CHAPTER 7

BEE3143:POWER SYSTEM ANALYSIS- Review of Balanced Fault

Expected Outcomes

Able to solve balanced fault analysis

Review on Balanced Fault

- A fault in a circuit is any failure which interferes with normal flow currents

- Examples of fault in a circuit:

i)Over-load in distribution system network
ii)Faults on electrical equipment
iii)Transmission lines faults

- Over-load faults are caused by the unexpected increasing of loads.
- Faults on electrical equipment are caused by:
  - lightning, insulator breakage, product design which is out of specification, improper installations of equipment
- Transmission and distribution overhead lines faults are caused by: lightning, storm, fallen trees, snow

Fault Analysis

- Analysis types
  - Power flow: evaluate normal operating conditions
  - Fault analysis: evaluate abnormal operating conditions
- Fault types
  - Balanced faults
    - Three-phase
  - Unbalanced faults
    - Single-line to ground
    - Double-line to ground
    - Line-to-line
- Results used for:
  - Specifying ratings of circuit breakers and fuses
  - Protective relay settings
  - Specifying the impedance of transformers and generators

...Fault Analysis

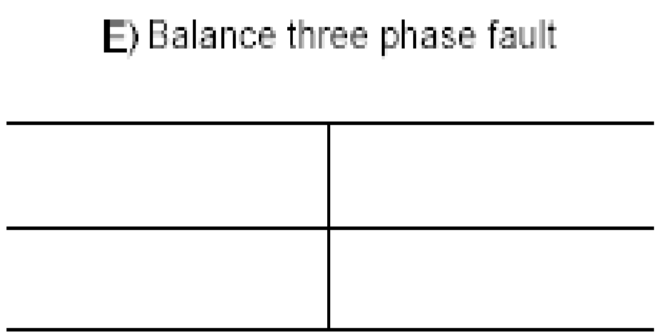
- Magnitude of fault currents depend on:
  - The impedance of the network
  - The internal impedances of the generators
  - The resistance of the fault (arc resistance)
- Network impedance are governed by:
  - Transmission line impedances
  - Transformer connections and impedances
  - Grounding connections and resistances

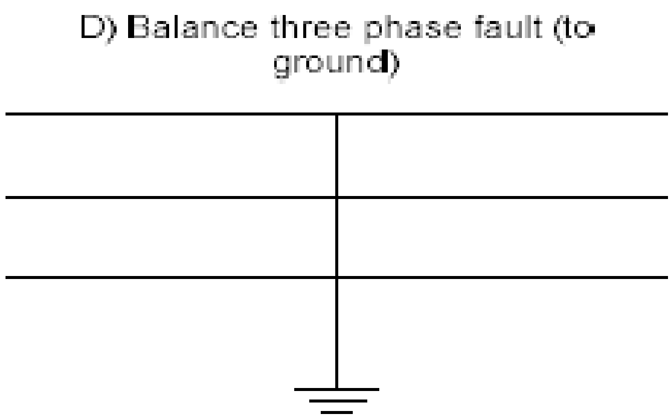
Fault Representation

- A fault represents a structural network change
  - Equivalent to the addition of an impedance at the place of the fault
  - If the fault impedance is zero, the fault is referred as a ***bolted fault*** or ***solid fault***
- First order method
  - The faulted network can be solved conveniently by Thevenin's method
  - Network resistances are neglected
  - Generators are modeled as an emf behind the sub-transient or transient reactance
  - Shunt capacitances are neglected & system is considered as having no-load

Balanced Three-phase Fault

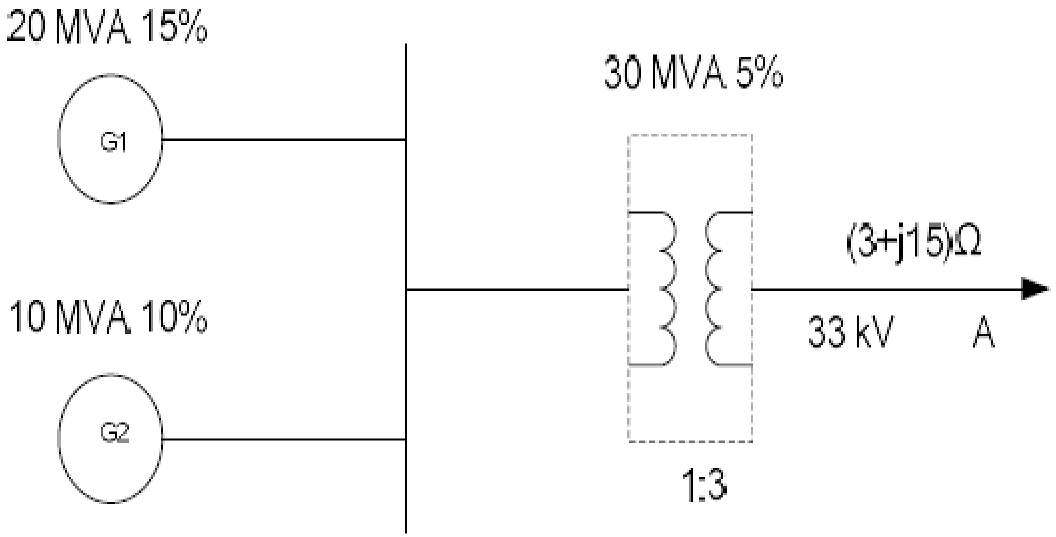
- This type of fault is defined as the simultaneous short circuit across all three phases
- Occurs not so frequently, but it is the most severe type of fault encountered





