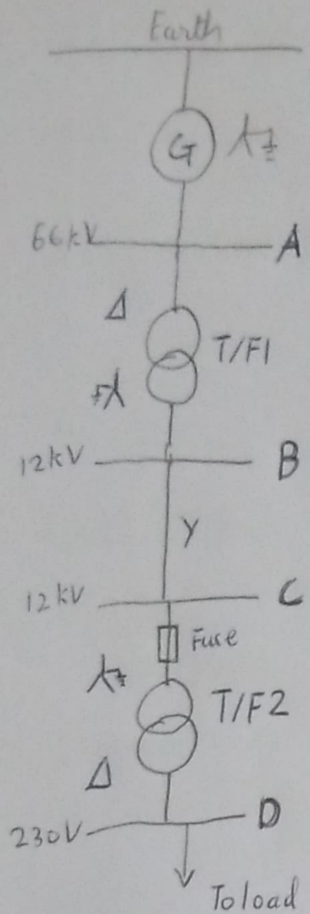
Q1 a)



b) $MVA_b = 20MVA$, $V_b = 66kV$

Generator: $Z_{p.u} = 0.18\left(\frac{20}{30}\right) = j0.12\ p.u$

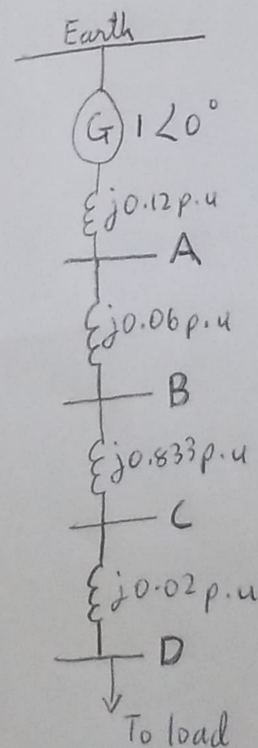
T/F1: $Z_{p.u} = 0.09\left(\frac{20}{30}\right) = j0.06\ p.u$

T/F2: $Z_{p.u} = 0.03\left(\frac{20}{30}\right) = j0.02\ p.u$

Line Y: $Z_b = \left(\frac{kV^2}{MVA_b}\right) = \left(\frac{12^2}{20}\right)$, ~~$Z_{p.u} =$~~

$Z_{p.u} = \frac{Z}{Z_b}$

$\Rightarrow Z_{p.u} = j6\left(\frac{20}{12^2}\right) = j0.833\ p.u$



~~Qu~~ Q1 c) For Fault at A:

$$MVA_{sc} = \frac{1\angle 0^\circ}{j0.12} = -j8.33 \text{ MVA p.u}$$

$$MVA_{sc}\ (actual) = MVA_{sc} \times MVA_b$$
$$= -j8.33 \times 20$$
$$= \underline{\underline{-j166.6 \text{ MVA}}}$$

For a Fault at B:

$$MVA_{sc} = \frac{1\angle 0^\circ}{j0.12 + j0.06} = -j5.56 \text{ MVA p.u}$$

$$MVA_{sc}\ (actual) = -j5.56 \times 20$$
$$= \underline{\underline{-j111.2 \text{ MVA}}}$$

For Fault at C:

$$MVA_{sc} = \frac{1\angle 0^\circ}{j0.12 + j0.06 + j0.833} = -j0.987 \text{ p.u}$$

$$MVA_{sc}\ (actual) = -j0.987 \times 20$$
$$= \underline{\underline{-j19.56 \text{ MVA}}}$$

For Fault at D:

$$MVA_{sc} = \frac{1\angle 0^\circ}{j0.12 + j0.06 + j0.833 + j0.02} = -j0.968 \text{ p.u}$$

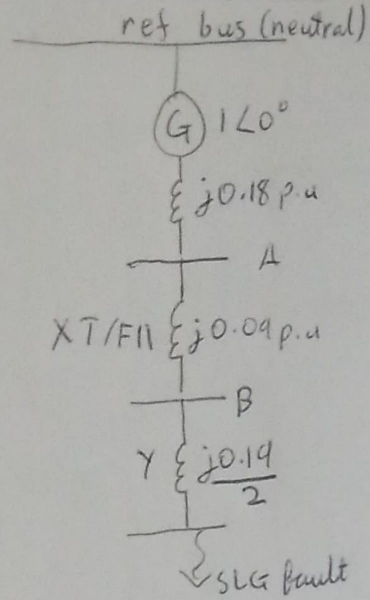
$$MVA_{sc}(actual) = -j0.968 \times 20$$
$$= \underline{\underline{-j19.36 \text{ MVA}}}$$

d) Fault Level at primary side of T/F2 is $-j19.56$ MVA (fault level at C)

$$I_{FC} = \frac{MVA_{sc}\ (actual)}{\sqrt{3} \times V} = \frac{-j19.56 \times 10^6}{\sqrt{3} \times 12 \times 10^3} = -j941.08 \text{ A}$$

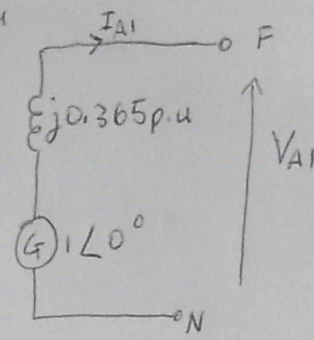
∴ 50 A fuses should be used to protect against this large ~~fau~~ fault current

Q2) a) <u>Positive Sequence</u>

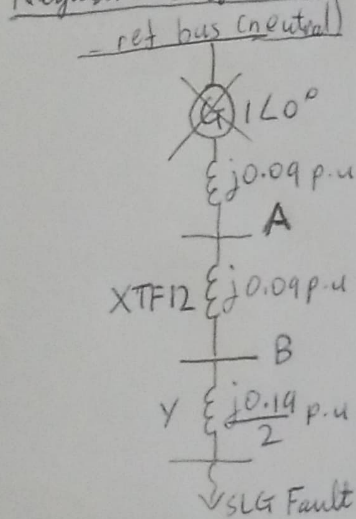


$Z_{TH} = j0.18 + j0.09 + j\frac{0.19}{2}$
$= j0.365\,p.u$

=> simplifies to

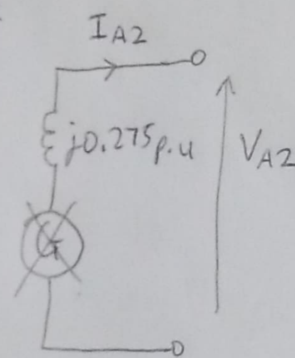


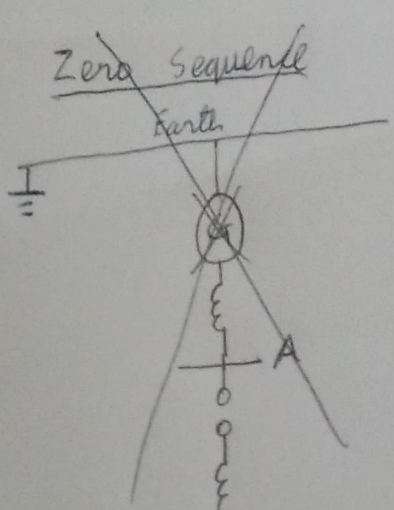
<u>Negative Sequence</u>



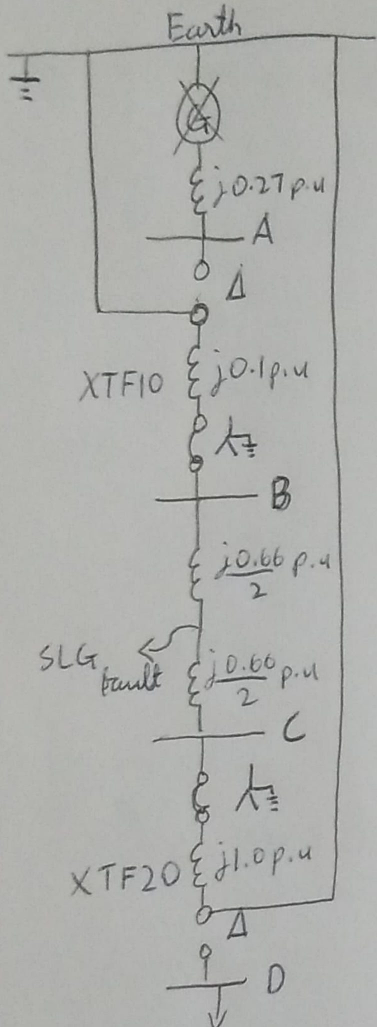
$Z_{TH} = j0.09 + j0.09 + j\frac{0.19}{2}$
$= j0.275\,p.u$

