UNIT 1
INTRODUCTION
PART A

1. Explain the requirements of planning the operation of a power system.

Planning the operation of a power system requires load studies, fault calculations, the design of means for protecting the system against lightning and switching surges and against short circuits, and studies of the stability of the system.

2. Define steady state operating condition.

A power system is said to be in a steady state operating condition, if all the measured(or calculated) physical quantities describing the operating condition of the system can be considered constant for the purpose of analysis

.

3. What is a disturbance and what are the two types of disturbances?

If a sudden change or sequence of changes occurs in one or more of the system parameters or one or more of its operating quantities, the system is said to have undergone a disturbance from its steady state operating condition.

The two types of disturbances in a power system are, i) Large disturbance ii) Small disturbance

4. What is a small disturbance? Give example.

If the power system is operating in a steady state condition and it undergoes change, which can be properly analyzed by linearized versions of its dynamic and algebraic equations, a small disturbance is said to have occurred.

Example of small disturbance is a change in the gain of the automatic voltage regulator in the excitation system of a large generating unit.

5. What is a large disturbance? Give some examples.

A large disturbance is one for which the nonlinear equations describing the dynamics of the power system cannot be validly linearized for the purpose of analysis.

Examples of large disturbances are transmission system faults, sudden load changes, loss of generating units and line switching.

6. When is a power system said to be steady-state stable?

The power system is steady state stable for a particular steady-state operating condition if, following a small disturbance, it returns to essentially the same steady state condition of operation.

7. When is a power system said to be transiently stable?

If the machines of the system are found to remain essentially in synchronism within the first second following a system fault or other large disturbance, the system is considered to be transiently stable.

8. What is transient state of the power system?

The state of the system in the first second following a system fault or large disturbance is called the transient state of the power system.

9. Give the formula to calculate base current, I_b and base impedance of a three-phase system.

The equation for base current I_b is,

$$I_b = \frac{kVA_b}{\sqrt{3}\, kV_b}$$

The equation for base impedance is,

$$Z_b = \frac{kV_b \times 1000}{\sqrt{3}\, I_b}$$

Where,

I_b = Line value of base current.
kVA_b = 3-phase base KVA
kV_b = line to line base kV
Z_b = Base impedance per phase.

10.Give the equation for load impedance and load admittance per phase of a balanced star connected load.

Load impedance per phase, $Z = \dfrac{|V_L|^2}{P - jQ}$

Load admittance per phase, $Y = \dfrac{1}{Z} = \dfrac{P - jQ}{|V_L|^2}$

Where,

P = Three phase active power of star connected load in watts. Q = Three phase reactive power of star connected load in VARs. V_L = Line voltage of load.

11. Give the equation for load impedance and load admittance per phase of a balanced delta connected load.

Load impedance per phase, $Z = \dfrac{3|V_L|^2}{P - jQ}$

Load admittance per phase, $Y = \dfrac{1}{Z} = \dfrac{P - jQ}{3|V_L|^2}$

Where,

P = Three phase active power of delta connected load in watts. Q = Three phase reactive power of delta connected load in VARs. V_L = Line voltage of load.

12. What is the advantage of per unit method over percent method?

The advantage of per unit method over percent method is that 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 the result in percent.

13. Define base impedance and base kilovoltamperes.

The base impedance is the impedance which will have a voltage drop across it equal to the base voltage when the current flowing in the impedance is equal to the base value of the current.

$$Z_b = \frac{(kV_b)^2 \times 1000}{kVA_b}$$

The base kilovoltamperes in single-phase systems is the product of base voltage in kilovolts and base current in amperes.

$$kVA_b = kV_b \times I_b$$

14.Define per unit value of any electrical quantity.

The per unit value of any electrical quantity is defined as the ratio of the actual value of the quantity to its base value expressed as a decimal.

$$\text{Per unit value} = \frac{\text{Actual value}}{\text{Base value}}$$

15. What are the quantities whose base values are required to represent the power system by reactance diagram?

The base value of voltage, current, power and impedance are required to represent the power system by reactance diagram. Selection of base values for any two of them determines the base values of the remaining two. Usually the base values of voltage and power are chosen in kilovolt and kVA or mVA respectively. The base values of current and impedance are calculated using the chosen bases

.

16. What is the need for base values?

The components of 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 power system components are expressed with reference to a common value called base value. Then all the voltages, power, current and impedance ratings of the components are expressed as a percent or per unit of the base value.

