UNIT – I INTRODUCTION

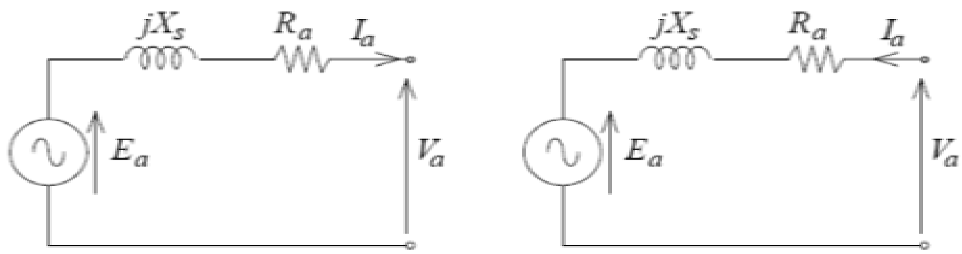
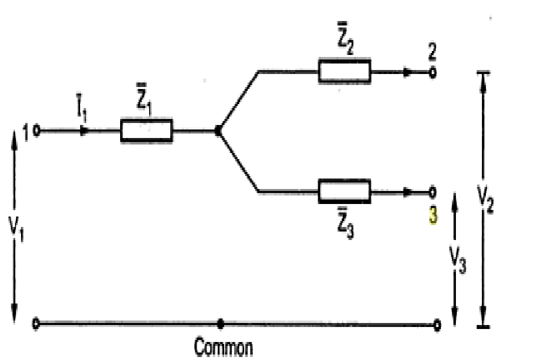
PART – A

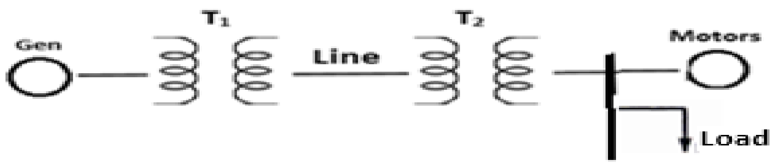
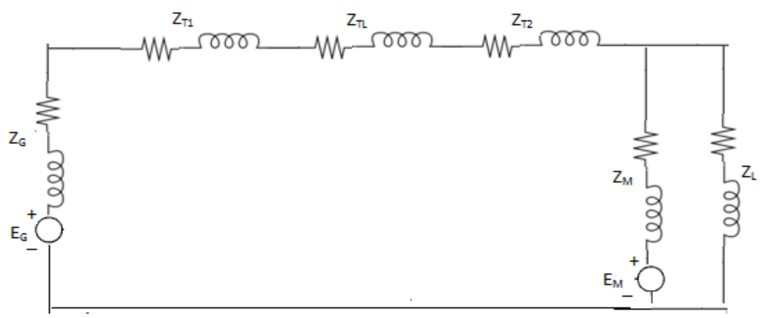
1.	**What is the advantage of per unit method over percentage method? (May 2017, Nov 2020)** The per unit method has an advantage over the percent method because the product of two quantities expressed in per unit is expressed in per unit itself, but the product of two quantities expressed in percent must be divided by 100 to obtain result in percent.
2.	**What is the need for base values? (Nov/Dec 2018, Apr/May 2018)** The components or various sections of power system may operate at different voltage and power levels. It will be convenient for analysis of power system if the voltage, power, current and impedance ratings of components of power system are expressed with reference to a common value called base value. Hence for analysis purpose, a base value is chosen for voltage, power, current and impedance ratings of the components are expressed as a percent of per unit of the base value.
3.	**Mention the requirements of planning the operation of a power system. (May 2018). (or) What are the needs of power system planning (Nov/Dec 2019) (Nov/Dec 2020)** To utilize the existing capacity in the best possible manner is of prime importance and is particularly relevant in a developing economy. The steps taken in the method of power system planning studies are, 1.Forecast of annual energy and power demand, 2. Load modeling 3. Generation and choice of mixing the various types of generating station. 4.Optimization of power plant characteristics 5. New substations and their capacity and location 6. New power plants and their subdivision in the main areas 7. Network expansion 8. Optimization of equipment characteristics.
4.	**What is single line diagram? (Nov 2015, May 2016 & Dec 2021)**

	A single line diagram is diagrammatic representation of power system in which the components are represented by their symbols and the inter connection between them are shown by a single straight line (even though the system is 3-phase system). The ratings and the impedances of the components are also marked on the single line diagram.
5.	**What are the components of power system? (May 2012)** The components of power system are generators, power transformers, motors, transmission lines, substation transformers, distribution transformers and loads.
6.	**Define per unit value of an electrical quantity and write the equation for base impedance for a three phase power system. (Dec 2017, Nov 2015)** Per unit value of any quantity is defined as the ratio of actual quantity to its base quantity expressed an a decimal. $$\text{Per unit value} = \frac{\text{Actual value}}{\text{Base value}}$$ The equation for base impedance for a three phase power system is given as, Base impedance $Z_b = kV_b^2/MVA_b$
7.	**Write the equation for converting the p.u. impedance expressed in one base to another? (May 2016, Dec 2017)** $$Z_{pu,New} = Z_{pu,old} X \left[\frac{KV_{b,old}}{KV_{b,new}}\right]^2 X \left[\frac{MVA_{b,new}}{MVA_{b,old}}\right]$$
8.	**What are the advantages (needs) of per unit computation? (Nov14, 16)** i) Manufactures usually specify the impedance of a device or machine in per unit on the base of the name plate rating. ii) The p.u. values of widely different rating machines lie within a narrow range, even though the ohmic values has a very large range.iii) The p.u. Impedance of circuit element connected by transformers expressed on a power base will be same is if it is referred to either side of a transformer. iv) The p.u. impedance of a 3ϕ transformer is independent of the type of winding connection (Y or Δ)
9.	**How the loads are represented in reactance or impedance diagram? (Nov 2016, Nov 2020)**

