QUESTION 2023

Group – A
(Very Short Answer Type Question)

1. Answer any ten of the following:

i) What is the expression of fault current in case of LG fault?
Chapter Name: "FAULTS IN ELECTRICAL SYSTEM"
Answer:
Expression of fault current in case of LG fault $I_f = [3E_a / (Z_1 + Z_2 + Z_3)]$

ii) What will be nature of stability if the torque angle δ continuously increases?
Chapter Name: "POWER SYSTEM STABILITY"
Answer: Steady state stability will break.

iii) What is the purpose of Buchholz relay?
Chapter Name: "PROTECTIVE RELAYS"
Answer:
Indicates high current is flowing through transformer winding due to some fault.

iv) What is the difference between per unit impedances of a transformer referred from the primary and secondary side?
Chapter Name: "FAULTS IN ELECTRICAL SYSTEM"
Answer:
Per unit impedance will remain same of a transformer referred to primary and secondary side.

v) What is the main criterion for selecting the size of a distributor for a redial distribution system?
Chapter Name: "DISTRIBUTION SUBSTATIONS"
Answer:
Criterion for selecting the size of a distributor for a radial distribution system is Voltage Drop.

vi) In which bus of the power network, voltage magnitude and angle are unknown?
Chapter Name: LOAD FLOW STUDIES ""
Answer: Load Bus

vii) A 100 kVA transformer has a reactance of 6%. What will be value reactance at 300 kVA base?

Chapter Name: "FAULTS IN ELECTRICAL SYSTEM"

Answer:

PU = 6% (reactance)

Actual value = 100 kVA

When actual value will be 300 kVA

$$\therefore \text{PU reactance value} = \frac{300 \times 6}{100} = 18\%$$

viii) What do you mean by distribution system?

Chapter Name: "DISTRIBUTION SUBSTATIONS"

Answer:

The part of the power system that distributes electric power for local use is as *distribution system*. Generally, a distribution system is the electrical system the substation fed by transmission system and the consumer's meters.

ix) For which condition, a voltage-controlled bus is treated as a load subsequent iteration?

Chapter Name: LOAD FLOW STUDIES ""

Answer:

If the reactive power value violates, the voltage-controlled bus is made to act as for that iteration only and the reactive power to be substituted in the expressio iteration will correspond to the limit it has violated.

x) What is the value of positive sequence component of voltage at the point in case of 3-phase fault?

Chapter Name: "FAULTS IN ELECTRICAL SYSTEM"

Answer:

The positive sequence component value will be equal to value of one third current in case of 3 phase fault.

xi) A 11 kV, 10 MVA alternators has impedance of 0.10 p.u when refer ratings as bases. What will be the new value for base as 110 kV, 20 MVA?

Chapter Name: "FAULTS IN ELECTRICAL SYSTEM"

Answer:

$$(Z_{pu})_{new} = (Z_{pu})_{old} \times \frac{(MVA)_{b,old}}{(MVA)_{b,new}} \times \frac{(KV)^2_{b,old}}{(KV)^2_{b,new}}$$

$$= 0.10 \times \frac{20}{10} \times \frac{(11)^2}{(110)^2} = \frac{2 \times 0.10 \times (11)^2}{(110)^2} = 0.005\ p.u$$

xii) What is the function of feeder in distribution system?
Chapter Name: "DISTRIBUTION SUBSTATIONS"
Answer:
Feeder transmits power from Generating station or substation to the distribution points. They are similar to distributors except the fact that there is no intermediate tapping done and hence the current flow remains same at the sending as well as the receiving end.

Group – B
(Short Answer Type Question)

2. What are the fundamental requirements of protective relaying? Depending upon their (i) construction and principle of operation and (ii) time of operation, how relays are classified?
Chapter Name: "PROTECTIVE RELAYS"
Answer:
Protective relays are designed, manufactured and applied with the optimization of the following criteria in mind:

Reliability - The ability of the relay or the relay system to perform correctly when needed (dependability) and to avoid unnecessary operation (security).
Speed - Minimum fault time and equipment damage.
Selectivity - Maximum service continuity with minimum system disconnection.
Economics - Maximum protection at minimum cost.
Simplicity - Minimum equipment, circuitry and sequence of operations.