17. Write the equation for converting the per unit impedance expressed in one base to another.

$$Z_{p.u,new} = Z_{p.u,old} \times \left(\frac{kV_{b,old}}{kV_{b,new}}\right)^2 \times \left(\frac{MVA_{b,new}}{MVA_{b,old}}\right)$$

18. List the advantages of per unit computations.

(1) The per unit impedance referred to either side of a single phase transformer is the same.
(2) The per unit impedance referred to either side of a three phase transformer is the same regardless of the three phase connections
(3) The chance of confusion between the line and phase quantities in a three phase balanced system is greatly reduced.
(4) The manufacturers usually provide the impedance values in per unit.
(5) The computational effort in power system is very much reduced with the use of per unit quantities.

19. What are the factors that affect the transient stability?

The transient stability is generally affected by two factors namely, (1) Type of fault (2) Location of fault.

20. List the methods of improving the transient stability limit of a power system.

(1) Increase of system voltage, use of AVR.
(2) Use of high speed excitation systems.
(3) Reduction in system transfer reactance.
(4) Use of high speed reclosing breakers.

PART B

1. What is the need for system analysis in planning and operation of power system?
2. Explain the advantages of the p.u form of representation from its derivation?
3. Define the per unit value of a quantity. How will you change the base impedance from one set of base values to another set?
4. Explain the steady state and transient state with the help of a RL circuit.
5. Why is Per phase analysis done in a symmetrical three-phase system.
6. What are the advantages of using per unit system?
7. Explain the per phase generator model with required diagrams.
8. With neat diagrams, explain the transformer model used for per phase analysis.
9. Discuss in detail about the modeling of transmission lines.
10. Problems based on per unit, Z bus, Ybus

UNIT 2

POWER FLOW ANALYSIS

1. Write the most important mode of operation of power system and mention the major problems encountered with it.

Symmetrical steady state is the most important mode of operation of power system. Three major problems are encountered in this mode of operation. They are,

1) Load flow problem
2) Optimal load scheduling problem
3) Systems control problem

2.Why power flow analysis is made?

Power flow analysis is performed to calculate the magnitude and phase angle of voltages at the buses and also the active power and reactive voltamperes flow for the given terminal or bus conditions. The variables associated with each bus or node are,

a. Magnitude of voltage |V|
b. Phase angle of voltage δ
c. Active power, P
d. Reactive voltamperes, Q

3. What is power flow study or load flow study?

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

4. What are the information that are obtained from a load flow study?

The information obtained from a load flow study are magnitude and phase angles of bus voltages, real and reactive power flowing in each line and line losses. The load flow solution also gives the initial conditions of the system when the transient behavior of the system is to be studied.

5. What is the need for load flow study?

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.

6. What are the works involved in a load flow study?

The following has to be performed for a load flow study.

a. Representation of the system by single line diagram.
b. Formation of impedance diagram using the information in single line diagram.
c. Formulation of network equations
d. Solution of network equations.

7. What are the different types of buses in a power system?

The buses of a power system can be classified into three types based on the quantities being specified for the buses, which are as follows:

a. Load bus or PQ bus (P and Q are specified)
b. Generator bus or voltage controlled bus or PV bus (P and V are specified)
c. Slack bus or swing bus or reference bus (|V| and δ are specified)

8. Define voltage controlled bus(generator bus/PV bus).

A bus is called voltage controlled bus if the magnitude of voltage |V| and real power (P) are specified for it. In a voltage controlled bus, the magnitude of the voltage is not allowed to change. Voltage controlled bus is also called as Generator bus and PV bus.

9. What is PQ bus(load bus)? (APR/MAY 2005)

A bus is called PQ bus or load bus when real and reactive components of power are specified for the bus. In a load bus, the voltage is allowed to vary within permissible limits.

10.What is swing bus(slack bus/reference bus)?

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 for the line losses. Usually one of the generator bus is selected as the swing bus.

11. What is the need for slack bus? (APR/MAY 2004),(NOV/DEC 2004)

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 the 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 line flow equations.

12. List the quantities specified and the quantities to be determined from load flow study for various types of buses. (MAY/JUNE 2006)

The following table shows the quantities specified and the quantities to be obtained for various types of buses.