	The resistive and reactive loads can be represented by any one of the following representation. i) Constant power representation, Load power $S = P + jQ$ ii) Constant current representation, Load Current $I = \sqrt{\frac{P^2+Q^2}{\lvert V \rvert}} \angle \delta - \theta$ iii) Constant impedance representation. Load impedance $Z = \frac{V^2}{P-jQ}$
10.	**A generator rated at 30MVA, 11KV has a reactance of 20% calculate its p.u reactance for a base of 50 MVA and 10KV.** $X_{pu,new} = X_{pu} = 0.2 \text{ x } (11/10)^2 \text{x } (50/30) = 0.403\text{pu}$
11.	**The base KV and base MVA of a 3-phase transmission line is 33KV and 10 MVA respectively calculate the base current and base impedance. (Dec 2021)** Base current, $I_b = \frac{(KVA)_b}{\sqrt{3}KV_b} = \frac{(MVA)_b \times 1000}{\sqrt{3}KV_b} = \frac{10 \times 1000}{\sqrt{3} \times 33} = 175A$ Base impedance, $Z_b = \frac{(KV_b)^2}{MVA_b} = \frac{33^2}{10} =$ 108.9Ω
12.	**What is impedance diagram? (April 2019)** The impedance diagram is the equivalent circuit of power system in which the various components of power system are represented by their approximate or simplified equivalent circuits. The impedance diagram is used for load flow studies.
13.	**What is reactance diagram?** The reactance diagram is the simplified equivalent circuit of power system in which the various components are represented by their reactance. The reactance diagram can be obtained from impedance diagram if all the resistive components are neglected. The reactance diagram is used for fault calculations.
14.	**What are the approximations made in impedance diagram? (Nov/Dec 2018, April 2019).** i) The neutral reactance are neglected ii) Shunt branches in the equivalent circuits of transformers are neglected iii) The resistance are neglected. iv) All static loads

	and induction motors are neglected. v) the capacitance of the transmission lines are neglected
15.	**Give equations for transforming base KV on LV side to HV side of transformer.** $\text{Base KV on HT side} = \text{Base KV on LT side X } \frac{\text{HT voltage rating}}{\text{LT voltage rating}}$ $\text{Base KV on LT side} = \text{Base KV on HT side X } \frac{\text{LT voltage rating}}{\text{HT voltage rating}}$ LT **-** Low Tension or Low Voltage HT- High Tension or High Voltage
16.	**What is bus?** The meeting point of various components in a power system is called as bus. The bus is a conductor made of copper or aluminum having negligible resistance. The buses are considered as points of constant voltage in a power system.
17.	**What are the disadvantages of per unit system?** The disadvantages of per unit system are some equations that hold in the unscaled case are modified when scaled into per unit factors such as √3 and 3 are removed or added in this method. Equivalent circuits of the components are modified making them somewhat more abstract. Sometimes these shifts that are clearly present in the unscaled circuit vanish in per unit circuit.
18.	**What are the methods available for forming bus impedance matrix?** (i) Form the bus impedance matrix and then take its inverse to get bus impedance matrix. (ii) Directly from the bus impedance matrix from the reactance diagram. This method utilizes the techniques of modifications of existing bus impedance matrix due to addition of new bus.
19.	**What are the representations of loads? (May 2014)** i) Constant power representation ii) Constant current representation iii) Constant impedance representation
20.	**What are the advantages of per unit system? (May 2011)**

	a) Calculations are simple. b) It will be convenient for analysis of power system if the voltage, power, current and impedance ratings of components of power system are expressed with reference to a common value called base value
21.	**Draw a simple per-phase model for a cylindrical rotor synchronous machine. May 2011)** 
22.	**If the reactance in ohms is 15, find the p.u value for a base of 15KVA an 10KV? (May 2012)** $$Z(pu) = \frac{Z \times MVA_b}{KV_b^2} = \frac{15\ \times 15}{10^2} = 2.25$$
23.	**Draw the equivalent circuit of a three winding transformer. (Nov 2012, May 2013)** 
24.	**What is meant by percentage reactance? (May 2013)** Percentage reactance of a transformer (or in general, a circuit) is the percentage of phase voltage drop when full load current flows through it, i.e %X= (I X / V)*100.
25.	**What are the functions of Modern power system? (Nov 2013)** The modern power system is a network of electric components which is used to supply (generating station), transmit (transmission system) and distribute

	(distribution system) the electrical power.
26.	**Name the diagonal and off diagonal elements of bus impedance matrix. (Nov2013)** The diagonal elements are called as driving point impedances and off diagonal elements are called as transfer impedances.
27.	**Draw the impedance diagram for the given single line representation of the power system (May 2014).**  
28.	**What are the main divisions of Power System?(Nov 2014)** The main divisions of power systems are :i) Generation ii) Transmission and iii) Distribution.
29.	**What is meant by base quantities in per unit representation? (April 2019)** In the power systems analysis field of electrical engineering, a per-unit system is the expression of system quantities as fractions of a defined base unit quantity. Calculations are simplified because quantities expressed as per-unit do not change when they are referred from one side of a transformer to the other.
30.	**Define bus incidence matrix. (Nov/Dec 2019) (Nov/Dec 2020)** In singular transformation method to find the Y_{bus} the matrix is derived In general $Y_{bus} = [A] [Y_{primitive}] [A]^T$ Where A is defined as the bus incidence matrix.
31.	**Give the representation of an off nominal transformer in power system.**

Nov/Dec 2020)

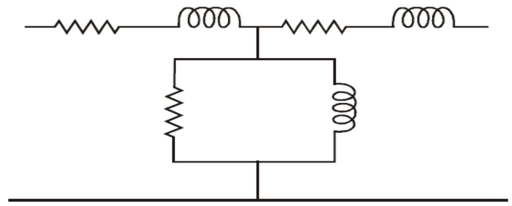
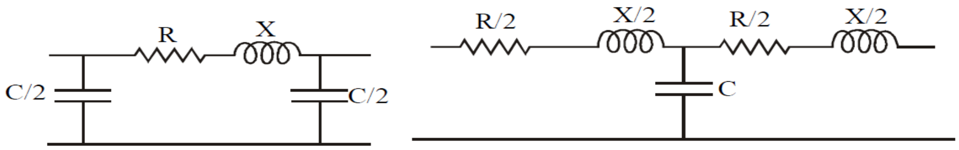


Figure 1.3 (b) Transformer



(i) π-Representation (ii) T-Representation

UNIT – II POWER FLOW ANALYSIS

<u>PART – A</u>

1. **What is power flow study or load flow study? (Nov 2014)**

The study of various methods of solution to power system network is referred to as load flow study. The solution provides the voltages at various buses, power flowing in various lines and line-losses.

