IQRA NATIONAL UNIVERSITY

Power System Analysis

Final Assignment Spring 2020

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Q1 (a) What is surge Impedence of transmission lines & how can it be Found?

Answerr <u>Surge Impedence</u>

The surge impedence loading or SIL (in MW) is equal to the voltage squared (in KV) divided by the surge impedence (in ohm) in equation form.

$$SIL\,(\text{in MW}) = \frac{KV_{L-L}^2}{\text{Surge Impedence}}$$

In the Formula the SIL is dependent only on the KV the line is energized & the line's Surge Impedence.

Q1(b) what is the effect of voltage on the number of insulators, distance from ground & distance between phases of Transmission lines?

Answer:- Electrical design shows the type, size & number of bundle conductors per phase. Phase conductors are selected to have sufficient thermal capacity to meet continuous, emergency overload & short-circuit current ratings. For EHV Lines the number of bundles conductors per phase is selected to control the voltage gradient at conductor surfaces thereby reducing or eliminating corona. Electrical design also shows the number of insulators discs, vertical or v-shaped string arrangement, phase to phase clearance & phase to tower clearance all selected to provide adequate Line insulation. Line insulation must withstand transient overvoltages due to lightning & switching surges even when insulators are containminated by fog, salt or industrial pollution. Line height is selected to satisfy prescribed conductor-to-ground clearances & to control the ground level, electric field & its potential shock hazard. Conductor spacing, size & types also determine the series impedence & shunt admittance. Series impedence effects line-voltage drops, I^2R losses & stability limits, shunt admittance, primarily capacitive, affects line-charging currents which injects reactive power into the power system. Shunt reactors (inductors) are often installed on hightly loaded EHV lines to absorb part of this reactive power therby reducing overvoltages.

Q 2(a) What are Bus Bars & what are the types of Bus Bars used in transmission lines?

Answer:- In electrical power distribution ~~or~~ a bus bar is a metallic strip or bar typically housed inside the switch gear, panel boards & busway enclousers for local high current power distribution.

Types & classification of Bus Bars on Power System Network. we have different types of Bus Bars.

(i) Swing Bus or Slack Bus:-

where we donot specify the generation but we specify the voltage, magnitude & angle. Since this Bus Bar is a refrence Bus Bar the angle specified is Normally zero. Since it is a generating Bus which have its own voltage magnitude. So the voltage level is fixed. So swing Bus Bar has voltage, magnitude & Angle specified.

(2) PV Bus (Voltage Control Bus).

The Bus Bar in which we have the magnitude & a Real power is specified. voltage regulators are installed which regularly check the voltage level.

(3) Load Bus

Where both the real & reactive powers are specified. so with each Bus 4 variables (P, Q, V & δ) are associated. Depending on the types of Bus two variables are known & two unknown variables are obtained from Power flow.

Q2 (b) In a 3-bus power flow system after current noddle analysis the following currents were found at each bus. Use jacobi Method to find the value of each current.

$$5I_1 - I_2 + 2I_3 = 12$$

$$3I_1 + 8I_2 - 2I_3 = -25$$

$$I_1 + I_2 + 4I_3 = 6$$

<u>Solution:-</u>

$$5I_1 = I_2 - 2I_3 + 12.$$

$$I_1 = \frac{I_2}{5} - \frac{2I_3}{5} + \frac{12}{5}$$

$$8I_2 = -25 + 3I_1 - 2I_3$$

$$I_2 = \frac{-25}{8} + \frac{3}{8}I_1 - \frac{2}{8}I_3$$

$$4I_3 = 6 - I_1 - I_2$$

$$I_3 = \frac{3}{2} - \frac{1}{4}I_1 - \frac{1}{4}I_2$$

$$k = 0$$

So

$$I_1 = \frac{0}{5} + 0(-2/5) + 12/5$$

$$I_1 = 2.4\,A$$

$$I_2 = -\frac{25}{8} + \frac{3}{8}(0) - \frac{1}{4}(0)$$

$$I_2 = -3.125\,A$$

~~$I_3 = -\frac{25}{8} + \frac{3}{8}$~~

$$I_3 = \frac{3}{2} - \frac{1}{4}(0) - \frac{1}{4}(0)$$

$$I_3 = 1.5\,A$$

when $k = 1$.

$$I_1 = \frac{1}{5} + (1)(-2/5) + \frac{12}{5}$$

$$I_1 = \frac{1}{5} - 2/5 + \frac{12}{5}$$

$$I_1 = 2.2\,A$$

$$I_2 = -\frac{25}{8} + \frac{3}{8}(1) - \frac{1}{4}(1)$$

$$I_2 = -\frac{25}{8} + \frac{3}{8} - \frac{1}{4}$$

$$I_2 = -3A$$

$$I_3 = \frac{3}{2} - \frac{1}{4}(1) - \frac{1}{4}(1)$$

$$I_3 = \frac{3}{2} - \frac{1}{4} - \frac{1}{4}$$

$$\boxed{I_3 = 1A}$$

when $k = 2$.

$$I_1 = \frac{2}{5} + (2)(-2/5) + \frac{12}{5}$$

$$I_1 = \frac{2}{5} - \frac{4}{5} + \frac{12}{5}$$

$$\boxed{I_1 = 2A}$$

$$I_2 = \frac{-25}{8} + \frac{3}{8}(2) - \frac{1}{4}(2)$$

$$I_2 = \frac{-25}{8} + \frac{6}{8} - \frac{2}{4}$$

$$\boxed{I_2 = -2.75A}$$

$$I_3 = \frac{3}{2} - \frac{1}{4}(2) - \frac{1}{4}(2)$$

$$I_3 = \frac{3}{2} - \frac{2}{4} - \frac{2}{4}$$

$$\boxed{I_3 = 0.75A}$$

Q3(a) A 3ϕ 765-kV, 60Hz, 300 km, Completely transposed line has impedence & admittance of $z = 0.0165 + j0.3306$ ohm/km & $y = j4.674 * 10^{-6}$ S/km calculate the exact ABCD parameters of the line.

Solution:-

$$A = D = \cosh(\gamma l)$$

$$C = \frac{1}{Z_c}\sinh(\gamma l)$$

$$B = Z_c \sinh(\gamma l)$$

$$Z_c = \sqrt{\frac{z}{y}}$$

$$Z_c = \sqrt{\frac{0.3310\angle 87.14}{4.674\times10^{-6}\angle 90^\circ}}$$

$$Z_c = \sqrt{7.082\times10^{4}\angle -2.86^\circ}$$

$$Z_c = 266.1\angle -1.43^\circ\ \Omega$$

$$\gamma l = \sqrt{(0.3310\angle 87.14^\circ)(4.674\times10^{-6}\angle 90^\circ)} \times 300$$

$$\gamma l = \sqrt{1.547\times10^{-6}\angle 177.14} \times 300$$

$$\gamma l = 0.3731\angle 88.57^\circ$$

$$\gamma l = 0.00931 + j0.3730 \text{ per unit.}$$

$e^{\gamma l} = e^{0.371 \angle 88.57}$

$e^{\gamma l} = e^{0.00931} \, e^{+j0.3730}$

$e^{\gamma l} = 1.0094 \angle 0.3730$ radians.

$e^{\gamma l} = 0.9400 + j0.3678.$

&

$e^{-\gamma l} = e^{-0.00931} \, e^{-j0.3730}$

$e^{-\gamma l} = 0.9907 \angle -0.3730$ radians.

$e^{-\gamma l} = 0.9226 - j0.3610.$

$$\cosh(\gamma l) = \frac{e^{\gamma l} + e^{-\gamma l}}{2}$$

$$\sinh(\gamma l) = \frac{e^{\gamma l} - e^{-\gamma l}}{2}$$

$$\cosh(\gamma l) = \frac{(0.9400 + j0.3678) + (0.9226 - j0.3610)}{2}$$

$\cosh(\gamma l) = 0.9313 + j0.0034$

$\cosh(\gamma l) = 0.9313 \angle 0.209^\circ.$

$$\sinh(\gamma l) = \frac{(0.9400 + j0.3678) - (0.9226 - j0.3610)}{2}$$

$\sinh(\gamma l) = 0.0087 + j0.3678$

$\sinh(\gamma l) = 0.3645 \angle 88.63^\circ.$

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$A = D = \cosh(\gamma l) = 0.9313 \angle 0.209^\circ$ per unit.

$B = (266.1 \angle -1.43^\circ)(0.3645 \angle 88.63^\circ)$

$B = 97.0 \angle 87.2 \ \Omega$

$$C = \frac{0.3645 \angle 88.63}{266.1 \angle -1.43^\circ}$$

$C = 1.37 \times 10^{-3} \angle 90.06^\circ \ S$

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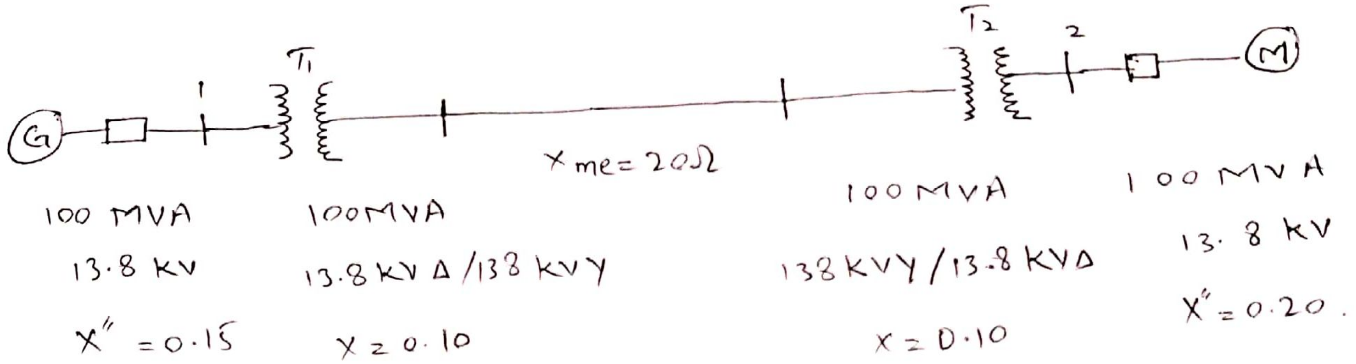
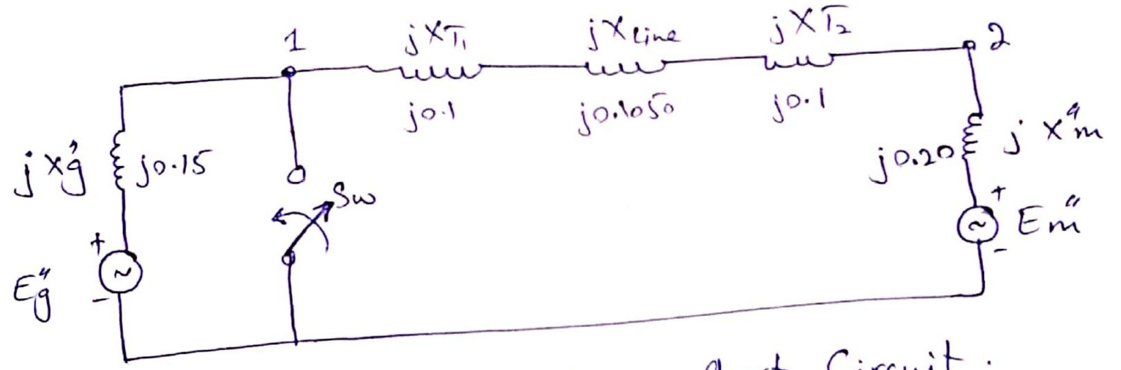
(12)

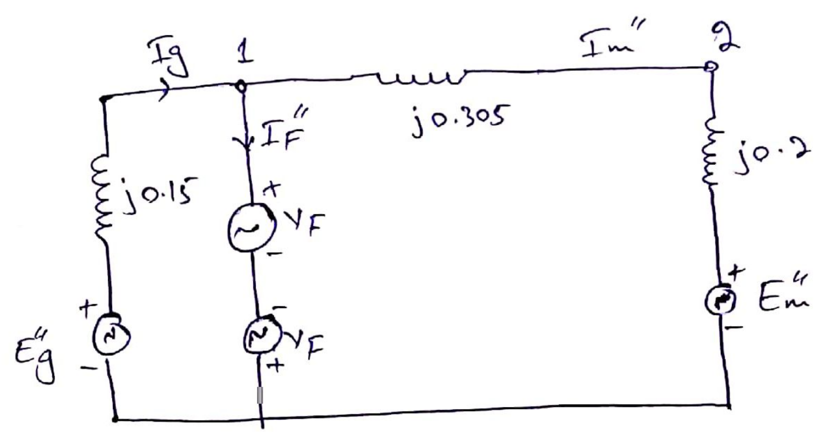
Q4 (a) Draw & Explain the equivalent pre-fault circuit diagram of the following three phase circuit & then draw & explain the post fault condition of the circuit.



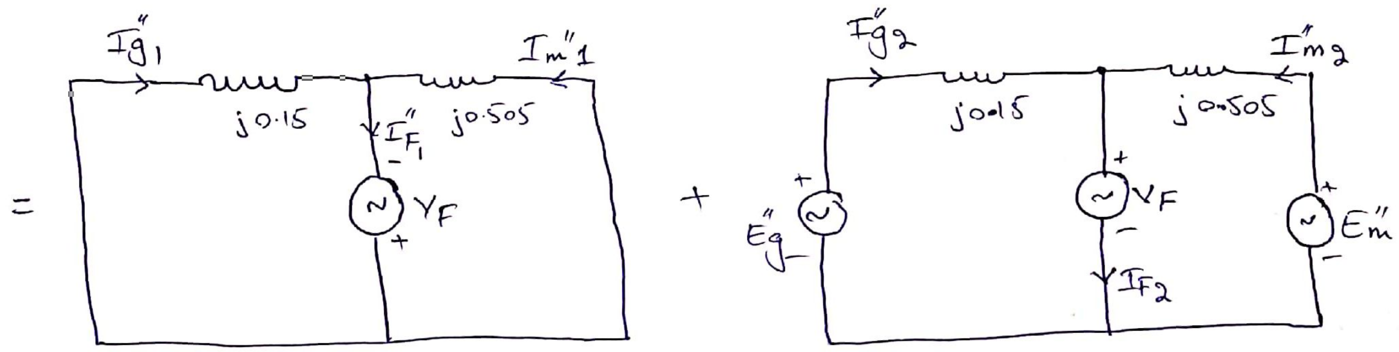
Answer:-



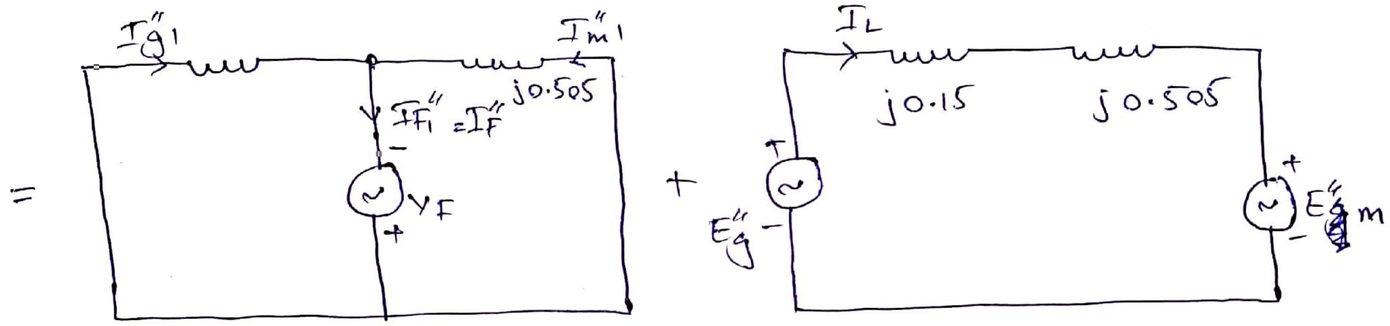
(a) Three phase Short Circuit.



(b) Short Circuit represented by two opposing voltage source.



(c) Application of Superposition.



(d) V_F set equal to prefault voltage at fault.

<u>Explaination:</u>

Application of superposition to a power system three phase short-circuit which has no effect & can be removed from the second circuit. The subtransient fault current is then determined from the first current $I_F'' = I_{F_1}''$. The contribution to the fault from the generator is $I_g'' = I_{g_1}'' + I_{g_2}'' = I_{g_1}'' + I_L$ where L is the prefault generator current.

Similarly $I_m'' = I_{m_1}'' - I_L$.

Q4(b) A fault occurs in the above system. The fault voltage is 1.05∠0 kV. The load current is 3.98∠−18.19 KA. Find the fault current & Generator current.

Solution = fault current = $I_F = \frac{V_F}{Z}$

$$I_F = \frac{1.05}{20}$$

$$I_F = 0.0525$$

$$\boxed{I_F = 0.525\ KA.}$$

Generator Current = $I_g = I_F + I_L$

$$I_g = 0.525\ KA + 3.98\angle{-18.19}\ KA$$

$$I_g = 3.84 - j1.24$$

$$\boxed{I_g = 4.03\angle{-17.89}\ KA}$$

Q5 (a) What is the difference between symmetric faults & un-symmetric faults. What are the main examples of each fault?

Answer:- <u>Difference Between Symmetric & un-Symmetric Faults.</u>

=> Symmetric Faults are those Faults which involve with all the three phases. It simply means that symmetric Faults effects all the three phases.

=> Un-Symmetric Faults are those Faults in which either one or two phases are involved. In Un-Symmetric Faults the three phases lines become unbalanced.

<u>Examples</u>

A line-to-line Fault occurs when two conductors short circuited. A double line-to-ground Fault occurs when two conductors Fall on the ground or come in contact with the neutral conductor. LG, LL & LLG are un-symmetrical Fault while LLL & LLG are the symmetrical Faults.

Q5(b) Calculate the sequence components of the line-to-neutral voltages & determine its sequence & if its balanced or not.

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \begin{bmatrix} 277\angle 0^\circ \\ 277\angle -120^\circ \\ 277\angle +120^\circ \end{bmatrix} \text{ volts.}$$

Solution:-

$a = 1\angle 120$

$a^2 = 1\angle 240$

$$V_p = A V_s$$

$$V_s = A^{-1} V_p$$

$$\begin{bmatrix} V_0 \\ V_1 \\ V_2 \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix} \begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix}$$

$$V_0 = \frac{1}{3}(V_{an} + V_{bn} + V_{cn})$$

$$V_1 = \frac{1}{3}(V_{an} + aV_{bn} + a^2 V_{cn})$$

$$V_2 = \frac{1}{3}(V_{an} + a^2 V_{bn} + a V_{cn})$$

So

$$V_0 = \frac{1}{3}(277\angle 0 + 277\angle -120 + 277\angle 120)$$

$$V_0 = \frac{0}{3}$$

$$\boxed{V_0 = 0}.$$

$$V_1 = \frac{1}{3}\left(277\angle 0 + (277\angle -120)(1\angle 120) + (1\angle 240)(277\angle 120)\right)$$

$$V_1 = 277\angle 0$$

$$\boxed{V_1 = 0}$$

$$V_2 = \frac{1}{3}\left(277\angle 0 + (1\angle 240)(277\angle -120) + (1\angle 120)(277\angle 120)\right)$$

$$\boxed{V_2 = 0}$$

This example illustrates the fact that balanced three-phase system with abc sequence have no zero sequence or negative sequence components. Forexample, the positive sequence voltage V_1 equals V_{an} & the zero sequence & negative sequence voltages are both zero.