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

***13.* What are the disadvantages of Newton-Raphson method?**
The disadvantages of Newton-Raphson method are,

a. Programming is more complex.
b. The memory requirement is more.

Computational time per iteration is higher due to larger number of calculations per iteration

14. Discuss the effect of acceleration factor in the load flow solution algorithm.

In load flow solution by iterative methods, the number of iterations can be reduced if the correction voltage at each bus is multiplied by some constant. The multiplication of the constant will increase the amount of correction to bring the voltage closer to the value it is approaching. The multipliers that accomplish this improved converged are called acceleration factors. An acceleration factor of 1.6 is normally used in load flow problems.

15How will you account for voltage controlled buses in the load flow algorithm? The acceleration factor is a real quantity and it modifies the magnitude of bus
voltage alone. Since in voltage controlled bus, the magnitude of bus voltage is not allowed to change, the acceleration factor is not used for voltage controlled bus
.

16.How will you account for voltage controlled buses in the load flow algorithm? The acceleration factor is a real quantity and it modifies the magnitude of bus
voltage alone. Since in voltage controlled bus, the magnitude of bus voltage is not allowed to change, the acceleration factor is not used for voltage controlled bus.

17. Why do we go for iterative methods to solve load flow problems?

The load (or power) flow equations are nonlinear algebraic equations and so explicit solution is not possible. The solution of nonlinear equations can be obtained only by iterative numerical techniques.

18. What do you mean by a flat voltage start?

In iterative methods of load flow solution, the initial voltage of all buses except slack bus are assumed as 1+j0 p.u. This is referred to as flat voltage start.

19.When the generator bus is treated as load bus? What will be the reactive power and bus voltage when the generator bus is treated as load bus?

If the reactive power of a generator bus violates the specified limits, then the generator bus is treated as 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.

20. What are the advantages of GS method?

The advantages of Gauss-Seidel method are,

a. Calculations are simple and so the programming task is less
b. The memory requirement is less
c. Useful for small systems.

PART B

1. With the help of a neat flow chart, explain the Newton-Raphson method of load flow solution when the system contains voltage controlled busses in addition to swing bus and load bus.

2. Compare Gauss-Seidel method and Newton-Raphson method of load flow studies

3. Explain clearly with detailed flowchart, the computational procedure for load flow solution using N-R method when the system contains all types of buses.

4. Explain the step by step computational procedure for the Newton-Raphson method of load flow studies.

5. Explain bus classification in power flow analysis with their known and unknown quantities.

6. Derive the static load flow equations of n-Bus System.

7. Explain the step by step computational procedure for the Gauss-Seidel method of load flow studies

8. Derive the basic equations for the load flow study using Gauss-Seidel method. With respect to this method, explain the following:

a. Acceleration factor.
b. Handling of PV buses.

9. Draw the representation schemes for

a. Phase shifting transformer
b. Tap changing transformer

10. Draw the mathematical model of phase shifting transformer to be used in power flow analysis.

UNIT 3

FAULT ANALYSIS-BALANCED FAULT

1. What is the need for short circuit studies or fault analysis?

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 of these devices mainly depends on various currents that may flow in the fault conditions.

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

The faults 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, so the faults are associated with transients.

3. What is meant by a fault?

A fault in a circuit is any failure which interrupts 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 equipments, if it is allowed to persist for a long time. Hence every part of a system has been protected by means of relays and circuit breakers to sense the faults and to isolate the faulty part from the healthy part of the network in the event of fault

4. Why faults occur in a power system?

Faults occur in a power system due to insulation failure of equipments, flashover of lines initiated by a lightening stroke, permanent damage to conductors and towers or accidental faulty operations.

5. How are the faults classified?

In one method, the faults are classified as,

1. **Shunt faults** - due to short circuits in conductors
2. **Series faults** - due to open conductors.

1. **Symmetrical faults** - fault currents are equal in all the phases and can be analyzed on per phase basis

2. **Unsymmetrical faults –** fault currents are unbalanced and so they can be analyzed only using symmetrical components.

6. List the various types of shunt and series faults.

1. Single line-to-ground fault
2. Line-to-line fault

3. Double line-to-ground fault
4. Three phase fault

1. One open conductor fault
2. Two open conductor fault

7. What is meant by symmetrical fault?

The fault is called symmetrical fault if the fault current is equal in all the phases. This fault conditions are analyzed on per phase basis using Thevenin's theorem or using bus impedance matrix. The three-phase fault is the only symmetrical fault.