2. **What is the need for load flow study? (Nov 2015, May 2016 & Nov 2017, Nov 2020)**

The load flow study of a power system is essential to decide the best operation of existing system and for planning the future expansion of the system. It is also essential for designing a new power system.

3. **What are the different types of buses in a power system?(May 2016, Nov 2017 & Dec 2021)**

The buses of a power system can be classified into three types based on the quantities being specified for the buses. The different types of buses are,(i) Load bus or PQ bus (ii)Generator bus or voltage controlled bus or PV bus(iii)Slack bus (or) swing bus (or) reference bus.

4. **When the generator bus is treated as load bus? (Nov 2013, May 2014, Nov 2015, Nov 2018, Nov 2020)**

If the reactive power of a generator bus violates the specified limit, then the generator bus is treated as a load bus. The reactive power of that particular bus is

	equated to the limit it has violated and the previous iteration value of bus voltage is used for calculating current iteration value.
5.	**What are the advantages and disadvantages of G-S method?** **Advantages:** i) Calculations are simple, so the programming task is less ii) the memory requirement is less iii) Useful for small systems **Disadvantages:** i) Requires large number of iterations to reach convergence. ii) Not suitable for large systems iii) Convergence time increases with size of the system
6.	**What are the advantages and disadvantages of N-R method? (Nov/Dec 2019)** **Advantages:** i) The N-R method is faster, more reliable and the results are accurate ii) Requires less number of iterations for convergence. iii) The number of iterations is independent of the size of the system.vi) Suitable for large size system. **Disadvantages:** i) Programming is more complex ii) The memory requirement is more iii) Computational time per iteration is higher due to large number of calculations per iteration.
7.	**How the disadvantages of N-R method are overcome?** The disadvantages of large memory requirement in NR method can be overcome by decoupling the weak coupling between P- δ and Q-V (i.e using de coupled load flow algorithm). The large computational time per iteration can be reduced by simplifying the decoupled load flow equations. The simplifications are made based on the practical operating conditions of a power system.
8.	**How are the diagonal elements of Y_{bus} known as?** The diagonal elements of Y_{bus} are known as the short circuited driving point admittance or self-admittance of the buses.
9.	**State the major steps involved in load flow studies?** The major steps involved in load flow studies are i) Mathematical modeling of the power system; this would be a set of non-linear algebraic equations. ii) Solution of the non-linear equations through an iterative technique.
10.	**Why acceleration factor is used in the G-S method? (May 2018)**

	The acceleration factor is used in G-S method to increase the rate of convergence of the iterative process. The value of acceleration factor varies from 1.2 to 1.6.
11.	**What is the need of load flow solution?** The load flow solution is essential for designing a new power system and for planning extension as well as operation of the existing one for increased power demand.
12.	**What is load bus?** A load bus is one at which the active power and reactive power are specified. In this bus, its voltage can be allowed to vary within permissible values. i.e ±5%. Also bus voltages phase angle is not very important for the load.
13.	**How the convergence of N-R method is speeded up?** The convergence of N-R method is speeded up using fast decoupled load flow (FDLF) method. In FDLF, the weak coupling between P-V and Q- δ are decoupled and the equations are further simplified equations are further simplified using the practical operating conditions of the power system.
14.	**What are the advantages of decoupled method over N-R method?** i) This method is simple and computationally efficient than the N-R method. ii) It requires less memory compared to N-R method.
15.	**What is the need for voltage control in a power system?** The various components of a power system (or equipments connected to power system) are designed to work satisfactorily at rated voltages. If the equipments are not operated at rated voltages then the performance of the equipments will be poor and the life of the equipments will reduce. Hence the voltages at various points in a power system should be maintained at rated value (specified value)
16.	**How the reactive power of a generator is controlled?** The reactive power of a generator is controlled by varying the magnitude and phase of induced emf, which in turn varied by varying excitation. For an increase in reactive power the magnitude of induced emf is increased and its phase angle is decreased. For a reduction in reactive power the magnitude of induced emf is

	decreased and its phase angle is increased.
17.	**What is Slack or swing bus? (May 2011, Nov/Dec 2019, April 2019).** A bus is called swing bus when the magnitude and phase of bus voltage are specified for it. The swing bus is the reference bus for load flow solution and it is required for accounting line losses. Usually one of the generator bus is selected as the swing bus.
18.	**What is Jacobian matrix? How the elements of Jacobian matrix are ermined?(May 2011, Nov 2016)** The matrix formed the first order derivatives of load flow equations is called Jacobian matrix (J).The elements of Jacobian matrix will change in every iteration. In each iteration the elements of this matrix are obtained by partial differentiating the load flow equations with respect to an unknown variable and then calculating the first derivatives using the solution of previous iteration.
`19.	**What are the information that are obtained from a power flow study? (May2012, April 2019)** Power flow or load flow study is used to find the state variables of the power system. the state variables of the power systems are voltage magnitude and angle. By using this value the power flows in various lines and the losses are calculated.
20.	**Compare Gauss-Seidal and Newton Raphson methods of load flow solutions. (May 2012, Nov 2015 & May 2017)**

S. N	Gauss Seidal	Newton Raphson
1.	Reliable	More reliable
2.	Require large number of iterations to reach convergence. It has linear convergence characteristics	Faster. Require less number if iteration to reach convergence It has quadratic convergence characteristics.
3.	Programming task is less	Programming is more complex.
4.	Suitable for small size system and not suitable for large system.	Suitable for large size system. Number of iterations does not

			Number iterations increases with increase in size.	depend on size of the system.
		5.	Memory required is less	Memory required is more.