Example

A balanced 3 phase fault occurs at point A of the system in figure below. The generator of G1 has sub-transient reactance of 15% and G2 has sub transient reactance of 10%. The transformer has sub-transient reactance of 5%. Assume base MVA is 30MVA and transmission line voltage base is 33kV, find the fault current.



Solution

Generator G1,

$$X_{G1} = j0.15 \times \frac{30MVA}{20MVA} = j0.225pu$$

Generator G2,

$$X_{G2} = j0.10 \times \frac{30MVA}{10MVA} = j0.3pu$$

Transformer,

$$X_{T1} = j0.05 \times \frac{30MVA}{30MVA} = j0.05pu$$

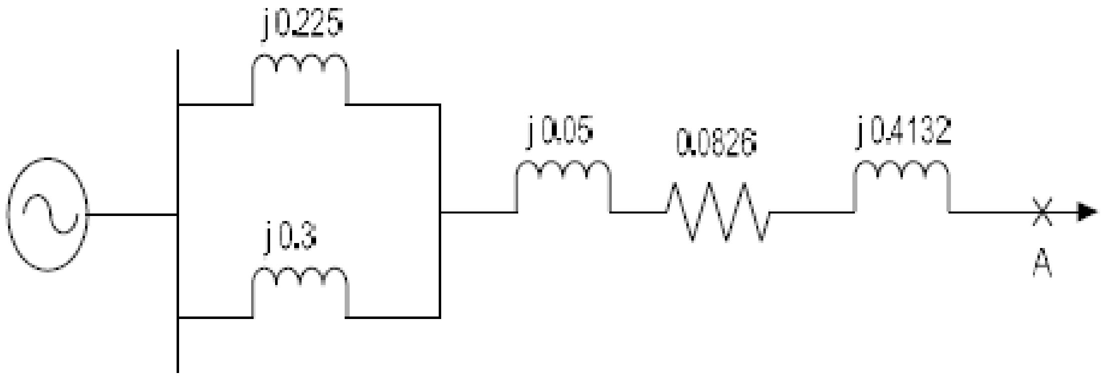
Z_{line} = (3 + j15) Ω

$Z_{base} = (V_{base})^2/S_{base} = \frac{(33kV)^2}{30\,MVA} = 36.3\Omega pu$

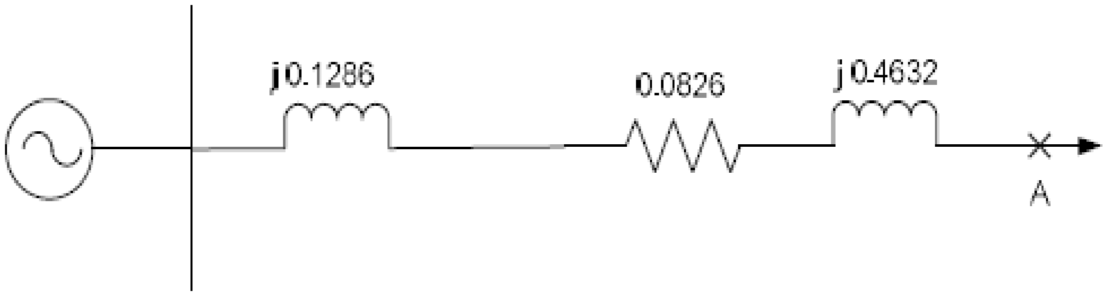
Z_{pu} line = $\frac{3 + j5}{36.3} = 0.0826 + j0.4132\,pu$

...Solution

Convert to pu system



Simplified network



...Solution

Z fault pu,

$$Zpu = 0.0826 + j0.5188 = 0.5975\angle 82^\circ$$

S fault,

$$MVA_F = \frac{MVA_{base}}{Z_{pu}} = \frac{30MVA}{0.5975\angle 82^\circ} = 50.21MVA$$

Current fault,

$$I_F = \frac{MVA_F}{\sqrt{3}V_L} = \frac{50.21MVA}{\sqrt{3}(33kV)} = 878.5\angle -82^\circ A$$

...Solution

Z fault pu,

$$Zpu = 0.0826 + j0.5188 = 0.5975\angle 82^\circ$$

S fault,

$$MVA_F = \frac{MVA_{base}}{Z_{pu}} = \frac{30MVA}{0.5975\angle 82^\circ} = 50.21MVA$$

Current fault,

$$I_F = \frac{MVA_F}{\sqrt{3}V_L} = \frac{50.21MVA}{\sqrt{3}\left(33kV\right)} = 878.5\angle -82^\circ A$$


والله أعلم