8. List out the differences in representing the power system for load flow and short circuit studies.

Load flow studies	Fault analysis
1. Both resistances and reactances are Considered.	Resistances are neglected.
2. Bus admittance matrix is useful.	Bus impedance matrix is used.
3. The exact voltages and currents are to be determined.	The voltages can be safely assumed as 1 p.u. and the prefault current can be neglected.

9. For a fault at a given location, rank the various faults in the order of severity.

In a power system, the most severe fault is three phase fault and less severe fault is open conductor fault. The various faults in the order of decreasing severity are,

1) 3 phase fault
2) Double line-to-ground fault
3) Line-to-line fault
4) Single line-to-ground fault
5) Open conductor fault

10. What is meant by fault calculations?

The fault condition of a power system can be divided into sub transient, transient, and steady state periods. The currents in the various parts of the system and in the fault locations are different in these periods. The estimation of these currents for various types of faults at various locations in the system is commonly referred to as fault calculations.

11. What are the assumptions made in short circuit studies of a large power system network? (APR/MAY 2005)

1) The phase to neutral emfs of all generators remain constant, balanced and unaffected by the faults.
2) Each generator is represented by an emf behind either the subtransient or transient reactance depending upon whether the short circuit current is to be found immediately after the short circuit or after about 3 – 4 cycles.
3) Load currents may often be neglected in comparison with fault currents.
4) All network impedances are purely reactive. Thus the series resistances of lines and transformers are neglected in comparison with their resistances.

5) Shunt capacitances and shunt branches of transformers are neglected. Hence, transformer reactances are taken as their leakage reactances.

12. What is synchronous reactance?

The synchronous reactance is the ratio of induced emf and the steady state rms current (i.e., it is the reactance of a synchronous machine under steady state condition). It is the sum of leakage reactance and the reactance representing armature reaction. It is given by,

$X_s = X_l + X_a$

Where,

X_s = Synchronous reactance

X_l = Leakage reactance

X_a = Armature reaction reactance.

13.How symmetrical faults are analyzed?

The symmetrical faults are analyzed using per unit reactance diagram of the power system. Once the reactance diagram is formed, then the fault is simulated by short circuit or by connecting the fault impedance at the fault point. The currents and voltages at various parts of the system can be estimated by any of the following methods.

1) Using Kirchoff's laws
2) Using Thevenin's theorem
3) By forming bus impedance matrix.

14.Define doubling effect?

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. This effect is called doubling effect.

15.Explain DC off-set current?

The unidirectional transient component of short circuit current is called DC off-set current.

16.Differentiate between subtransient and transient reactance.

Subtransient reactance	Transient reactance
1) This is the ratio of induced emf and subtransient current. 2) Flux created by induced currents in the damper winding is included. 3) This is the smallest reactance among the reactance values. 4) This cannot be extrapolated.	1) This is the ratio of induced emf and transient current. 2) There is no damper winding and hence no flux is created. 3) This is larger than the subtransient reactance. 4) This can be extrapolated backwards in time

17.What are symmetrical components?

An unbalanced system of N related vectors can be resolved into N systems of balanced vectors called symmetrical components. Positive sequence components Negative sequence components

Zero sequence components.

18. Write the symmetrical components of three phase system.

In a 3-phase system, the three unbalanced vectors (either current or voltage vectors) can be resolved into three balanced system of vectors. They are,

1) Positive sequence components
2) Negative sequence components
3) Zero sequence components.

19. **What assumption is made at the star / delta transformer?**

It is that the positive sequence quantities on the HV side lead their corresponding positive sequence quantities on the LV side by 30^o. The reverse is the case for negative sequence quantities wherein HV quantities lag the corresponding LV quantities by 30^o.

20.What is an unsymmetrical fault? List the various unsymmetrical faults.

The fault is called unsymmetrical fault if the fault current is not equal in all the phases. The unsymmetrical faults in a power system are,

1) Single line-to-ground fault.
2) Line-to-line fault.
3) Double line-to-ground fault
4) Open conductor fault.

PART B

1. Explain the need for short circuit studies.

2. Draw the relationship between the phase components and the sequence components.
3. The phase 'b' of a three phase circuit is open. The currents in phases 'c' and 'a' are I and –I respectively. Determine the positive, negative and zero sequence components of the current in phase 'a'.
4. With the help of a detailed flow chart, explain how a symmetrical fault can be analysed using Z_{Bus}.

5. What are the various types of faults? Discuss their frequency of occurrence and severity? Find the fault current when an L-L-G fault occurs at the terminals of an unloaded generator.
6. Derive an expression for the positive sequence current I_{a1} of an unloaded generator when it is subjected to a double line to ground fault.

7. Explain the short circuit model of a synchronous machine under short circuit conditions.
8. What symmetrical components? Explain the symmetrical component transformation.
9. What is meant by sequence impedance? Explain the sequence network of an unloaded generator..
10. Explain the procedure for making short circuit studies of a large power system using digital computer. Illustrate the answer by considering a symmetrical fault.
11. problems based on fault analysis in per unit.

UNIT 4
FAULT ANALYSIS-UNBALANCED FAULT

1. What is meant by a fault?

A fault in a circuit is any failure which interrupts 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 equipments, if it is allowed to persist for a long time.

2. Give the reason for faults in power system?

Faults occur in a power system due to insulation failure of equipments, flashover of lines initiated by a lightening stroke, permanent damage to conductors and towers or accidental faulty operations.

3. List the various types of symmetrical and unsymmetrical faults.
Symmetrical fault:

5. Three phase fault

6. Single line-to-ground fault
7. Line-to-line fault
8. Double line-to-ground fault

4. For a fault at a given location, rank the various faults in the order of severity.

In a power system, the most severe fault is three phase fault and less severe fault is open conductor fault. The various faults in the order of decreasing severity are,

6) 3 phase fault
7) Double line-to-ground fault
8) Line-to-line fault
9) Single line-to-ground fault
10) Open conductor fault

5. What is meant by fault calculations?

The fault condition of a power system can be divided into subtransient, transient, and steady state periods. The currents in the various parts of the system and in the fault locations are different in these periods. The estimation of these currents for various types of faults at various locations in the system is commonly referred to as fault calculations

6.**What is the significance of subtransient reactance and transient reactance in short circuit studies?**

The subtransient reactance can be 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 initial fault current.

The transient reactance is used to estimate the transient state fault current. Most of the circuit breakers open their contacts only during this period.

7. **Define doubling effect and DC off-set current.**

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. This effect is called doubling effect.

DC off-set current:

The unidirectional transient component of short circuit current is called DC off-set current.

8.Differentiate between subtransient and transient reactance.

Subtransient reactance	Transient reactance
1) This is the ratio of induced emf and subtransient current. 2) Flux created by induced currents in the damper winding is included. 3) This is the smallest reactance among the reactance values. 4) This cannot be extrapolated.	1) This is the ratio of induced emf and transient current. 2) There is no damper winding and hence no flux is created. 3) This is larger than the subtransient reactance. 4) This can be extrapolated backwards in time

9.What are symmetrical components?

An unbalanced system of N related vectors can be resolved into N systems of balanced vectors called symmetrical components. Positive sequence components Negative sequence component Zero sequence components.

10. Write the symmetrical components of three phase system.

In a 3-phase system, the three unbalanced vectors (either current or voltage vectors) can be resolved into three balanced system of vectors. They are,

4) Positive sequence components
5) Negative sequence components
6) Zero sequence components.

11.Define negative sequence and zero sequence components.

Negative sequence components consist of three phasors equal in magnitude, displaced from each other by 120^o in phase, and having the phase sequence opposite to that of the original phasors. V_{a2}, V_{b2} and V_{c2} are the negative sequence components of V_a, V_b and v_c.

Zero sequence components consist of three phasors equal in magnitude and with zero phase displacement from each other. V_{ao}

12.Define primitive network.

Primitive network is a set of unconnected elements which provides information regarding the characteristics of individual elements only. The performance equations of primitive network are given below.

V + E = ZI (In Impedance form)

I + J = YV (In Admittance form)

where V and I are the element voltage and current vectors respectively.

J and E are source vectors.

Z and Y are the primitive Impedance and Admittance matrices respectively.

13. What is a bus?

The meeting point of various components in a power system is called a bus. The bus is a conductor made of copper (or) aluminium having negligible resistance. The buses are considered as points of constant voltage in a power system.

14.Explain bus incidence matrix.

For the specific system, we can obtain the following relation (relation between element voltage and bus voltage).