21.	**Why power flow analysis is made? (Nov2012)** Power flow analysis is performed to calculate the magnitude and phase angle of voltage at the buses and also the active power and reactive volt amperes flow for the given terminal or bus conditions. The variables associated with each bus or node arei) magnitude of voltage (v) ii) phase angle of voltage (δ) iii) active power (P) iv) reactive volt amperes (Q).
22.	**What is acceleration factor? (Nov2012, May 2013 & Dec 2021)** The acceleration factor is a numerical multiplier which is used to increase the rate of convergence in an iterative process. The previous value at the bus is multiplied by the acceleration factor to obtain a correction to be added to previous values.
23.	**What is the need of slack bus? (May 2013, May 2014, Nov 2016, Nov 2018, May 2018) (Nov/Dec 2020)** The slack bus is needed to account for transmission line losses. In a power system, the total power generated will be equal to sum of power consumed by loads and losses. In a power system only the generated power and load power are specified for buses. The slack bus is assumed to generate the power required for losses. Since the losses are unknown the real and reactive power are not specified for slack bus .They are estimated through the solution of load flow equations.
24.	**Why do Y_{Bus} used in load flow study instead of Z_{Bus}? (Nov 2013)** Y_{bus} is sparse matrix ie. zero elements are more. So that the no of equations need to be solved to obtain the power flow solution is less compared to using a Z_{bus} (full matrix). Using Y_{bus} matrix is occupying less memory than using the Z_{bus} matrix.
25.	**Define voltage controlled bus (Nov 2014)** These are the buses where generators are connected. Therefore the power generation in such buses is controlled through a prime mover while the terminal voltage is controlled through the generator excitation. Keeping the input power

	constant through turbine-governor control and keeping the bus voltage constant using automatic voltage regulator, we can specify constant P_{Gi} and $\|V_i\|$ for these buses. This is why such buses are also referred to as P-V buses. It is to be noted that the reactive power supplied by the generator Q_{Gi} depends on the system configuration and cannot be specified in advance. Furthermore we have to find the unknown angle δ_i of the bus voltage.
26.	**Why is Bus impedance matrix preferred for fault analysis? (May 2015) (or) The Z- bus method is very suitable for fault studies rather than Y bus. Why? (Nov/Dec 2020)** Bus impedance matrix is preferred for the fault analysis because fault analysis required full matrix for calculating line flows in all the lines. The admittance matrix is sparse in nature, so it is not preferred for fault analysis.
27.	**Write the quantities that are associated with each bus in a system. (May 2017)**

Bus type	Quantities specified	Quantities to be obtained
Slack bus	**|V|, δ**	P,Q
Load bus	P,Q	**|V|, δ**
Generator bus	P, **|V|**	Q, **δ**

UNIT – III FAULT ANALYSIS - BALANCED FAULT

PART – A

1.	**What is Short Circuit MVA and how it is calculated? (May 2015, Nov 2016 & Dec 2021)** The short circuit capacity or the short circuit MVA at a bus is defined as the product of the magnitudes of the rated bus voltage and the fault current. S.C MVA capacity of the circuit breaker = √ 3 x pre fault voltage in KV x S.C current in KA.
2.	**How the shunt and series fault are classified? (Nov, 2016)**

	SERIES FAULT: (a) One open conductor fault (b) Two open conductor fault SHUNT FAULT: (a) Symmetrical or balanced fault (i) Three phase Fault (LLLG) (b) Unsymmetrical or unbalanced fault (i) Line to line fault (LL) (ii) Line to ground fault (LG) (iii) Double line to ground fault. (LLG).
3.	**What are the factors to be considered for selecting the C.B.?** The factors to be considered in selecting a circuit breaker for a protection scheme are: Normal operating voltage, Momentary, interrupting current. Speed of the breaker and S.C interrupting MVA.
4.	**What you mean by symmetrical faults? (Nov 2014, May 2016, Nov 2017, May 2018, Nov/Dec 2019).** The fault is called symmetrical fault if the fault current is equal in all the phases and the phase difference between any two phases is equal. A symmetrical fault is a fault where all phases are affected so that the system remains balanced
5.	**What you mean by doubling effect?** If a symmetrical fault occurs when the voltage wave is going through zero then the maximum momentary short circuit current will be double the value of maximum symmetrical short circuit current. The first peak of the resultant current will become twice the peak value of the final steady current. This effect is called as doubling effect.
6.	**What you mean by transient and sub transient reactance? (May 2018)** X_d'(transient reactance) is the ratio of no load emf and the transient symmetrical r.m.s current. X_d''(sub transient reactance) is the ratio of no load emf and the sub transient symmetrical r.m.s current.
7.	**What is the application of transient reactance?** The transient and sub transient reactance helps in calculating the interrupting and maximum momentary short circuit currents.
8.	**Give the various assumptions made for fault analysis. (May 2018, April 2019)** The assumptions made in analysis of faults are: i) Each synchronous machine

	model is represented by an e.m.f behind a series reactance ii) In the transformer models the shunt that account for core loss and magnetizing components are neglected.iii) In the transmission line models the shunt capacitances are neglected. iv)All series resistances in generators, transformers, lines are neglected. v) In the normal operating conditions the pre fault voltage may be considered as 1.0 p.u.vi) Load impedances are neglected; hence the pre fault system may be treated as unloaded. vii) As the pre fault currents are much smaller than the post fault currents the pre fault currents can be neglected.
9.	**Name any methods of reducing short circuit current.** By providing neutral reactance and by introducing a large value of shunt reactance between buses.
10.	**What is the reactance used in the analysis of symmetrical faults on the synchronous machines as its equivalent reactance.** i) Sub transient reactance X_d'' ii) Transient Reactance X_d' iii) Synchronous reactance X_d
11.	**11. What is synchronous reactance?** It is the ratio of induced emf and the steady state r.m.s current. $X_d = E_g / I$ It is the sum of leakage reactance and the armature reaction reactance. It is given by $X_d = X_l + Xa$, Where, X_d = Synchronous reactance. X_l= Leakage reactance & X_a = Armature reaction reactance.
12.	**What are the causes of fault in power system. (May 2015)** A fault may occur on a power system due to a number of reasons. Some of the causes are (i)Insulation failure of the system, (ii) Falling of a tree along a line, (iii) Wind and ice loading on the transmission lines, (iv)Vehicles colliding with supporting structures, (v) Overloading of underground cables, (vi)Birds shorting the lines.
13.	**Name the main differences in representation of power system for load flow and short circuits studies**

S.N	Load flow studies	Short circuit studies
1	The resistances and reactances are considered	The resistances are neglected
2	To solve load flow analysis, the bus admittance matrix is used	To solve load flow analysis, the bus impedance matrix is used
3	It is used to determine the exact voltages and currents	Prefault voltages are assumed to be 1 p.u and the prefault current can be neglected

14. What is the reason for transients during short circuits?

The fault or short circuits are associated with sudden change in currents. Most of the components of the power system have inductive property which opposes any sudden change in currents and so the faults (short circuit) are associated with transients.

15. What is the significance of transient reactance in short circuit studies? (May 2017)

The transient reactance is used to estimate the transient value of fault current. Most of the circuit breakers open their contacts only during this period. Therefore, for a circuit breaker used for fault clearing, its interrupting short – circuit rating should be less than the transient fault current.

16. What is the significance of sub - transient reactance in short circuit studies? (May 2017, Nov 2018, Nov 2020)

The sub - transient reactance is used to estimate the initial value of fault current immediately on the occurrence of the fault. The maximum momentary short circuit current rating of the circuit breaker used for protection or fault clearing should be less than this fault clearing value.

17. How to conduct fault analysis of a power system network?

The fault current and voltages in the various part of the system can be determined by any one of the following methods: By using KVL & KCL method, using equivalent circuit representation and by using bus impedance matrix

18.	**What is meant by fault calculations? (May 2018)** The fault condition of a power system can be dived into sub transient, transient and steady state periods. The currents in the various parts of the system and in the fault are different in these periods. The estimation of these currents for various types of faults at various locations in the system are commonly referred as fault calculations.
19.	**Mention the objectives of short circuit studies or fault analysis. (May 2011, Nov 2012, Nov2014, Nov 2016, Nov 2018 & Dec 2021) (or) What is the need of short circuit analysis? (Dec 2019).** The short circuit studies are essential in order to design or develop the protective schemes for various parts of the system. The protective scheme consists of current and voltage sensing devices, protective relays and circuit breakers. The selection or proper choice of these mainly depends on various currents that may flow in the fault conditions.
20.	**Write down the balanced and unbalanced faults occurring in a power system. (May 2011)** BALANCED FAULT:3 phase short circuit fault UNBALANCED FAULT: Single line to ground fault, line to line fault and double-line to ground fault.
21.	**Distinguish symmetrical and unsymmetrical fault. (Nov 2012, May 2013)** The fault is called Symmetrical fault if the fault current is equal in all the phases.eg. 3ϕ short circuit fault. The fault is called unsymmetrical fault if the fault current is not equal in all the three phases. eg. i) single line to ground fault ii) line to line fault iii) double line to ground fault iv) open conductor fault
22.	**What is meant by fault level? (May 2013, April 2019) (Nov/Dec 2020)** It relates to the amount of current that can be expected to flow out of a bus in to a 3 phase fault. Fault level in MVA at bus $i = V_{i\,pu\,nominal} * I_{i\,pu\,fault} * S_{3\phi\,base}$.
23.	**Give the frequency of various faults occurrence in ascending order (Nov 2013, May 2014 & May 2017)**

Types of Faults	Relative Frequency of Occurrence of Faults
3 phase fault	5%
Double Line to Ground Fault	10%
Line to Line Fault	15%
Single Line to Ground Fault	70%

24. Define bolted fault. (May 2014, May 2016 & Nov 2017, Nov 2020)

A fault represents a structural network change equivalent with that caused by the addition of impedance at the place of the fault. If the fault impedance is zero, then the fault is referred as **bolted** or **solid fault**.

25. For a system, the bus impedance matrix was found to be Z= $j\begin{bmatrix} 0.0450 & 0.0075 & 0.030 \\ 0.0075 & 0.06375 & 0.030 \\ 0.030 & 0.030 & 0.0210 \end{bmatrix}$**. The impedances are in pu. A three phase symmetrical fault occurs at bus 3 through a fault impedance of Z_f = j0.19 pu. Find out the post fault voltage at bus 2 assuming zero prefault current. (May 2015).**

Solution: $I_k(F) = \dfrac{V_k(0)}{Z_{kk} + Z_f}$

$$I_3(F) = \frac{V_k(0)}{Z_{33} + Z_f} = \frac{1\angle 0°}{j0.0210 + j0.19} = -j4.7393$$

The post fault voltage, $V_2(0) - Z_{23} I_3(f) = 1\angle 0° - (j0.06375)(-j4.7393) = 1 - 0.302 = 0.698\,pu$

26. What is direct axis reactance? (Dec 2015)

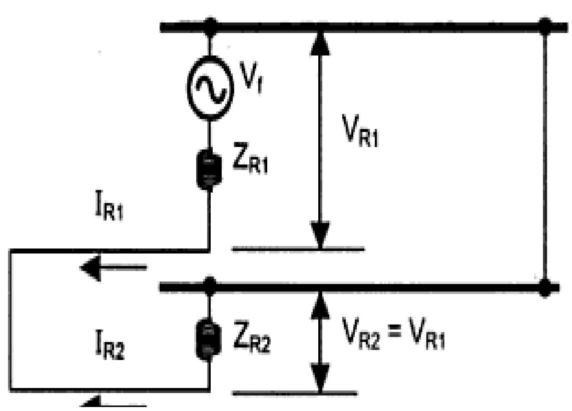
The direct axis is defined as the direction along the rotor that the field winding current causes magnetic flux to flow and also it is defined as the reactance offered to the armature flux when the peak of armature mmf is directed along the direct axis. Under this condition, the air gap length is minimum and hence the reluctance is also minimum.. X_d - direct axis reactance.

27. For a fault at a given location, rank the various faults in the order of severity. Nov 2020)

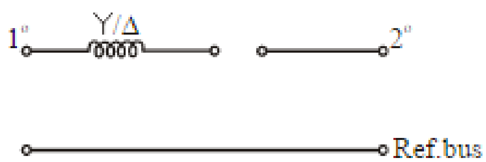
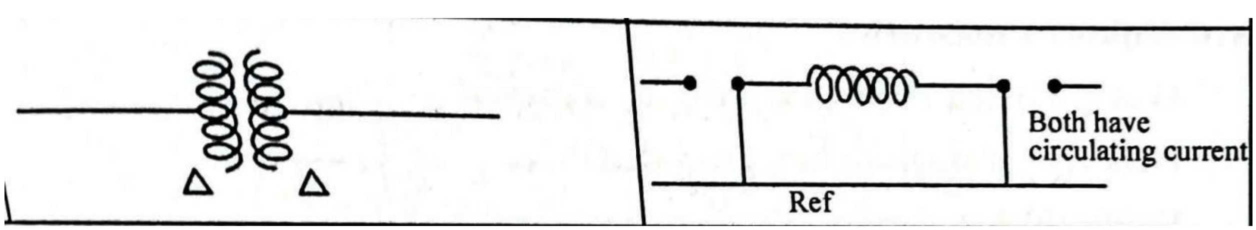
	The rank of the faults based on the severity is listed below, • Three phase symmetrical fault • Double line to ground fault • Line to line fault • Single line to ground fault
28.	**Write the four ways of adding an impedance to an existing system so as to modify Z_{Bus} matrix. (April 2019).** 1. Adding a branch of impedance Z_b from a new bus p to the reference bus. 2. Adding a branch of impedance Z_b from a new bus p to an existing bus. 3. Adding a branch of impedance Z_b from an existing bus q to the reference bus. 4. Adding a branch of impedance Z_b between two existing buses p and q.

UNIT – IV FAULT ANALYSIS –UNBALANCED FAULT PART – A (C301.4)	
1.	**Name the faults involving ground.** The faults involving ground are: single line to ground fault ii) double line to ground fault iii) Three phase fault
2.	**Define positive sequence impedance. (Nov/Dec 2019).** The positive sequence impedance of equipment is the impedance offered by the equipment to the flow of positive sequence currents.
3.	**In which fault the negative and zero sequence currents are absent? (April 2019)** In three phase fault the negative and zero sequence currents are absent.
4.	**What are the boundary condition in line-to-line fault?** The boundary condition for the line-to-line fault between the phases b and c is given below, $I_a=0$; $I_b+I_c=0$; $V_b=V_c$
5.	**Write down the boundary condition in double line to ground fault?** The boundary condition for the double line-to ground fault between the phases b and c to the ground is given below, $I_a=0$; $V_b=0$; $V_c=0$
6.	**Give the boundary condition for the 3-phase fault.**

	The boundary condition for the symmetrical three phase fault between tall the three phases given below, $I_a + I_b = I_c=0$; $V_a=V_b=V_c=0$
7.	**Name the fault in which positive, -ve and zero sequence component currents are equal. (May 2012)** In single line to ground fault the +ve, -ve and zero sequence component currents are equal.
8.	**Write a short notes on Zero sequence network.** The impedance or the reactance diagram formed by using zero sequence impedance is called Zero sequence network.
9.	**Write a short notes on negative sequence network.** The impedance or the reactance diagram formed by using negative sequence impedance is called Negative sequence network.
10.	**Write a short notes on positive sequence network.** The impedance or the reactance diagram formed by using positive sequence impedance is called Positive sequence network.
11.	**How will you express positive, negative and zero – sequence impedances of Y – connected loads?** Positive sequence impedance $Z^1 = Z_s + 3Z_n + 2Z_m$. Negative sequence impedance $Z^2 = Z_s - Z_m$ Zero sequence impedance $Z^0 = Z_s - Z_m$ Where, Z_s = self impedance of Y – connected load, Z_n= load neutral impedance Z_m = Mutual impedance.
12.	**Define unsymmetrical fault.** The fault is called unsymmetrical fault if the fault current is not same in all the three phases. It is also called as asymmetrical fault is defined as a fault that affects one or two phases of a three-phase system
13.	**What is sequence network? (May 2011, Nov 2014)** The network which is used to represent the positive, negative and zero sequence components of unbalanced system is called as sequence network
14.	**What are the symmetrical components of a three phase system? (May 2011, Nov**

	2012, Nov 2014, Nov 2015, May 2016 & Nov 2018) The symmetrical components are used to represent unbalanced quantities, they are 1) Positive sequence 2) negative sequence 3) Zero sequence
15.	**What is meant by a Fault? (May 2012)** A fault in a circuit is any failure which interferes with the normal flow of current .The faults are associated with abnormal change in current, voltage and frequency of the power system. The faults may cause damage to the equipment if it is allowed to persist for a long time.
16.	**List the various symmetrical and unsymmetrical faults in a power system. (May 2012, Nov/Dec 2019).** **Symmetrical fault:** 3 phase short circuit fault. **Unsymmetrical fault:** i) single line to ground fault ii) line to line fault iii) double line to ground fault iv) open conductor fault
17.	**Define negative sequence impedance? (May 2013)** The negative sequence impedance of an equipment is the impedance offered by the equipment to the flow of negative sequence current.
18.	**Draw the sequence network connections corresponding to L-L fault at bus. (May 2013 & Dec 2021)** 
19.	**What are the observations made from the analysis of various faults? (Nov 2013 & Dec 2021)** i) To check the MVA ratings of the existing circuit breakers, when new generation are added into a system; ii) To select the rating for fuses, circuit breaker and switch gear in

