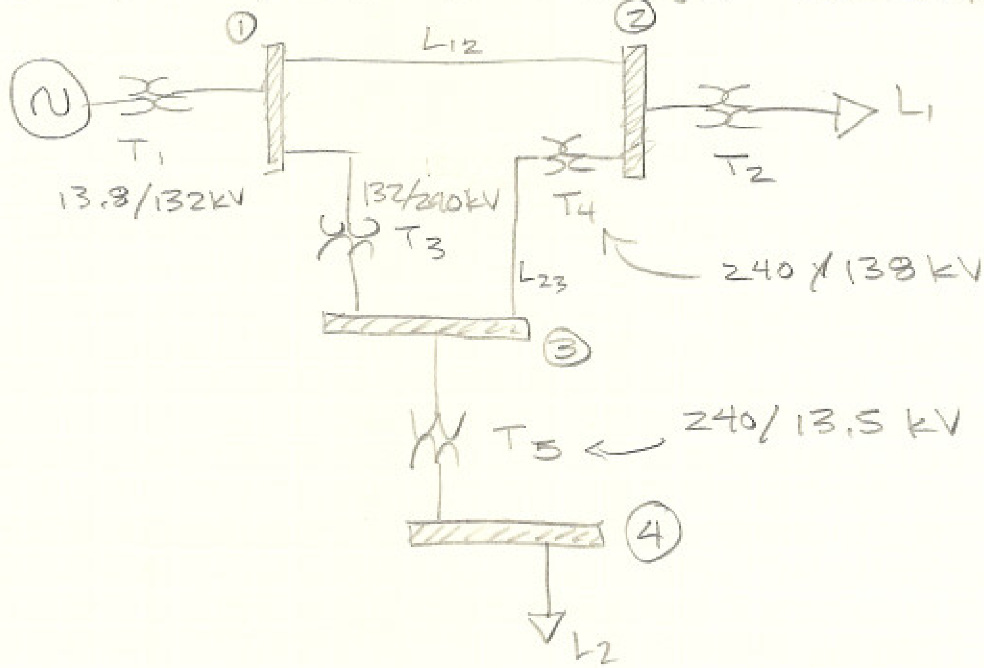
#1

Determine the PU impedance diagram of the following power system ... choose base voltage of 250 kV on bus #3 for the HV side of the system, and 100 MVA for the entire system.



System information

Unit	Rated kV	Rated MVA	Z p.u.	Z Ω
G_1	14.0	150	j0.2	
T_1	13.8/132	150	j0.1	
T_2	138/13.8	75	j0.1	
T_3	132/240	75	j0.1	
T_4	240/138	75	j0.1	
T_5	240/13.5	50	j0.1	
L_{12}	138			j25Ω
L_{23}	240			j50Ω

note: use transformation ratios to go from one base to another

BUS #3

$$V_{base} = 250\ kV$$

BUS #1

$$V_{base} \cdot \frac{132}{240} \cdot 250 = 137.5\ kV$$

BUS #2

$$V_{base} \cdot \frac{138}{240} \cdot 250 = 143.8\ kV$$

GEN G_1

$$V_{base} \cdot \frac{13.8}{132}\ 137.5 = 14.4\ kV$$

BUS # 4

$$V_{base} \cdot \frac{13.5}{240} \cdot 250 = 14.1\ kV$$

LOAD #1

$$V_b \cdot \frac{13.8}{138} \cdot 143.8 = 14.4\ kV$$

for the 240 kV V_b part of the system.

$$Z_b = \frac{(250\ kV)^2}{100\ MVA} = 625\ \Omega$$

yeilding

$$Z_{L23} = \frac{j50\ \Omega}{625\ \Omega} = j0.08\ PU.$$

$$Z_{T3} = j0.1\left(\frac{240}{250}\right)^2\left(\frac{100}{50}\right) = j0.123\ PU$$

$$Z_{T4} = j0.123\ PU$$

$$Z_{T5} = (j0.1)\left(\frac{240}{250}\right)^2\left(\frac{100}{50}\right) = j0.184 \text{ PU}$$

$$L_{12} \Rightarrow Z_{12} = \frac{j25}{\left(\frac{137.5^2}{100 \text{ MVA}}\right)} = j0.132 \text{ PU}$$