$V = A\ V_{BUS}$

where A is the bus incidence matrix, which is a rectangular and singular matrix. Its

elements are found as per the following rules.

a_{ik} = 1, if i^{th} element is incident to and oriented away from the k^{th} node (bus).

= -1, if i^{th} element is incident to but oriented towards the k^{th} node.

= 0, if i^{th} element is not incident to the k^{th} node.

15.What is bus admittance matrix? (MAY/JUNE 2006)

The matrix consisting of the self and mutual admittance of the power system network is called bus admittance matrix. It is given by the admittance matrix Y in the node basis matrix equation of a power system and it is denoted as Y_{bus}. Bus admittance matrix is a symmetrical matrix.

16, Write the equation for the bus admittance matrix.

The equation for bus admittance matrix is,

$Y_{bus}V = I$

where

Y_{bus} = Bus admittance matrix of order (n x n)

V = Bus voltage matrix of order (n x1)

I = Current source matrix of order (n x1)

n = Number of independent buses in the system

17.**Mention the advantages of bus admittance matrix, Y_{bus}.**

i) Data preparation is simple.

ii) Formation and modification is easy.

Since the bus admittance matrix is sparse matrix(i.e., most of its elements are zero), the computer memory requirements are less

18 **.Write any three assumptions upon transient stability.**

a. Rotor speed is assumed to be synchronous. In fact, it varies insignificantly during the course of the stability study.
b. Shunt capacitances are not difficult to account for in a stability study.
c. Loads are modeled as constant admittances.

19. What is meant by steady state stability limit?

When the load on the system is increased gradually,maximum power that can be transmitted without losing synchronism is termed as steady state stability limit. In steady state, the power transferred by synchronous machine of a power system is always less than the steady state stability limit.

20. What is transient stability limit?

When the load on the system is increased suddenly, maximum power that can be transmitted without losing synchronism is termed as transient state stability limit.

Normally, steady state stability limit is greater than transient state stability limit.

PART B

1.Draw the relationship between the phase components and the sequence components..

2.Derive the expression for fault current for a double line to ground fault in an unloaded generator in terms of symmetrical components.

3.Derive the expression for fault current for a single line-to-ground fault in a power system faulted through fault impedance Z_f.

4.Explain the need for short circuit studies

5.The phase ‘b’ of a three phase circuit is open. The currents in phases ‘c’ and ‘a’ are I and –I respectively. Determine the Fpositive, negative and zero sequence components of the current in phase ‘a’.

6.What are the various types of faults? Discuss their frequency of occurrence and severity?

7.Find the fault current when an L-L-G fault occurs at the terminals of an unloaded generator. Derive an expression for the positive sequence current I_{a1} of an unloaded generator when it is subjected to a double line to ground fault.

8.Explain the short circuit model of a synchronous machine under short circuit conditions. What symmetrical components? Explain the symmetrical component transformation.

9.Write about the impedances in phase and sequence form and derive L-L.

10.What is meant by sequence impedance? Explain the sequence network of an unloaded generator.

UNIT 5

STABILITY ANALYSIS

1.Define Stability.

The stability of a system is defined as the ability of power system to return to a stable operation in which various synchronous machines of the system remain in synchronism or 'in step' with each other, when it is subjected to a disturbance.

2. Define steady state stability.

The steady state stability is defined as the ability of a power system to remain stable i.e., without loosing synchronism for small disturbances.

3. Define transient stability.

The transient stability is defined as the ability of a power system to remain stable i.e., without loosing synchronism for large disturbances.

4.Write any three assumptions upon transient stability.

d. Rotor speed is assumed to be synchronous. In fact, it varies insignificantly during the course of the stability study.
e. Shunt capacitances are not difficult to account for in a stability study.
f. Loads are modeled as constant admittances.

5. What is meant by steady state stability limit?

When the load on the system is increased gradually,maximum power that can be transmitted without losing synchronism is termed as steady state stability limit. In steady state, the power transferred by synchronous machine of a power system is always less than the steady state stability limit.

6. What is transient stability limit?

When the load on the system is increased suddenly, maximum power that can be transmitted without losing synchronism is termed as transient state stability limit.

Normally, steady state stability limit is greater than transient state stability limit.

7. How to improve the transient stability limit of power system?

a. Increase of system voltages
b. Use of high speed excitation systems.
c. Reduction in system transfer reactance
d. Use of high speed reclosing breakers.