=> simplifies to

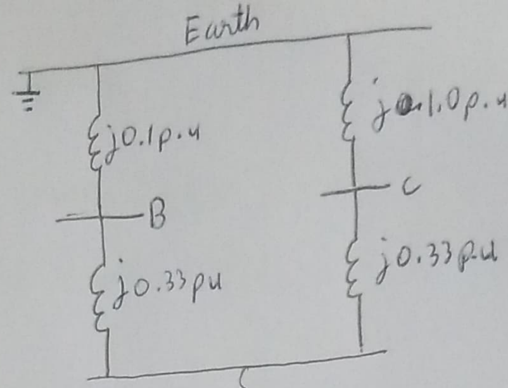




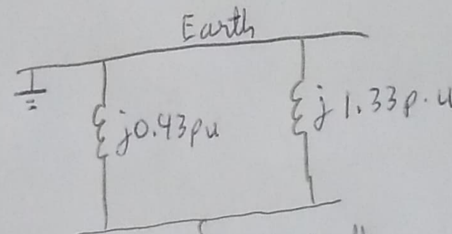
Q2) a) Zero Sequence



=> simplifies to



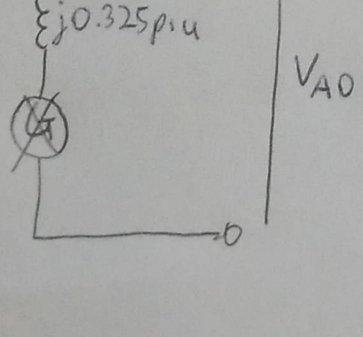
⇓ simplifies to



⇓

$$Z_{TH} = \frac{(j0.43)(j1.33)}{j0.43 + j1.33} = j0.325 p.u$$

Equivalent zero sequence network can be seen below.



Q2) b) For a single line to ground fault on the A phase,

$V_A = 0, \quad I_B = I_c = 0$

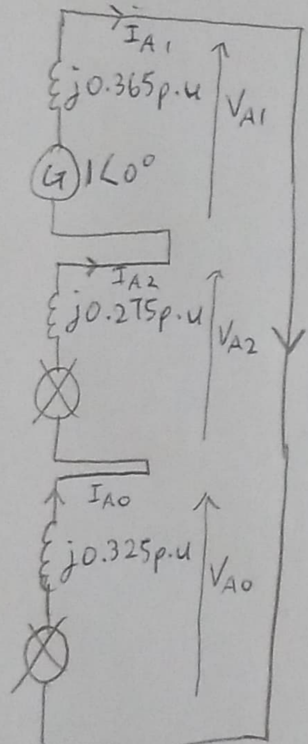
From the theory of symmetrical components:

$$\begin{bmatrix} I_{A0} \\ I_{A1} \\ I_{A2} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix}\begin{bmatrix} I_A \\ I_B \\ I_c \end{bmatrix}$$

since I_B and $I_c = 0$

$\Rightarrow I_{A0} = I_{A1} = I_{A2} = \frac{1}{3} I_A$

Since the currents are equal then the system must be connected in series as seen below.



From the diagram we see that:

$I_{A0} = I_{A1} = I_{A2} = \frac{1}{3} I_A = \dfrac{1\angle 0^\circ}{j0.365 + j0.275 + j0.325} = -j1.036\,p.u$

Current at fault, $I_F = I_A$

$\Rightarrow I_F = 3 \times (-j1.036\,pu) = -j3.108\,p.u$

$I_B = \dfrac{MVA_b}{\sqrt{3}V_b} = \dfrac{30\times10^6}{\sqrt{3}\times 66\times10^3} = 262.432A$

$I_F\,(actual) = (262.432)(-j3.108) = \underline{\underline{-j815.64\,A}}$

c) The current flowing is too high for the fuses to handle.

d) This problem can be solved by either utilising sectionalisers or reactors.