Based on operation mechanism protection relay can be categorized as electromagnetic relay, static relay and mechanical relay. Actually, a relay is nothing but a combination of one or more open or closed contacts. These all or some specific contacts the relay change their state when actuating parameters are applied to the relay. That means open contacts become closed and closed contacts become open. In an electromagnetic relay, these closing and opening of relay contacts are done by the electromagnetic action of a solenoid.
Based on time of operation relays are classified as On Time Delay relay and Off Time Delay relay.

3. What do you mean by sub-station? Classify the substations.
Chapter Name: "DISTRIBUTION SUBSTATIONS"

Answer:

A substation is a high-voltage electric system facility. It is used to switch [illegible] equipment, and circuits or lines in and out of a system. It also is used to change voltages from one level to another, and/or change alternating current to direct current or direct current to alternating current. Some substations are small with little more than a transformer and associated switches. Others are very large with several transformers, dozens of switches and other equipment. There are three aspects to substations: Substation Types: Although, there are generally four types of substations there are substations that are a combination of two or more types.

- Step-up Transmission Substation
- Step-down Transmission Substation
- Distribution Substation
- Underground Distribution Substation

4. A single-phase transformer is rated as 2.5 kVA, 11/0.4 kV. If the reactance is 0.96 ohm when referred to low-voltage side, then determine leakages reactance in per unit.

Chapter Name: "PROTECTIVE RELAYS"

Answer:

$$\text{Base impedance} = \frac{(KV_b)^2}{(MVA)_b} = \frac{(0.4)^2}{0.025} = \frac{0.16}{0.025} = 6.40 \text{ ohm.}$$

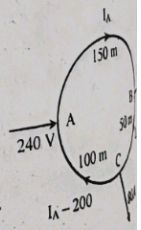
$$\text{Leakage reactance in pu} = \frac{0.96}{6.4} = 0.15 \text{ pu.}$$

5. A 2-wire DC ring distributor is 300 m long and is fed at 240 V at point A. B, 150 m from A, a load of 120A is taken and at C, 100 m in the opposite dir load of 80 A is taken. If the resistance per 100 m of signal conductor 0.03 Ω

i) Current in each section of distributor

ii) Voltage at point B and C.

Chapter Name: "MISCELLANEOUS"



Answer:

$$\text{Resistance per 100 m of conductor} = 2 \times 0.03 = 0.06\Omega$$

$$\text{Resistance of section AB, } R_{AB} = 0.06 \times \frac{150}{100} = 0.09\Omega$$

$$\text{Resistance of section BC, } R_{BC} = 0.06 \times \frac{50}{100} = 0.03\Omega$$

$$\text{f section CA, } R_{CA} = 0.06 \times \frac{100}{100} = 0.06\Omega$$

According to Kirchhoff's voltage law, voltage drop in the closed loop ABCA is zero.

$$I_{AB}R_{AB} + I_{BC}R_{BC} + I_{CA}R_{CA} = 0$$

$$\Rightarrow 0.09I_{AB} + 0.03I_{BC} + 0.06I_{CA} = 0$$

$$\Rightarrow 0.09I_A + 0.03(I_A - 120) + 0.06(I_A - 200) = 0$$

$$\Rightarrow 0.09I_A + 0.03I_A - 3.6 + 0.06I_A - 12 = 0$$

$$\Rightarrow 0.18I_A - 15.6 = 0$$

$$\Rightarrow 0.18I_A = 15.6$$

$$\Rightarrow I_A = 86.67A \text{ from A to B}$$

i) Current in section AB, $I_{AB} = 86.67$ A

Current in section BC, $I_{BC} = (I_A - 120) = (86.67 - 120) = -33.33$ A from B to C

Current in section CA $I_{CA} = (I_A - 200) = (86.67 - 200) = -113.33$ A from C to A

ii) Voltage drop at point, $V_B = V_A - I_{AB}R_{AB} = 240 - (86.67 \times 0.09) = 232.2$ V

voltage drop at point C, $V_C = V_B + I_{BC}R_{BC} = 240 - (33.33 \times 0.03) = 233.3$ V

6. A generator of negligible resistance having 1.0 per unit voltage behind transient reactance in subjected to different types of faults.