8. What is stability study?

The procedure of determining the stability of a system upon occurrence of a disturbance followed by various switching off and switching on actions is called stability study.

9.How do you classify steady state stability limit. Define them.

Depending on the nature of the disturbance, the steady state stability limit is classified into,

a. **Static stability limit** refers to steady state stability limit that prevails without the aid of regulating devices.
b. **Dynamic stability limit** refers to steady state stability limit prevailing in an unstable system with the help of regulating devices such as speed governors, voltage regulators, etc.

10.What are the machine problems seen in the stability study.

1. Those having one machine of finite inertia machines swinging with respect to an infinite bus
2. Those having two finite inertia machines swinging with respect to each other.

11. Give the expression for swing equation. Explain each term along with their units.

Where H = Inertia constant in MJ/MVA.
f = Frequency in Hz.
M = Inertia constant in p.u.
P_m= Mechanical power input to the system (neglecting mechanical losses) in p.u.
P_e = Electrical power output of the system (neglecting electrical losses) in p.u.

12.What are the assumptions made in solving swing equation?

1) Mechanical power input to the machine remains constant during the period of electromechanical transient of interest.
2) Rotor speed changes are insignificant that had already been ignored in formulating the swing equations.
3) Effect of voltage regulating loop during the transient are ignored.

13.Define swing curve. What is the use of swing curve?

The swing curve is the plot or graph between the power angle δ, and time, t.

It is usually plotted for a transient state to study the nature of variation in δ for a sudden large disturbance. From the nature of variations of δ, the stability of a system for any disturbance can be determined.

14.Give the control schemes included in stability control techniques?

The control schemes included in the stability control techniques are:

a. Excitation systems
b.Turbine valve control
c.Single pole operation of circuit breakers
d.Faster fault clearing times

15.What are the systems design strategies aimed at lowering system reactance?

The system design strategies aimed at lowering system reactance are:

a. Minimum transformer reactance

b.Series capacitor compensation of lines

c.Additional transmission lines.

16.What are coherent machines?

Machines which swing together are called coherent machines. When both ωs and δ are expressed in electrical degrees or radians, the swing equations for coherent machines can be combined together even though the rated speeds are different. This is used in stability studies involving many machines.

17.State equal area criterion.

In a two machine system under the usual assumptions of constant input , no damping and constant voltage being transient reactance , the angle between the machines either increases or else, after all disturbances have occurred oscillates with constant amplitude. There is a simple graphical method of determining whether the system comes to rest with respect to each other. This is known as equal area criterion

18. What is Multimachine stability?

If a system has any number of machines, then each machine is listed for stability by advancing the angular position, δ of its internal voltage and noting whether the electric power output of the machine increases (or) decreases. If it increases, i.e if $\partial P_n / \partial \delta_n > 0$

then machine n is stable. If every machine is stable, then the system having any number of machine is stable.

19.What is meant by an infinite bus?

The connection or disconnection of a single small machine on a large system would not affect the magnitude and phase of the voltage and frequency. Such a system of constant voltage and constant frequency regardless of the load is called infinite bus bar system or infinite bus.

20. **List the assumptions made in multimachine stability studies.**

The assumptions made are,

- The mechanical power input to each machine remains constant during the entire period of the swing curve computation
- Damping power is negligible
- Each machine may be represented by a constant transient reactance in series with a constant transient voltage.
- The mechanical rotor angle of each machine coincides with δ , the electrical phase angle of the transient internal voltage.

PART B

1. Derive the swing equation for a single machine connected to infinite bus system. State the assumptions if any and state the usefulness of this equation. Neglect the damping.

2.Discuss the various factors affecting the transient stability of the system.

3. With the help of a neat flowchart, explain the modified Euler method of solving the swing equations.

4.State the bad effects of instability. Distinguish between steady state and transient stability.

5.Write short notes on assumptions made in deducing equal area criterion.

6. State and explain equal area criterion. How do you apply equal area criterion to find the maximum additional load.

7. Describe the equal area criterion for transient stability analysis of a system.

8. Mention the assumptions clearly and developing necessary equations, describe the step by step solution of swing bus.

9. Derive the swing equation of a synchronous machine swinging against an infinite bus. Clearly state the assumptions in deducing the swing equation.

10. Derive the swing equation SMIB

12.Explain the solution of swing equation by Runge Kutta Method..