2.5. Evaluation Process and Reforms Metric

(2.5.1)

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No.	Key Indicator- 2.5. Evaluation Process and Reforms Metric
2.5.1. QIM	*Mechanism of internal assessment is transparent and robust in terms of frequency and mode* • Internal assessment tests are conducted by the institute's exam cell as per the academic calendar. The time tables, seating arrangements for internal tests are informed through circulars and displayed in notice boards well in advance. • Once the examinations are conducted, the answer scripts of students are evaluated by concerned course instructor and distributed to the students. Answers to all the questions given in the examinations are discussed with students during the distribution of answer scripts. The system is made transparent by providing the scheme of evaluation and answer key to the students so that they verify the marks awarded and understand their mistakes committed by them in the examination. Grievances in the evaluation process made by the students are addressed and modifications of marks are carried out, if necessary. Answer scripts are verified by the HoD to ensure that there is no discrepancy in the evaluation. • The internal test marks of the students are disseminated in the notice board to ensure transparency. • The internal assessment and end semester examination marks are communicated to the parents through post and SMS.

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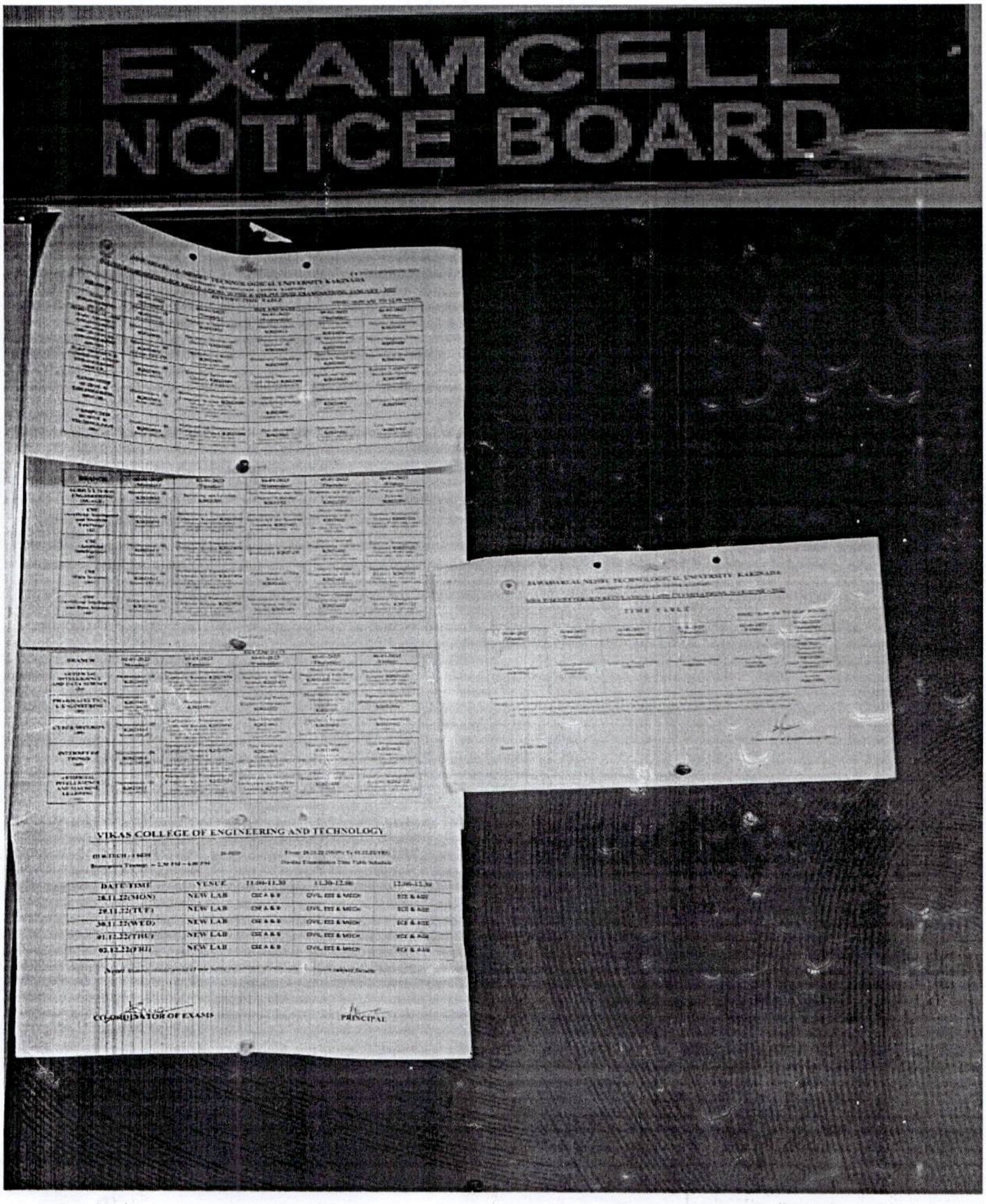

CIRCULAR FROM UNIVERSITY REGARDING I MID EXAMINATIONS FOR II B. TECH/MBA ONLINE EXAMINATION TIME TABLE AND DESCRIPTIVE TIME TABLE WITH SUBJECTS AND CODES

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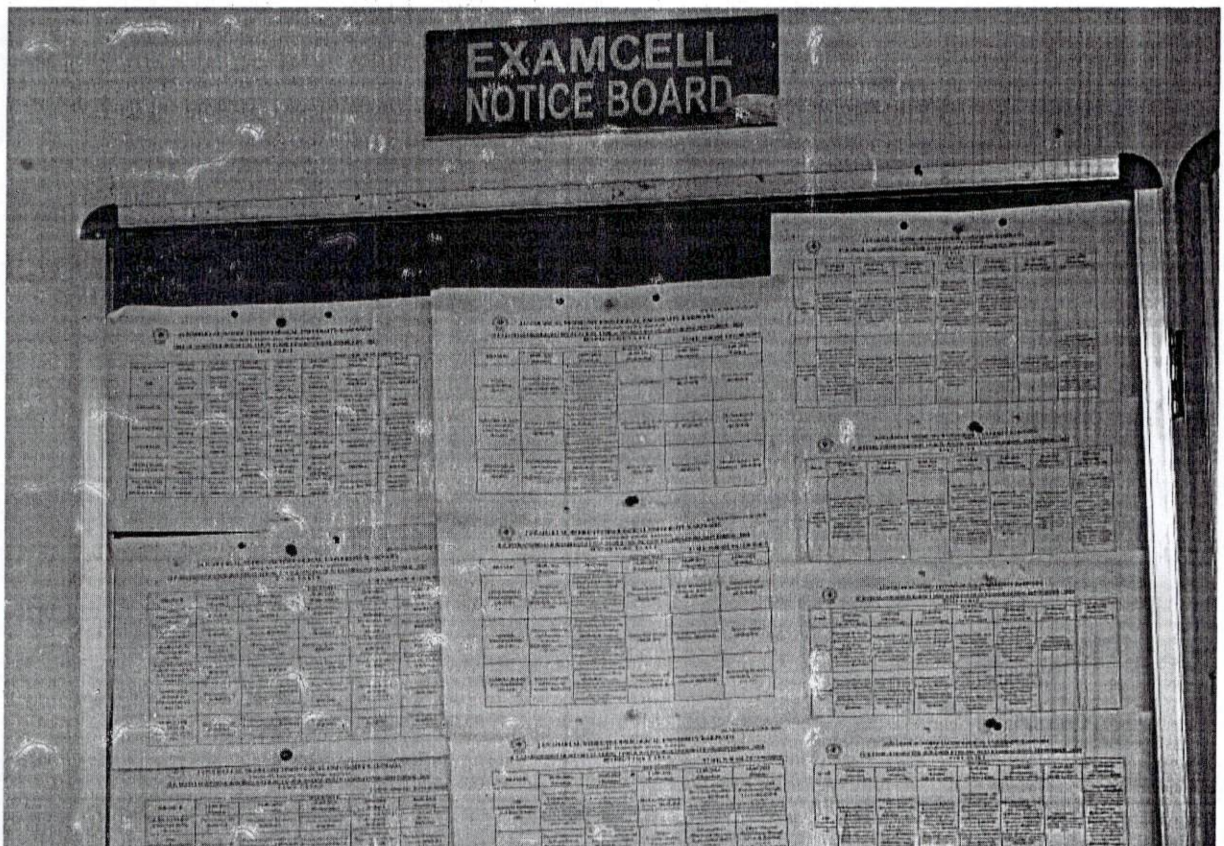

II B. TECH I SEM I MID EXAMINATION TIME TABLE
I M. TECH II MID EXAMINATION TIME TABLES
III MBA I MID EXAMINATION TIME TABLE
IV B. TECH I SEM I MID EXAMINATION TIME TABLE

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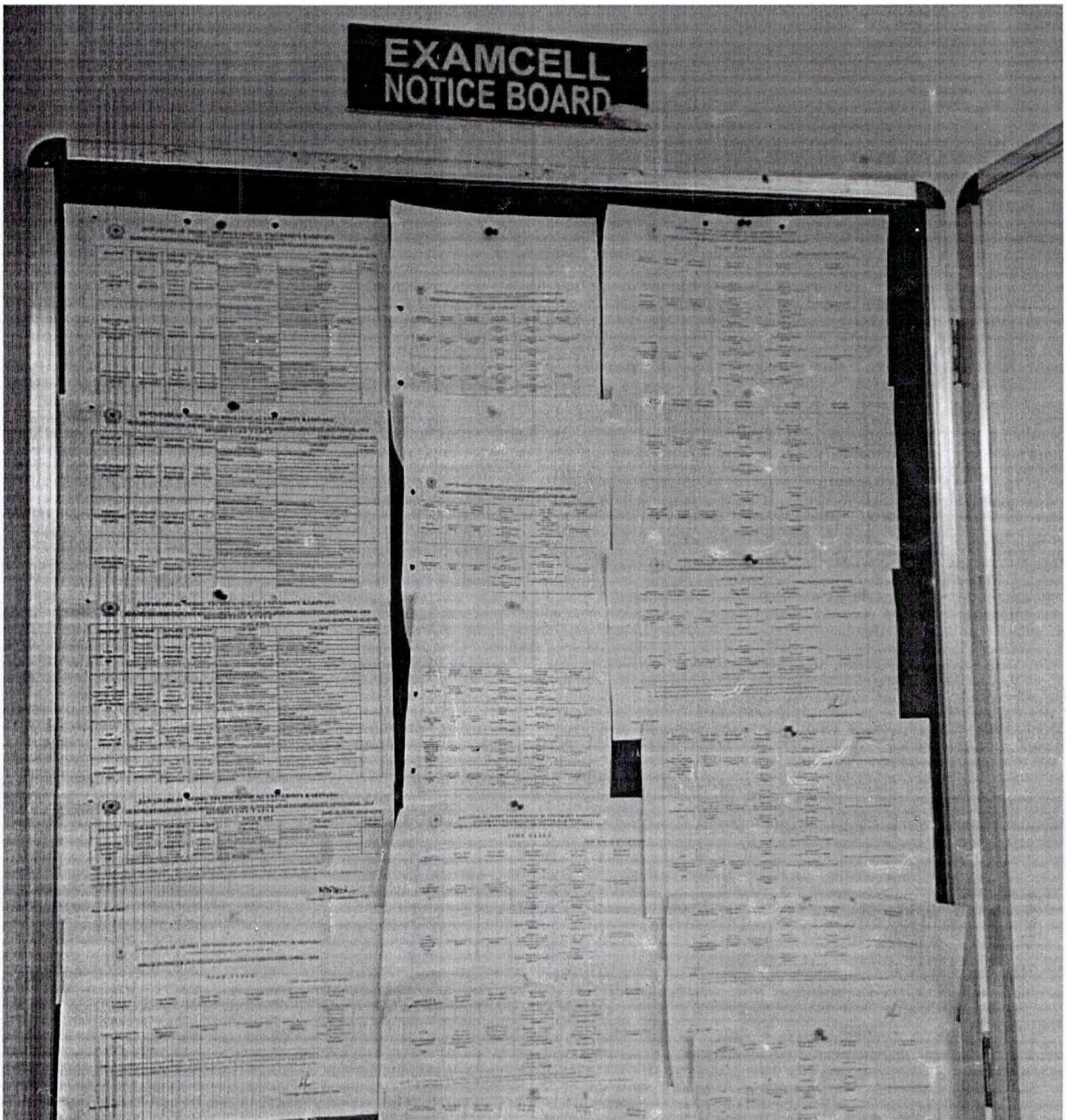

M.TECH I SEM TIME TABLE
III B.TECH I SEM I MID EXAMINATION TIME TABLE FROM UNIVERSITY
II M.B.A TIME TABLE

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DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

III- II - Sem, II - Mid Exam

		SET	B
ACADAMIC YEAR:	2023-24	Year-Semester:	III- II
COURSE NAME:	Power System Analysis		
Faculty Name:	B. Lakshmana Nayak	Date:	01-05-2024.
Duration :	90 mins	Max Marks:	45 M

Course Outcomes:

CO3 Able to form a Zbus for a power system networks. Able to find Symmetrical fault analysis for power systems.

CO4 Able to find the sequence components of currents for unbalanced power system network. Find the fault currents for all types faults to provide data for the design of protective devices.

CO5 Able to analyze the steady state, transient and dynamic stability concepts of a power system.

Answer the Following Questions:

Q. N	Question	Marks	CO	BL
1.A	Explain the three phase short circuit currents on unloaded synchronous generator with neat diagrams.	7	CO3	L2
1.B	What do you understand by short circuit MVA? Explain.	8	CO3	L1
2.A	What are sequence impedances? Obtain expression for sequence impedances in a balanced static 3-phase circuit.	7	CO4	L1
2.B	Derive an expression for the fault current for a double line fault as an unloaded generator and draw its equivalent diagram.	8	CO4	L2
3.A	Describe the methods of improving the transient stability limit of a power system.	7	CO5	L2
3.B	Derive swing equation for a single machine connected to infinite bus system. State the assumptions if any and state the usefulness of this equation.	8	CO5	L2

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DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

III- II - Sem, II - Mid Exam

		SET	B
ACADAMIC YEAR:	2023-24	Year-Semester:	III- II
COURSE NAME:	Power System Analysis		
Faculty Name:	B. Lakshmana Nayak	Date:	01-05-2024.
Duration :	90 mins	Max Marks:	45 M

ANS KEY:

1.Explain the three phase short circuit currents on unloaded synchronous generator with neat diagrams?

DEFINITION:2M, DIAGRAM:2M, DERIVATION:3M

A. Short Circuit of a Synchronous Machine on No Load:

Short Circuit of a Synchronous Machine on No Load – Under steady state short circuit conditions, the armature reaction of a synchronous generator produces a demagnetizing flux. In terms of a circuit this effect is modelled as a reactance X_a in series with the induced emf. This reactance when combined with the leakage reactance X_l of the machine is called synchronous reactance X_d (direct axis synchronous reactance in the case of salient pole machines). Armature resistance being small can be neglected. The steady state short circuit model of a Synchronous Machine on No Load is shown in Fig. 9.3a on per phase basis.

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- X_d= direct axis synchronous reactance
- X'_d= direct axis transient reactance
- X''_d= direct axis subtransient reactance
- $|E_g|$ = per phase no load voltage (rms)
- Oa, Ob, Oc = intercepts shown in Figs. 9.4a and b.

The intercept Ob for finding transient reactance can be determined accurately by means of a logarithmic plot. Both $\Delta i''$ and $\Delta i'$ decay exponentially as

$$\Delta i'' = \Delta i''_0 \exp(-t/\tau_{dw})$$
$$\Delta i' = \Delta i'_0 \exp(-t/\tau_f)$$

where T_{dw} and T_f are respectively damper, and field winding me constants with $T_{dw} \ll T_f$. At me t $\gg T_{dw}$, $\Delta i''$ practically dies out and we can write

$$\log(\Delta i'' + \Delta i')|_{t \gg \tau_{dw}} = \log \Delta i' = -\Delta i'_0 t/\tau_f$$

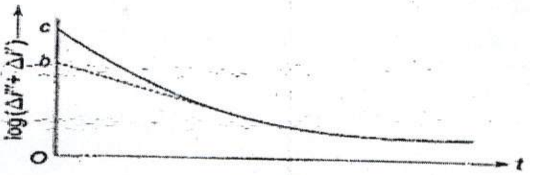

Fig. 9.5

The plot of log ($\Delta i''$ + $\Delta i'$) versus me for t $\gg T_{dw}$ therefore, becomes a straight line with a slope of ($-\Delta i'_0/T_f$) as shown in Fig. 9.5. As the straight-line portion of the plot is extrapolated (straight line extrapolation is much more accurate than, the exponential extrapolation of Fig. 9.4), the intercept corresponding to t = 0 is

$$\Delta i'|_{t=0} = \Delta i'_0 \exp(-t/\tau_f)|_{t=0} = \Delta i'_0 = ob$$

where

- r_a = AC resistance of the armature winding per phase.

Though the machine reactance's are dependent upon magnetic saturation (corresponding to excitation), the values of reactance's normally lie within certain predictable limits for different types of machines. Table 9.1 gives typical values of machine reactance's which can be used in fault Calculations and in stability studies.

Normally both generator and motor sub transientreactance's are used to determine the momentary current flowing on occurrence of a short circuit. To decide the interrupting capacity of circuit breakers, except those which open instantaneously, sub transient reactance is used for generators and transient reactance for synchronous motors

2. What do you understand by short circuit MVA? Explain.

DEFINITION:4M, EXPLANATION:4M

A. Short Circuit Current Calculation:

What is the importance of short circuit current calculation?

Short circuit current calculation studies are important for every Electrical engineer to es mate the value of fault currents and hence to find the following details.

1. To determine the switchgear rating for protective relaying
2. To determine the voltage, drop during the star ng of large motors.
3. To determine the rating of the protective equipment, MCCs, and Breaker panels.

Why MVA method is preferable compared to other methods?

We can also find the short circuit parameters using Ohmic and Per Unit Methods. The conversion formulas used for both these methods are complex and not easy to memorize.

In the MVA method, it is not necessary to convert impedances from one voltage to another as in the Ohmic method. And it is not required any base MVA value as in the Per Unit method. So, the calculations using MVA Method are simple hand calculations and also quick.

Short circuit current calculation using MVA method:

The following is the procedure

1. Convert the typical single line diagram to an equivalent MVA diagram.
2. Simplification of an equivalent MVA diagram into a single short-circuits MVA value at the point of fault.

This can be easily achieved with the following three steps.

Step-1: Convert all single line components to short circuit MVA's.

In practice, the MVA method is used by separating the circuit into components and calculating each component with its own infinite bus. Equipment such as generators, motors, transformers, etc., is normally given their own MVA and impedance or reactance ratings.

The short circuit MVA of each component in the given SLD is equal to its MVA ra ng divided by its own per unit impedance or reactance.

Step-2: Combine individual MVA values.

1) Series MVA's are combined as resistances in parallel.

2) Parallel MVA's are added arithmetically.

Step-3: Reduce MVA diagram into a single short-circuits MVA value at the point of fault.

Reduce MVA diagram by simplifying the equivalent MVA diagram using the MVA quantities obtained in the previous step.

3. What are sequence impedances? Obtain expression for sequence impedances in a balanced static 3-phase circuit.

DEFINITION:2M, DIAGRAM:2M, DERIVATION:3M

Sequence Impedance

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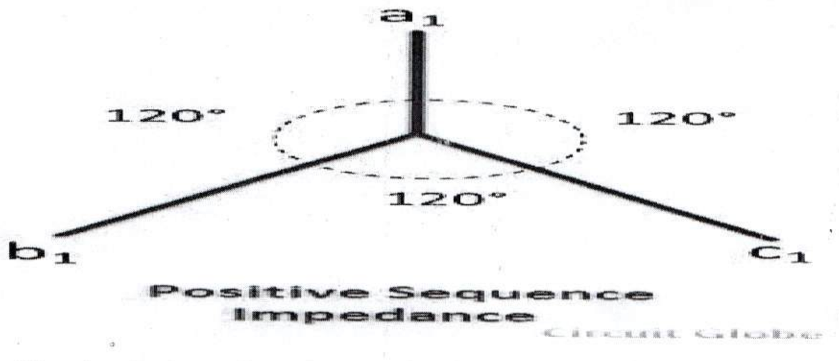
DEFINITION:2M, DIAGRAM:2M, DERIVATION:3M

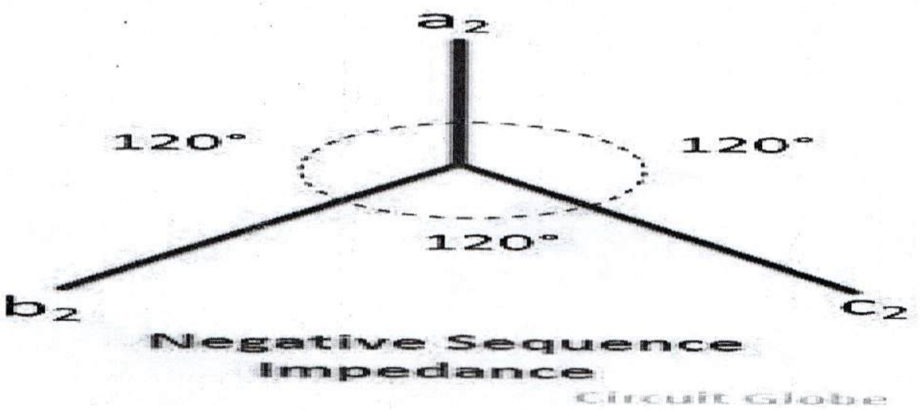
Sequence Impedance

The sequence impedance of the network describes the behaviour of the system under asymmetrical fault conditions. The performance of the system determines by calculating the impedance offered by the different element of the power system to the flow of the different phase sequence component of the current. Every power system component (static or rotating) has three values of impedance one for each symmetrical value of current. The sequence impedance of power system is of three types namely positive sequence impedance, negative sequence impedance and zero sequence impedance.

Positive Sequence Impedance – The impedance offered by the network to the flow of positive sequence current is called the positive sequence impedance. The positive sequence means all the electrical quantities are numerically equal and displaces each other by 120º.



Negative Sequence Impedance – The negative sequence impedance means the impedance offered by the network to the flows of negative sequence current.



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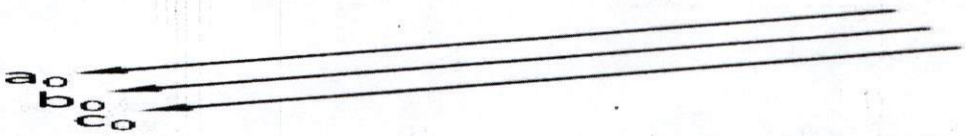
Zero Sequence Impedance – The impedance offered to zero sequence current is called the zero-sequence impedance.



Zero Sequence Impedance

The impedance of the positive, negative and zero sequence component is given by the ra o of the phase sequence voltage to the phase sequence current of the system.

$$\text{Positive Sequence Impedance } Z_1 = \frac{V_1}{I_1}$$

$$\text{Negative Sequence Impedance } Z_2 = \frac{V_2}{I_2}$$

$$\text{Zero Sequence Impedance } Z_3 = \frac{V_3}{I_3}$$

4.Derive an expression for the fault current for a double line fault as an unloaded generator and draw its equivalent diagram

DEFINITION:2M, DIAGRAM:2M, DERIVATION:3M

Unsymmetrical Faults on 3-Phase System

Those faults on the power system which give rise to unsymmetrical fault currents (i.e., unequal fault currents in the lines with unequal phase displacement) are known as unsymmetrical faults. On the occurrence of an unsymmetrical fault, the currents in the three lines become unequal and

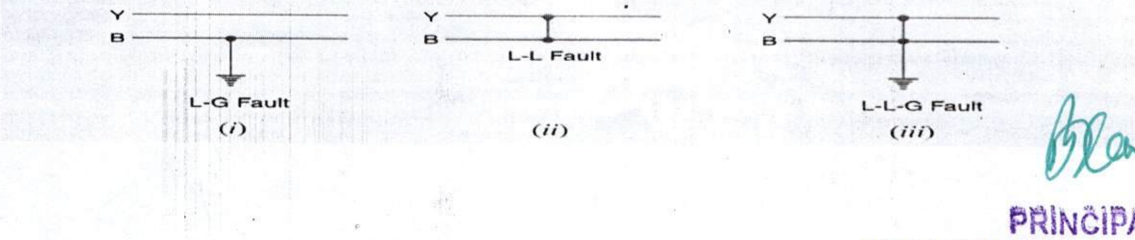
so is the phase displacement among them. It may be noted that the term 'unsymmetry' applies only to

the fault itself and the resulting line currents. However, the system impedances and the source volt- ages are always symmetrical* through its main elements viz. generators, transmission lines, synchronous reactors etc. There are three ways in which unsymmetrical faults may occur in a power system (see Fig. 18.1).

(i) Single line-to-ground fault (L — G)

(ii) Line-to-line fault (L — L)

(iii)Double line-to-ground fault (L — L — G)



The solution of unsymmetrical fault problems can be obtained by either (a) Kirchhoff's laws or (b) Symmetrical components method. The la er method is preferred because of the following reasons:

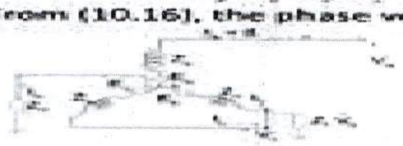
(i) It is a simple method and gives more generality to be given to fault performance studies. (ii) It provides a useful tool for the protection engineers, particularly in connect on with tracing out of fault currents.

Double Line-To-Ground Fault

Figure 10.14 shows a three-phase generator with a fault on phases b and c through an impedance Zf to ground. Assuming the generator is initially on no- load, the boundary conditions at the fault point are

[illegible]

From (10.16), the phase voltages V_b and V_c are



5.Describe the methods of improving the transient stability limit of a power system.

DEFINITION:2M, DIAGRAM:2M, DERIVATION:3M

A. Here are some methods to improve the transient stability of a power system:

- Increase voltage: Increasing the voltage profile of the system increases its power transfer ability. This also increases the difference between the critical clearance angle and the initial angle.
- Use high-speed circuit breakers: High-speed circuit breakers help clear faults as quickly as possible.
- Use STATCOMs: STATCOMs can provide active and reactive power independently, and can provide inductance and capacitance for voltage support.
- Use high-speed governors: High-speed governors can be used on machines.
- Use turbine fast valving: Turbine fast valving can be used to improve transient stability.
- Use high-speed excita on: High-speed excita on can be used to improve transient stability.
- Use auto re-closing breakers: Auto re-closing breakers can be used to improve transient stability.

The equal area criterion is a method that can be used to quickly predict the stability of a power system. It's based on the graphical interpretation of the energy stored in the rota ng mass.

2 Basics of Transient Stability Assessment and Improvement 2.1 Nomenclature Pe, pre (W) - Active power transfer capability before the fault. Pe, f (W) – Active power transfer capability during the fault. Pe, post (W) - Active power transfer capability after the

Pm (W) - Mechanical power supplied to the turbine. Pa (W) - Acceleration/deceleration power defined as difference between mechanical and electrical power. J (kgm2) - Moment of inert a.

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δ0 (rad) - Steady-state rotor angle before the fault. δ1 (rad) - Steady-state rotor angle a er the fault. δc (rad) - Critical rotor angle which defines stability limit during fault. δm (rad) - Maximum permissible rotor angle perturbation a er fault clearance. A1, A2 - Acceleration and deceleration areas. 2.2 Transient Stability Mechanism In order to understand the different effects of the improvement techniques, the basics of transient stability assessment are briefly summarized by means of the well-known equal area criterion (EAC) [12, 13]. The EAC determines the transient stability limit according to the acceleration and deceleration area A1 and A2, respectively. The corresponding P − δ diagram is shown in Fig. 1. The physical relation between the mechanical and electrical quantities is given by the equation of motion shown in (1). Generators are accelerating or decelerating once there is a mismatch between mechanical power supplied to the turbine and electrical power delivered to the grid. Pa = Pm − Pe = Jω0 d 2 δ dt2 (1) The stability limit is derived by calculating the maximum clearing angle and, based on that, the critical clearing me (CCT) which describes the me that the generator takes to advance from the initial rotor angle to the critical rotor angle. Hence, the greater the CCT, the more severe disturbances the generator (system) can withstand.

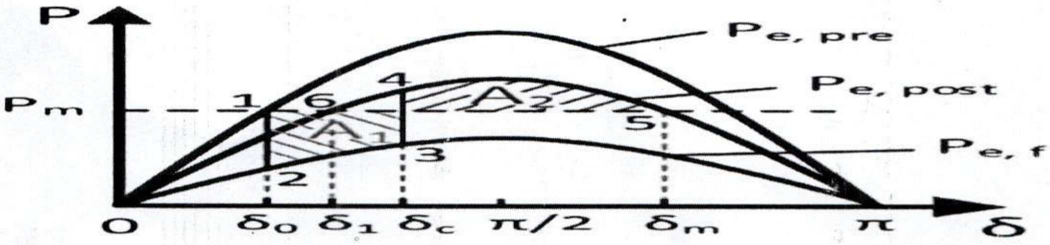


Fig. 1: P–δ curve

6.Derive swing equa on for a single machine connected to infinite bus system. State the assumptions if any and state the usefulness of this equation.

DEFINITION:2M, DIAGRAM:2M, DERIVATION:3M

A. Swing equation for a SMIB (Single machine connected to an infinite bus bar) system.

$$\frac{H}{\pi f}\frac{d^2\delta}{dt^2} = P_m - P_e$$

Since M in p.u = H/πf

$$M\frac{d^2\delta}{dt^2} = P_m - P_e$$

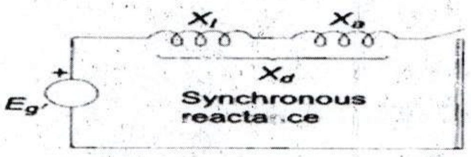
Where H = inert a constant in MW/MVA

f = frequency in Hz

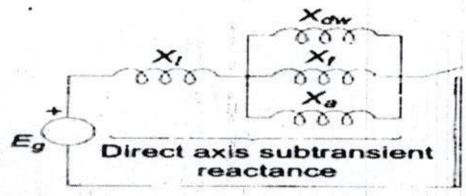
M = inert a constant in p.u

Swing curve

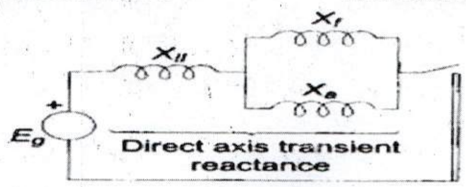
The swing curve is the plot or graph between the power angle δ and me t. From the nature of variations of δ the stability of a system for any disturbance can be determined.



(a) Steady state short circuit model of a synchronous machine



(b) Approximate circuit model during subtransient period of short circuit



(c) Approximate circuit model during transient period of short circuit

Consider now the sudden short circuit (three-phase) of a synchronous generator initially opera ng under open circuit conditions. The machine undergoes a transient in all the three phase finally ending up in steady state conditions described above.

The circuit breaker must, of course, interrupt the current much before steady conditions are reached. Immediately upon short circuit, the DC off-set currents appear in all the three phases, each with a different magnitude since the point on the voltage wave at which short circuit occurs is different for each phase. These DC off-set currents are accounted for separately on an empirical basis and, therefore, for short circuit studies, we need to concentrate our attention on symmetrical (sinusoidal) short circuit current only.

Immediately in the event of a short circuit, the symmetrical short circuit current is limited only by the leakage reactance of the machine. Since the air gap flux cannot change instantaneously (theorem of constant flux linkages), to counter the demagnetization of the armature short circuit current, currents appear in the field winding as well as in the damper winding in a direction to help the main flux. These currents decay in accordance with the winding me constants.

The me constant of the damper winding which has low leakage inductance is much less than that of the field winding, which has high leakage inductance. Thus, during the initial part of the short circuit, the damper and field windings have transformer currents induced in them so that in the circuit

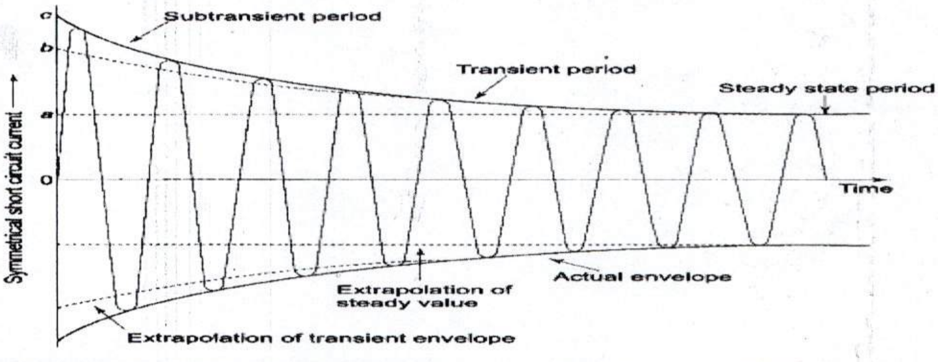
model their reactances—X_f of field winding and X_{dw} of damper winding—appear in parallel with X_a as shown in Fig. 9.3b. As the damper winding currents are first to die out, X_{dw} effectively becomes open circuited and at a later stage X_f becomes open circuited. The machine reactance thus changes from the parallel combination of X_a, X_f and X_{dw} during the initial period of the short circuit to X_a and X_f in parallel (Fig. 9.3c) in the middle period of the short circuit, and finally to X_a in steady state (Fig. 9.3a). The reactance presented by the machine in the initial period of the short circuit, i.e.

$$X_l + \frac{1}{(1/X_a + 1/X_f + 1/X_{dw})} = X''_d \qquad (9.5)$$

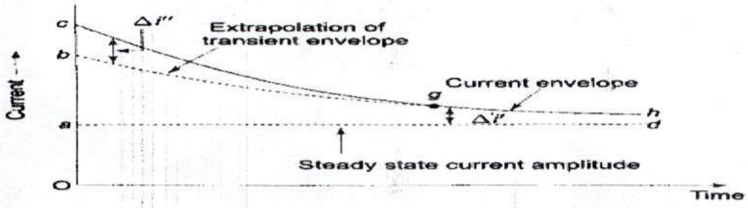
is called the subtransient reactance of the machine. While the reactance effective after the damper winding currents have died out, i.e.

$$X'_d = X_l + (X_a \parallel X_f) \qquad (9.6)$$

is called the transient reactance of the machine. Of course, the reactance under steady conditions is the synchronous reactance of the machine. Obviously $X''_d < X'_d < X_d$. The machine thus offers a time varying reactance which changes from X''_d to X'_d and finally to X_d.



(a) Symmetrical short circuit armature current in synchronous machine



(b) Envelope of synchronous machine symmetrical short circuit current

Fig. 9.4

If we examine the oscillogram of the short circuit current of a Synchronous Machine on No Load a er the DC off-set currents have been removed from it, we will find the current wave shape as given in Fig. 9.4a. The envelope of the current wave shape is plotted in Fig. 9.4b. The short circuit current can be divided into three periods—initial subtransient period when the current is large as the machine offers subtransient reactance, the middle transient period where the machine offers transient reactance, and finally the steady state period when the machine offers synchronous reactance.

If the transient envelope is extrapolated backwards in me, the difference between the transient and subtransient envelopes is the current Δi″ (corresponding to the damper winding current) which decays fast according to the damper winding me constant. Similarly, the difference Δi′ between the steady state and transient envelopes decays in accordance with the field me constant.

In terms of the oscillogram, the currents and reactances discussed above, we can write

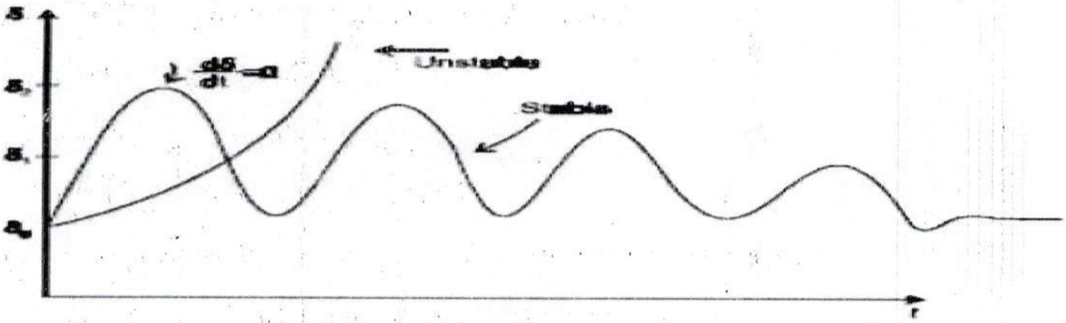
$$|I| = \frac{oa}{\sqrt{2}} = \frac{|E_g|}{X_d} \qquad (9.7a)$$

$$|I'| = \frac{ob}{\sqrt{2}} = \frac{|E_g|}{X'_d} \qquad (9.7b)$$

$$|I''| = \frac{oc}{\sqrt{2}} = \frac{|E_g|}{X''_d} \qquad (9.7c)$$

where

- $|I|$ = steady state current (rms)
- $|I'|$ = transient current (rms) excluding DC component
- $|I''|$ = subtransient current (rms) excluding DC component



3 machine system having ratings G1, G2 and G3 and inert a constants M1, M2 and M3. What is the inert a constants M and H of the equivalent system.

$$M_{eq} = \frac{M_1 G_1}{G_b} + \frac{M_2 G_2}{G_b} + \frac{M_3 G_3}{G_b}$$

$$H_{eq} = \frac{\pi f M_{eq}}{G_b}$$

Where G1, G2, G3 – MVA ra ng of machines 1, 2, and 3

Gb = Base MVA or system MVA

Assumptions made in stability studies.

(i). Machines represents by classical model

(ii). The losses in the system are neglected (all resistance are neglected)

(iii). The voltage behind transient reactance is assumed to remain constant.

(iv). Controllers are not considered (Shunt and series capacitor)

(v). Effect of damper winding is neglected.

Equal Area Criterion

The equal area criterion for stability states that the system is stable if the area under P – δ curve reduces to zero at some value of δ.

This is possible if the positive (accelerating) area under P – δ curve is equal to the negative (decelerating) area under P – δ curve for a finite change in δ. hence stability criterion is called equal area criterion.

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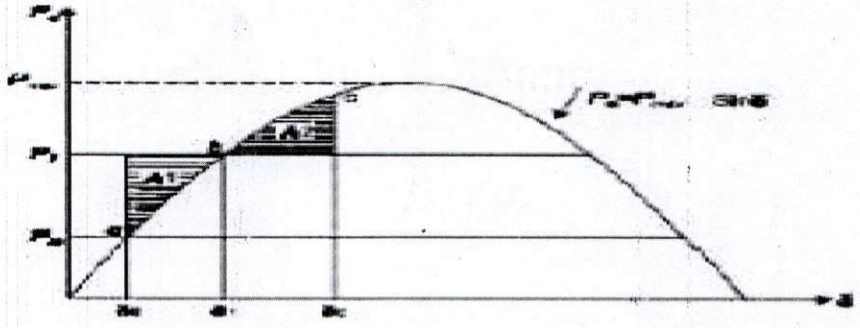
A1
A2