Type of fault	Resulting fault current in p.u
3-phase	3.33
L-L	2.23
L-G	3.01

Calculate the per unit values of 3 sequence - reactance.

Chapter Name: "FAULTS IN ELECTRICAL SYSTEM"

Answer:

3-phase fault current $= \dfrac{E_a}{X_1}$

$$\Rightarrow 3.33 = \frac{1}{X_1}$$

$$\Rightarrow X_1 = \frac{1}{3.33} = 0.3 \text{ pu}$$

Line to line fault current $= \dfrac{\sqrt{3}E_a}{X_1 + X_2}$

$$\Rightarrow 2.23(0.3 + X_2) = \sqrt{3}$$

$$\Rightarrow 0.06 + 2.23X_2 = \sqrt{3}$$

$$\Rightarrow 2.23X_2 = \sqrt{3} - 0.66$$

$$\Rightarrow X_2 = \frac{1.056}{2.23} = 0.47 \text{ pu}$$

$$\text{Line to ground fault current} = \frac{3E_a}{X_1 + X_2 + X_0}$$

$$\Rightarrow 3.01 = \frac{3}{X_0 + 0.3 + 0.47}$$

$$\Rightarrow 3.01(X_0 + 0.3 + 0.47) = 3$$

$$\Rightarrow 3.01X_0 + 2.31 = 3$$

$$\Rightarrow X_0 = \frac{0.69}{3.01} = 0.22 \text{ pu}$$

Group – C
(Long Answer Type Question)

7. a) What do you mean by Per Unit (pu) system?

Chapter Name: "REPRESENTATION OF POWER SYSTEM COMPONEN

Answer:

The per-unit value of any quantity is defined as the ratio of actual value in any un base or reference value in the same unit. Any quantity is converted into per unit by dividing the numeral value by the chosen base value of the same dimension. T unit value is dimensionless.

$$\text{Per Unit Value} = \frac{\text{Actual value in any unit}}{\text{Base or reference value in the same unit}}$$

The base values can be selected arbitrarily. It is usual to assume the base values a below

- ase voltage = rated voltage of the machine
- e current = rated current of the machine
- impedance = base voltage /base current
- se power = base voltage x base current

b) What are the advantages of Per Unit (pu) system?

Chapter Name: "REPRESENTATION OF POWER SYSTEM COMPONE

Answer:

There are mainly two advantages of using the Per Unit System.

The parameters of the rotating electrical machines and the transformer lie roug of numerical values, irrespective of their ratings if expressed in

It relieves the analyst of the need to refer circuit quantities to one or the other side of the transformer, making the calculations easy.

Taking the example of a transformer having the resistance in the per unit as R_{pu} ohm and the reactance as X_{pu} in ohm with referred to primary then per unit values will be

$$R_{ep_{pu}} = \frac{R_{ep}}{\text{Base Impedance}} = \frac{R_{ep}}{V_1/I_1}$$

Similarly,

$$X_{ep_{pu}} = \frac{X_{ep} \times I_1}{V_1}$$

where R_{ep} and X_{ep} are resistance and reactance referred to primary and pu means in the per-unit system.

The resistance and leakage reactance referred to primary in per unit are the same as referred to as secondary in the per-unit system because

$$R_{ep_{pu}} = \frac{R_{ep} \times I_1}{V_1} = \frac{\frac{R_{ep}}{K^2} \times JI_1}{V_1/K} = \frac{R_{es} I_2}{V_2} = R_{es}(p.u)$$

$$X_{ep_{pu}} = \frac{X_{ep} \times I_1}{V_1} = \frac{\frac{X_{ep}}{K^2} \times KI_1}{V_1/K} = \frac{X_{es} I_2}{V_2} = X_{es}(p.u)$$

where R_{es} and X_{es} are the equivalent resistance and reactance referred to secondary.

Therefore, from the above two equations, it is clear that the need for an ideal transformer is eliminated. This is so because the per-unit impedance is the same for the equivalent circuit of the transformer whether computed from the primary or secondary as long as the voltage bases on the two sides are selected in the ratio of transformation.

c) An 11/0.4 kV, 200 kVA transformer has an equivalent impedance of (2.4+j12.4) ohms referred to the hv side. Determine the base values for the p.u. system, the per-unit equivalent impedance and the equivalent impedance drop at one-half rated current.

Answer:

Refer to "REPRESENTATION OF POWER SYSTEM COMPONENTS", Short Answer Type Question No. 4.

8. a) What are the comparisons between overhead distribution system and underground distribution system?

Chapter Name: "DISTRIBUTION SUBSTATIONS"

Answer:

Underground System	Overhead System
The public safety are more in Underground system.	The Public safety are less in system.
The Underground system are more expensive.	The Overhead system are less expe
The Underground system are less flexible because load expansion are possible in underground system.	The overhead system are more because load expansion are possible
The underground system working voltage limited to 66KV because of insulation problem.	The overhead system working 400KV or more.
The fault detection and clearance are difficult in the case of underground system.	The fault detection and clearance are overhead system.
In Underground system voltage drop is less due to the less spacing between the conductor and inductance of the cable is low.	In overhead system voltage drop due to the more spacing betwe conductor and inductance of the co is more.
The appearance of the underground system is good because wiring are not visible.	The appearance of the overhead sy not good because wiring and pi visible.
The underground system are free from interruption due to thunderstorm, lightning and objects falling across the conductors.	The overhead system are not fre interruption due to thunderstorm, li and objects falling across the conduct
In underground system, the proximity effect is more.	In overhead system, proximity effect
In underground system, the corona discharge does not occurs.	In overhead systems, the corona di will be occur.
The underground system are used for transmission and distribution of the power at shorter distance.	The overhead system are us transmission and distribution of el power at longer distances.
The layout flexibility of the underground system is very less.	The layout flexibility of the system is very high.
The underground system are more reliable.	The overhead system are less reliable

b) What are the advantages of double end fed distribution system over single end fed distribution system?

Chapter Name: "DISTRIBUTION SUBSTATIONS"

Answer:

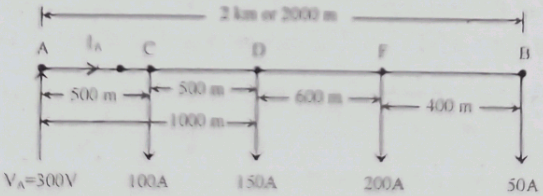
In this type, the distributor is connected to supply at both ends and voltages at feeding points may or may not be equal. The minimum voltage occurs at some load point which is shifted with the variation of load on different sections of the distributor.

- If a fault occurs at any feeding point, continuity of the supply is ensured from the other feeding point.
- If a fault occurs on any section of the distributor, continuity of the supply is ensured on both sides of the fault with respective feeding points.
- The conductor cross-section area required for a doubly fed distributor is much less than that required for a distributor fed at one end.

c) A 2-wire DC distributor cable AB is 2 km long and supplies loads of 100A, 150A, 200A and 50A situated 500m, 1000m, 1600m and 2000m from the feeding point A. Each conductor has a resistance of 0.01Ohm/1000m. Calculate the potential difference at each load point if a p.d. of 300V is maintained at point A.

Chapter Name: "DISTRIBUTION SUBSTATIONS"

Answer:



Each conductor resistance – $0.01\Omega/1000\,\text{m}$

$V_C = V_A - \left(500 \times 5 \times 10^{-3}\right)$

$\Rightarrow V_C = 300 - 2.5$

$\Rightarrow V_C = 297.5$ Volts

$V_D = V_C - \left(400 \times 5 \times 10^{-3}\right)$

$\Rightarrow V_D = 297.5 - 2$

$\Rightarrow V_D = 295.5$ Volts

$V_E = V_D - \left(250 \times 6 \times 10^{-3}\right)$

$\Rightarrow V_E = 295.5 - 1.5$

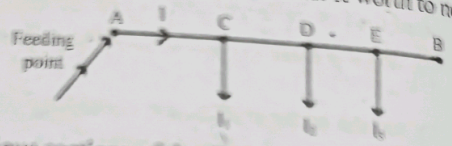
$\Rightarrow V_E = 294$ Volts

9. a) Classify different kind of distribution system along with relevant

***Chapter Name:* "DISTRIBUTION SUBSTATIONS"**

Answer:

Distributor Fed at One End: In this type distributor is connected to the end and loads are tapped at different points along its length. The following the single line diagram of a distributor fed at one end. It worth to note that -

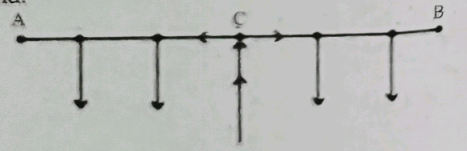


- The current in various sections of the distributor away from the feeding decreasing. From the above figure, the current in section DE is less tha in section CD and likewise.
- The voltage also goes on decreasing away from the feeding point figure, voltage at point E will be minimum.
- In case of a fault in any section of the distributor, the whole distributor be disconnected from the supply. Thus continuity of supply is interrupted

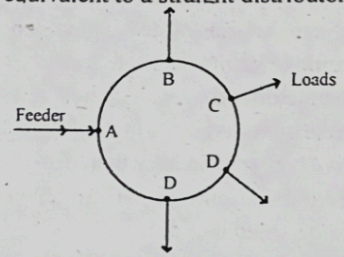
Distributor Fed at Both Ends: I this type the distributor is connected to s ends and voltages at feeding points may or may not be equal. the minim occurs at some load point which is sifted with the variation of load on diffe of the distributor.

- If a fault occurs at any feeding point, continuity of the supply is ensu other feeding point.
- If a fault occurs on any section of the distributor, continuity of the supp on both sides of the fault with respective feeding points.
- The conductor cross-section area required for a doubly fed distributor than that required for a distributor fed at one end.

Distributor Fed at the Center: As the name implies, the distributor is s center point. Voltage drop at the farthest ends is not as large as that w distributor fed at one end.



Ring Main DC Distributor: In this type, the distributor is in the form of a closed ring and fed at one point. This is equivalent to a straight distributor fed at both ends with equal voltages.



b) A 250m, 2-wire DC distributor fed from one end is loaded uniformly at the rate of 1.6A/metre. The resistance of each conductor is 0.0002Ohm/metre. Find the voltage necessary at feed point to maintain 250V

i) At the far end

ii) At the midpoint of the distributor.

Chapter Name: "DISTRIBUTION SUBSTATIONS"

Answer:

Current loading $i = 1.6$ A/m

Current entering the distributor $(I) = i \times l = 1.6 \times 250 = 400$ A

Resistance of distributor per metro run –

$$r = 2 \times 0.002 = 0.0004\Omega$$

Total resistance of the distributor $= R = r \times l = 0.0004 \times 250 = 0.1\Omega$

i) Voltage drop over the entire distributor

$$= \frac{1}{2} \times R \times I = \frac{1}{2} \times 400 \times 0.1 = 20\text{V}$$

ii) Voltage drop upto a resistance of x m from feeding point –

$$= Ir\left(lx - \frac{x^2}{2}\right)$$

Here, $x = \frac{l}{2} = \frac{250}{2} = 125$ m

Voltage at feeding point $= 250 + 15 = 265$ V

Voltage drop $= 1.6 \times 0.004\left(250 \times 125 - \frac{(125)^2}{2}\right) = 15\text{V}$

c) What are the advantages of AC system over DC system?

Chapter Name: "DISTRIBUTION SUBSTATIONS"