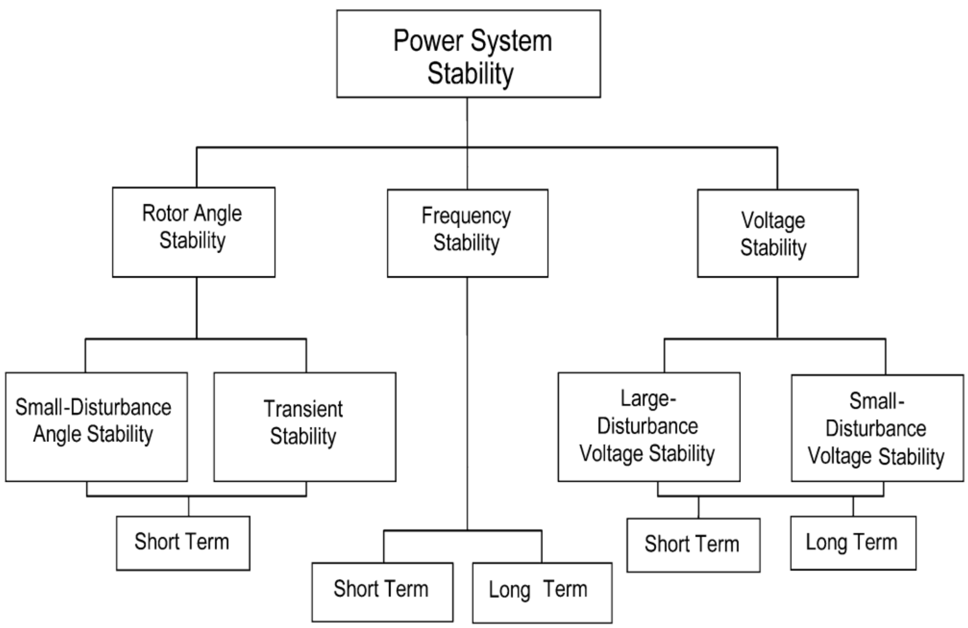
	addition to setting up of protective relays; iii) To determine the magnitudes of currents flowing throughout the power system at various time intervals after a fault occurs.
20.	**Write the boundary conditions for single line to ground fault. (Nov 2013)** The boundary condition for the single line to ground fault between the phase a to the ground is given as, Va = 0; $I_b=I_c=0$
21.	**What are the features of zero sequence current?(May 2014 & Nov 2017)** As zero sequence currents in three phases are equal and of same phase, three systems operate like single phase as regards zero sequence currents. Zero sequence currents flow only if return path is available through which circuit is completed.
22.	**Write the symmetrical component current of phase 'a' in terms of 3ϕ currents. (May2016, Nov 2018)** $I_{a0} = \frac{1}{3}[I_a + I_b + I_c]$ $I_{a1} = \frac{1}{3}[I_a + aI_b + a^2I_c]$ $I_{a2} = \frac{1}{3}[I_a + a^2I_b + aI_c]$
23.	**State the reason why, the negative sequence impedance of a transmission line is taken as equal to positive sequence impedance of the line. (May 2015).** A transmission line is a passive and bilateral device. By passive, we mean there are no voltage or current sources present in the equivalent model of a transmission line. Bilateral means the line behaves the same way regardless of the direction of the current. Note that although a single transmission line is bilateral. Because of a transmission line's passive and bilateral properties, the phase sequence of the applied voltage makes no difference, as a-b-c (positive-sequence) voltages produce the same voltage drops as a-c-b (negative-sequence) voltages. This means that the positive- and negative-sequence impedances of a transmission line are identical, provided that the line is transposed.
24.	**What is sequence Operator? (Nov 2015)** In balanced problem, to find the relationship between phase voltages and phase currents, we use sequence operator. An operator which will turn a phasor through 120 degree in three phase problems. This operator is called as ' a ' operator.
25.	**Why the neutral grounding impedance Z_n appears as $3Z_n$ in zero sequence equivalent circuit? (Nov 2016)** If the neutral of a transformer is grounded through a grounding impedance $\bar{Z}$ n, then, the

	total zero-sequence equivalent impedance to be used in the equivalent circuit is $\bar{Z}0$ total $= \bar{Z}0 + 3\bar{Z}n$. This is due to the fact that the neutral current is 3 times the zero-sequence current per phase.
26.	**Express the unbalanced voltages in terms of symmetrical components. (May 2017)** $V_a = [V_{a0} + V_{a1} + V_{a2}]$ $V_b = [V_{a0} + aV_{a2} + a^2V_{a1}]$ $V_c = [V_{a0} + a^2V_{a2} + aV_{a1}]$ Where, V_a, V_b, V_c– Unbalanced phase voltages V_{a0}, V_{a1}, V_{a2} – Symmetrical components of phase'a'
27.	**Draw the zero-sequence network of Y/Δ transformer with neutral ungrounded. (May 2017)** 
28.	**Explain the concept of sequence impedances and sequence networks.** Sequence impedances and sequence networks are the fault analyzing and calculating parameters in power system networks. Sequence impedances are of three types. They are positive, negative and zero sequence impedances. The sequence impedances are the impedances offered by the device or components to respective sequence current. The single phase equivalent circuit of power system formed using impedance of any one sequence only is called sequence circuit or sequence network.
29.	**Draw the zero sequence impedance equivalent circuit for Δ-Δ type three phase transformers. April 2019** 
30.	**What are the advantages of symmetrical components? (Nov/Dec 2020)** Symmetrical components are balanced phasor. They are used to represent the unbalanced

	phasor. Very complex unbalanced phasor analysis can be performed easily by using symmetrical components. Systematic computer analysis is possible using symmetrical components.
31.	**Name the faults in which zero sequence currents are absent. (Nov/Dec 2020)** The faults in which zero sequence currents are absent are Line-to-Line fault and Three-phase fault.

UNIT–V STABILITY ANALYSIS **PART – A (C301.5)**	
1.	**Define Dynamic stability of a power system.** Dynamic stability is the stability given to an inherently unstable system by automatic control devices and this dynamic stability is concerned with small disturbances lasting for times of the order of 10 to 30 seconds.
2.	**Define the inertia constants M & H.** Angular momentum (M) about a fixed axis is defined as the product of moment of inertia about that axis and the associated angular velocity. M = I. ω watt/rad/Sec^2.Inertia constant (H) is the K.E in Mega joules to the three phase MVA rating of the machine.
3.	**Define load angle of a generator**. Load angle:- This is the angle between the generated e.m.f or the supply voltage (E) and the terminal voltage. This angle is also called as torque or power angle of the machine.
4.	**State equal area criterion of stability. (May 2017 & Nov 2017), Nov/Dec 2019** The system is stable if the area under accelerating power (Pa) - δ curve reduces to zero at some value of δ. In other words, positive area under Pa -δ curve must be equal to the negative area and hence the name equal area criterion of stability.
5.	**What are limitations of equal area criterion?** The limitations of equal area criterion are: i) The critica clearing time cannot be calculated even though the critical clearing angle is known. Hence numerical methods

	such as Runge-kutta method, point by point or Euler's method are employed. ii) It's a more simplified approach.
6.	**If two machines with inertia's H_1, H_2 are swinging together, what will be the inertia of the equivalent machine?** $$H_s = \frac{H_1 G_1 + H_2 G_2}{G_s}$$ H_1 and H_2 is the Inertia constant of M_1 and M_2; G_1 and G_2 is the capacity of M_1 and M_2. H_s is the equivalent inertia of M_1 and M_2 ; G_s is the equivalent capacity of M_1 and M_2.
7.	**On what basis do you conclude that the given synchronous machine has lost stability?** Following a sudden disturbance on a power system rotor speeds, rotor angular differences and power transfer undergo fast changes whose magnitude is dependent on the severity of the disturbance. If these disturbances leads to growing oscillations in the power system even after some period of time say more than 30 seconds then system said are in asynchronous state and it has lost synchronism.
8.	**On what a factor does the critical clearing angle depends.** The critical clearing angle depends upon the clearing time, which depends upon auto closing/reclosing and opening of circuit breakers.
9.	**Define steady state stability limit. (Nov 2014), Nov/Dec 2019.** It is the maximum power that can be transferred without the system becoming unstable when the system is subjected to small disturbances.
10.	**Mention methods of improving stability limit. (Nov 2016, Nov 2018, Nov 2020 & Dec 2021)** The steady state stability limit can be increased by i) Reducing the X, in case of transmission lines by using double circuit lines. ii) Use of series capacitors to get better voltage. iii) Higher excitation systems and quick excitation system are employed. The following methods are employed to increase the transient stability limit of the power system- (i)Increase of system voltages, (ii) use of AVR. (iii) Use of High speed excitation systems. (iv) Reduction in transfer reactance. (v) Use of high speed reclosing breakers.