* 137.5 kV is the voltage of bus # 1 *

$$G_1 \Rightarrow Z_{G1} = (j0.2)\left(\frac{14}{14.4}\right)^2\left(\frac{100}{150}\right) = j0.126 \text{ pu}$$

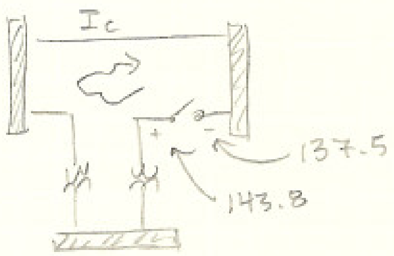
$$Z_{T1} = (j0.1)\left(\frac{132}{137.5}\right)^2\left(\frac{100}{150}\right) = j0.06 \text{ PU}$$

$$Z_{T2} = (j0.1)\left(\frac{138}{143.8}\right)^2\left(\frac{100}{75}\right) = j0.123 \text{ PU}$$

A problem remains at T4 on the LV. side of T4 is not the same as that of bus #2. Based on the fact that L12 carries the same base from bus #1. If the connection is open as shown below, there will exist a voltage difference of (143.8 ⇔ 137.5) kV = 6.3 kV = ΔV, or voltage difference.

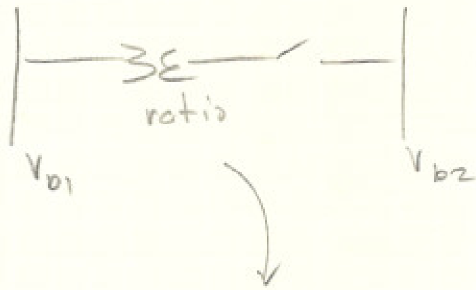
$$\frac{6.3 \text{ kV}}{143.8 \text{ kV}} = 0.044 \text{ PU}$$

①

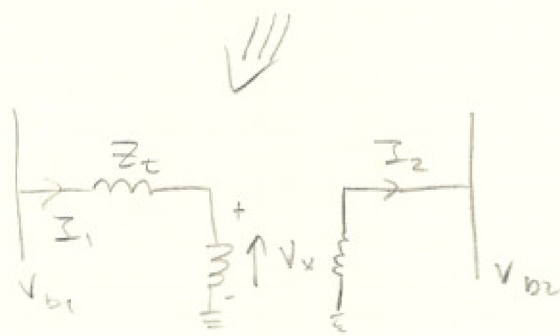


If the circuit is closed a circulating current will form.

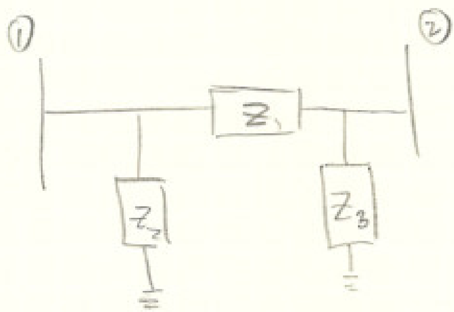
Both the secondary of the transformer and the bus are at 1.0 pu. This circulating current can be represented as an autotransformer.



$$\frac{V_{b1}}{a - V_{b2}}$$



this is an awkward alternative cct, using a voltage and a current source shown below can be more conviently represented by a π network.



The π network has passive elements only, so it is easy to include in the bus impedance or admitance matrix.

$$Z_1 = a Z_t$$

$$Z_2 = \frac{a Z_t}{(a-1)}$$

$$Z_3 = \frac{a^2 Z_t}{(1-a)}$$

The final PU impedance diagram is: