POWER SYSTEM-II
(ELEC 3201)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The rating of circuit breaker is usually determined on the basis of
(a) symmetrical fault (b) single line-to-ground fault
(c) double line-to-ground fault (d) line-to-line fault

(ii) In which type of fault positive, negative and zero sequence currents are equal to each other?
(a) Symmetrical fault (b) single line-to-ground fault
(c) double line-to-ground fault (d) line-to-line fault

(iii) Negative sequence reactance of a transformer is
(a) equal to the positive sequence reactance
(b) larger than the positive sequence reactance
(c) smaller than the positive sequence reactance
(d) equal to the zero sequence reactance

(iv) Which among the following quantities are specified at the generator bus?
(a) P and Q (b) P and |V|
(c) Q and |V| (d) P and δ

(v) A generator of 10MVA rating has an inertia constant of 5MJ/MVA, its stored energy is
(a) 50 MJ (b) 2 MJ
(c) 500 MJ (d) 20MJ

(vi) If in a power system, the per unit fault impedance at the fault point is 0.5 p.u. and the base MVA of the system is 20, the short circuit MVA will be
(a) 10 MVA (b) 20MVA
(c) 50 MVA (d) 40 MVA

(vii) Which of the following relays has inherent directional characteristics?
(a) Mho relay (b) Reactance relay
(c) Impedance relay (d) Differential relay

(viii) In an over-current protection the current setting of the phase fault relay is
(a) more than the earth fault relay
(b) equal to the earth fault relay
(c) less than the earth fault relay
(d) the two settings are unrelated to each other

(ix) Purpose of backup protection is
(a) to increase the speed
(b) to increase the reach
(c) to leave no blind spot
(d) to guard against failure of primary protection

(x) Plug setting of a relay can be changed by changing
(a) Air gap (b) Backstop position
(c) Number of ampere turns (d) Damping magnet

Group – B

2. (a) Discuss and explain the sub transient, transient and steady state reactances when a sudden 3-phase short circuit occurs at the unloaded generator terminals.

(b) Fig.1 shows a generating station feeding power to a 132 kV system. Determine the total fault current, fault level and fault current supplied by each alternator for a 3-phase fault at the receiving end bus. The line is 200 km long.

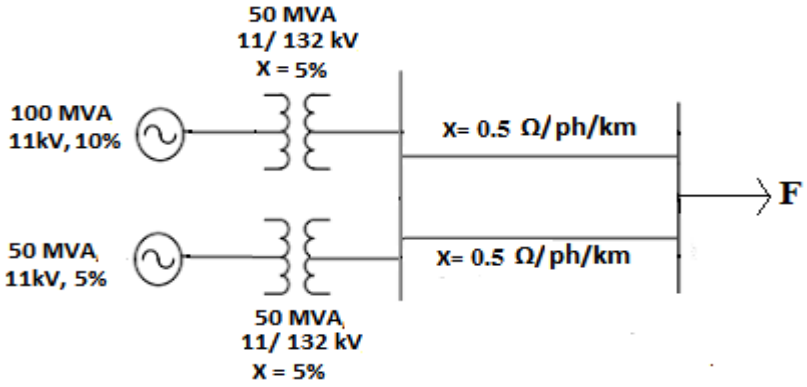

Fig.1

4 + (4 + 1 + 3) = 12

3. (a) Develop the connection diagram of sequence networks for a single line to ground (L-G) fault. Also derive the expression for fault current.

(b) Draw the zero sequence diagram for the following three phase transformers:

(i) 

(ii) 

(c) A 25 MVA, 11 kV, 3-phase synchronous generator was subjected to the different types of faults. The fault currents were as under :
L-G fault = 2200A; L-L fault = 1400A; 3-phase fault = 1000A.
The generator neutral is solidly grounded. Find the per unit values of the three sequence reactances of the generator.

(3 + 2) + 2 + 5 = 12

Group – C

4. (a) Deduce the swing equation of a synchronous machine connected to an infinite bus.

(b) What is meant by swing curve? What information is supplied by it?

(c) A synchronous generator of reactance 1.10 pu is connected to an infinite bus bar (|V| =1.0 pu) through transformers and a line of total reactance of 0.50 pu. The generator no load voltage is 1.10 pu and its inertia constant is H= 5 MW-s/MVA. The resistance and machine damping may be assumed negligible. The system frequency is 50 Hz. Calculate the frequency of natural oscillations if the generator is loaded to 50% of its maximum power limit.

4 + 3 + 5 = 12

5. (a) Derive static load flow equations (SLFE).

(b) A three bus power system is shown in Fig. 2. The relevant per unit line admittances on 100 MVA base are indicated on the diagram and bus data are given in the Table 1. calculate:
(i) Y_{bus} matrix
(ii) The voltages at bus 2 and 3 after the 1st iteration using Gauss –Seidel method.

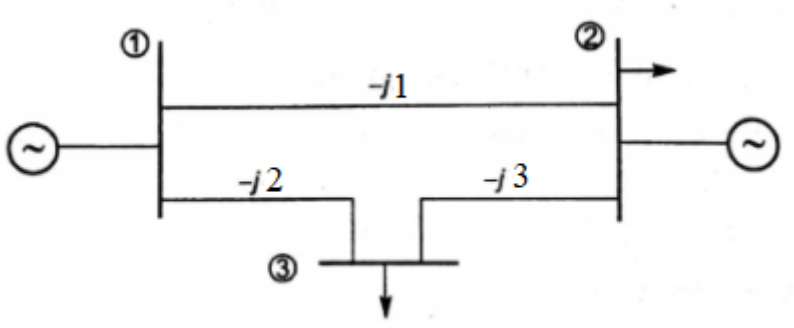

Fig. 2

Table 1

Bus No	Type	Generation		Load		Bus Voltage
		P_G(MW)	Q_G(MW)	P_L(MW)	Q_L(MW)	
1	slack	--	--	0	0	$1.02 \angle 0^0$
2	PQ	20	10	40	20	?
3	PQ	0	0	50	20	?

5 + (3 + 4) = 12

Group – D

6. (a) What is Universal Torque Equation? Using this equation derive the operating characteristics of
   (i) Impedance relay
   (ii) Reactance relay
   (iii) Mho relay.

   (b) Reference to the Fig. 3 given that
   Fault current = 2000 A ; Relay-1 set on 100% ; CT ratio = 400/5 ; Relay-2 set on 200%. For discrimination the time gradient margin between the relays in 0.84 second.

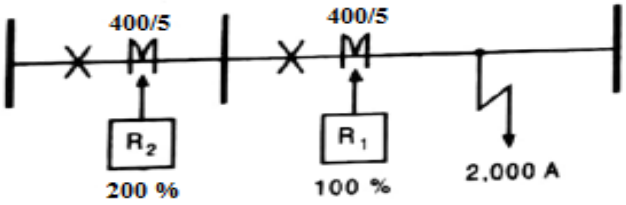

Fig. 3

   (i) Determine the time of operation of the two relays assuming that both the relays have the characteristic as shown in the Table 2 and the Relay-1 has a time multiplier setting = 0.4 .

Table 2

Plug setting multiplier	2	2.5	3.9	5	8.4	10	12	15	20
Time in seconds for a time multiplier of 1	10	8	6	3.9	3.15	2.8	2.6	2.2	2.1

   (ii) Also determine the time multiplier setting of Relay-2.

(1 + 2 + 2 + 2) + (3 + 2) = 12

7. (a) Explain clearly the basic principle of operation of a differential relay. What is meant by per cent bias? How is this achieved in practice in differential relay? Under what circumstances is a percentage differential relay preferred over differential relay?

   (b) Fig. 4 shows the percentage differential relay used for the protection of an alternator winding. The relay has a minimum pick up current of 0.2 Ampere and has a percentage slope of 20%. A high resistance ground fault occurs near the grounded neutral end of the generator winding with the current distribution as shown in Fig. 4. Assume CT ratio of 400/5 in both side. Determine whether the relay will operate or not.

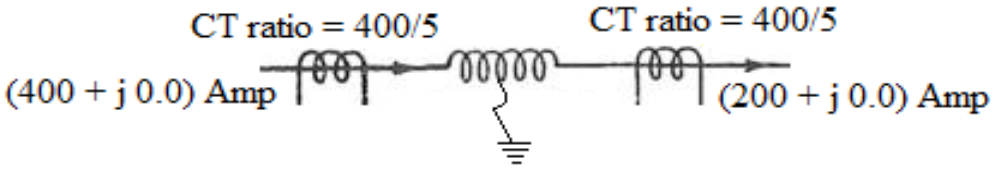

Fig. 4

(2 + 1 + 3 + 2) + 4 = 12

Group – E

8. (a) Explain the following terms in a Circuit Breaker:
   (i) Restriking voltage
   (ii) Recovery voltage
   (iii) RRRV

   (b) A three phase Oil Circuit Breaker is rated at 1200 A, 1000 MVA, 33 kV, 3 seconds. Calculate
   (i) the rated symmetrical breaking current
   (ii) the rated asymmetrical breaking current assuming 50% dc component
   (iii) the rated making current
   (iv) the short time current rating

(2 + 2 + 2) + (2 + 2 + 1 + 1) = 12

9. (a) A 230 kV, 3-phase, 50 Hz transmission line 250 km long consists of three conductors of effective diameter 30 mm arranged in a vertical plane with 4 m spacing and regularly transposed. Find the inductance and kVA rating of the arc suppressor coil.

   (b) What is the difference between system grounding and equipment grounding? What is effectively grounded system? Explain.

6 + (2 + 4) = 12

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