11.	**A 50Hz, 4 pole turbo alternator rated at 20 MVA, 13.2 KV has as inertia constant H = 4 KW –sec/ KVA. Find the K.E stored in the rotor at synchronous speed. (Dec 2021)** F = 50Hz. P = 4, G = 20 MVA, H = 4 KW – Sec/ KVA. Stored K.E = 4 x 20 = 80MJ.
12.	**Mention the methods used for the solution of swing equation.** Methods used for solution of swing equation are: Point by point method, Modified Euler's method and Runge-kutta method.
13.	**How is the power system stability classified? (May 2015)** 
14.	**What are Coherent Machines? (Nov 2018, Nov 2020)** Two synchronous machines with similar parameters swinging together are called as coherent machines. This is very much used in multi machine stability analysis.
15.	**What are the applications of equal area criterion?** (i) Switching operation. (ii) Fault and subsequent circuit isolation. (iii) Fault, circuit isolation and reclosing
16.	**What are the classifications of angle stability?** Small signal stability (steady state) and transient stability (large signal).Small signal is further classified as Oscillatory and Non oscillatory stability. Oscillatory includes Inter

	area mode, control mode and Torsional mode
17.	**Define critical clearing angle and time? (May 2011, May 2012, Nov 2012, Nov 2014, May 2015, April 2019) or State the significance of critical clearing time. Nov/Dec 2020)** **<u>Critical clearing angle 'δ_c':</u>** The critical clearing angle is defined as the maximum change in the load angle curve before clearing the fault without loss of synchronism. In other words, when the fault occurs in the system the load angle curve begin to increase, and the system becomes unstable. The angle at which the fault becomes clear and the system becomes stable is called critical clearing angle. **<u>Critical clearing time 't_c':</u>** If any fault occurs in a system, which leads to increase in the load angle, and if it is not cleared before critical clearing time, then the system becomes unstable. The time at which the fault becomes clear before losing the synchronism is nothing but critical clearing time.
18.	**Write swing equation (May 2011)** $P_m - P_e = M d^2\delta/dt^2$ Where, P_{m-} Input Mechanical power, P_{e-} output electrical power, M- Angular momentum
19.	**Define transient stability and stability limit. (May 2012, Nov 2017, May 2018)** The **transient stability** is defined as the ability of a power system to return to stable operation when it is subjected to a large disturbance. The maximum power that can be transferred through the system during a very large disturbance without loss of synchronism is called **transient stability limit**.
20.	**Distinguish between steady state and transient state stability. (Nov 2012)** Steady state stability is basically concerned with the ability of the system to restore back to its stable state upon a small disturbance whereas the transient stability is concerned with large disturbances.

21.	**What is meant by power angle curve? (May 2013 & Nov 2015)** The graphical plot of real power versus power/torque angle is called as power angle curve. $P_e = P_m \sin \delta$. $P_m = E_1E_2 / X$.
22.	**Define Infinite bus in power system. (Nov 2012 & May 2013), April 2019** The capacity of a system comprising of many machines is so large, that its voltage & frequency may be taken as constant. The connection or disconnection of a single machine does not change the |V| and frequency. Such a constant voltage and frequency system is called as Infinite bus.
23.	**Differentiate between voltage stability and rotor angle stability. (Nov 2013, Nov 2016)** Voltage stability is the ability of a power system to maintain steady acceptable voltage at all buses in the system under normal operating conditions and after being subjected to a disturbance. Rotor angle stability is the ability of interconnected synchronous machines of a power system to remain in synchronism.
24.	**Define swing curve? What is the use of this curve? (Nov 2013, May 2017)** A graph of power angle 'δ' versus time 't' in seconds is called **swing curve**. The stability of the machine is calculated by using swing curve. This curve is obtained by solving the swing equation of the machine. The critical angle and critical clearing time is calculated by using swing curve.
25.	**Define dynamic stability (May 2014)** The dynamic stability study is concerned with the study of nature of oscillations and its decay for small disturbances.
26.	**Find the frequency of oscillation for a synchronizing co-efficient of 0.6, inertia constant H= 4 and system frequency of 50 Hz. (May 2014)** Frequency of oscillation = $\sqrt{\frac{C}{M}}$; $M = \frac{H}{\pi f} = \frac{4}{\pi \times 50} = 0.0255$ p.u

	Frequency of oscillation = $\sqrt{\frac{0.6}{0.0255}} = 4.85\,\frac{rad}{sec} = \frac{4.85}{2\pi} = 0.7719\ Hz$
27.	**A four pole , 60 Hz synchronous generator has a rating of 200 MVA, 0.8 power factor lagging. The moment of inertia of the motor is 45,100kg-m^2. Determine M and H. (Nov 2015)** **Solution.** **Ns=** $\frac{120f}{p}$ **= 1800rpm,** **n_s= Ns/60 = 30 rps, ω_s = 2$\pi$$n_s$= 188.4** **Kinetic Energy=**$\frac{1}{2}J\omega_s^2$ **=** $\frac{1}{2}x45000x188.4^2 = 798627600J = 798.62MJ$ **Inertia Constant H =**$\frac{KE}{G} = \frac{798.62}{200} = 3.99.MJ/MVA$ **M=**$\frac{GH}{180xf} = \frac{KE}{180xf} = \frac{798.62}{180x60} = 0.073946MJ\sec/Electrical\deg ree$
28.	**Define Rotor angle stability. (Nov/Dec 2020)** Rotor angle stability is the ability of the interconnected synchronous machines running in the power system to remain in the state of synchronism. Two synchronous generators running parallel and delivering active power to the load depends on the rotor angle of the generator (load sharing between alternators depends on the rotor angle).