POWER SYSTEM-II
(ELEC 3201)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) If the percentage reactance of a system up to the fault point is 20% and the base MVA is 100, then short circuit MVA is
(a) 200 MVA (b) 400 MVA (c) 500 MVA (d) 800 MVA

(ii) 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

(iii) In which type of unbalanced fault, zero sequence currents do not exist?
(a) LG (b) LL (c) LLG (d) LLLG

(iv) The arc voltage in a circuit breaker is
(a) in phase with the arc current (b) lagging the arc current by 90°
(c) leading the arc current by 90° (d) lagging the arc current by 180°

(v) Why are load flow studies carried out?
(a) To study of stability of the system
(b) For fault calculations
(c) For planning the power system
(d) All of these

(vi) The transient voltage that appears across the contacts of circuit breaker at the instant of arc extinction is called
(a) recovery voltage (b) restriking voltage
(c) supply voltage (d) peak voltage

(vii) The angle δ in the swing equation of a synchronous generator is the
(a) angle between stator voltage and current
(b) angular displacement of the rotor with respect to the stator
(c) angular displacement of the stator mmf with respect to the synchronously rotating axis
(d) angular displacement of the axis fixed to the rotor with respect to the synchronously rotating axis

(viii) The zero sequence current of a generator for line to ground fault is j2.4 pu. Then the current through the neutral during the fault is

(a) j2.4pu (b) j0.8 pu
(c) j7.2 pu (d) j0.24 pu

(ix) Which among the following quantities are specified at the load bus?

(a) P and Q (b) P and |V|
(c) Q and |V| (d) P and δ

(x) The equal area criteria of stability is used for:

(a) No load on the busbar (b) One machine and infinite busbar
(c) More than one machine and infinite (d) Steady state stability analysis

Fill in the blanks with the correct word

(xi) Mho relay is a directional relay with _____ restraint.

(xii) The torque angle, δ for which maximum power transfer takes place, is_____.

(xiii) Transient stability limit is _____ than steady-state stability limit.

(xiv) When Single Line to Ground fault occurs in a three phase system, the voltage of other two healthy phases increase _____ times.

(xv) If a phasor is multiplied by α then the phasor gets rotated in anticlockwise direction by an angle equal to _____.

Group - B

2. (a) Draw and explain equivalent circuits of synchronous machine under subtransient, transient and steady –state conditions. *[(CO1) (Remember/LOCQ)]*

(b) Two 3 phase, 6.6 kV, 5 MVA generators having subtransient reactances of 12.5% operate in parallel. The generators supply power to a transmission linethrough a 10 MVA transformer of ratio 6.6/33kV and having a leakage reactance of 4 %. Calculate fault current and fault MVA for 3-phase fault on HT side of the transformer. *[(CO1) (Analyse/IOCQ)]*

5 + 7 = 12

3. (a) Prove that a line-to-ground fault at the terminals for a synchronous generator with solidly grounded neutral is more severe than a three phase fault.

[(CO1)(Apply/HOCQ)]

(b) A generator of negligible resistance having 1.0 per unit voltage behind transient reactance is subjected to different types of faults.

Type of Fault	Resulting fault current in pu
3- phase	3.33
L-L	2.23
L-G	3.01

Calculate the per unit values of different sequence reactances.

[(CO1)(Analyse/IOCQ)]

6 + 6 = 12

Group - C

4. (a) Explain the equal area criterion for the stability of an alternator supplying infinite bus-bar via an inductive interconnector. Mention the limitations of the method. *[(CO2) (Apply/IOCQ)]*

(b) A synchronous generator of reactance 1.20 pu is connected to an infinite bus bar (|V| =1.0 pu) through transformers and a line of total reactance of 0.60 pu. The generator no load voltage is 1.20 pu and its inertia constant is H= 4 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 loading. *[(CO2) (Analyze/HOCQ)]*

(5 + 1) + 6 = 12

5. (a) Explain the classification of different types of buses in power system for load flow analysis. *[(CO2) (Understand/LOCQ)]*

(b) Obtain the voltage at bus 2 for the power system shown in Fig. 1 using Gauss-Seidel method (up to two iterations). Take $V_1 = 1+j0$ pu.

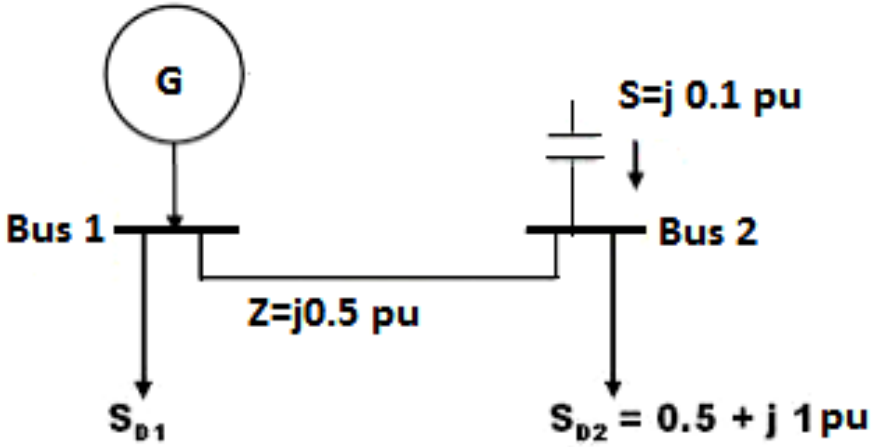

Fig.1

[(CO2)(Analyse/HOCQ)]

(c) For a 15 bus power system with 3 voltage controlled buses calculate the dimension of Jacobian matrix. *[(CO2)(Analyse/HOCQ)]*

4 + 6 + 2 = 12

Group - D

6. (a) Describe the construction and operating principle of induction disc type relay. Also derive its torque equation. *[(CO3)(Apply/IOCQ)]*

(b) Determine the time of operation of an IDMT type overcurrent relay of rating 5A and having a plug setting of 150%. Time setting is 0.6. The relay is connected through a C.T. of 400/5 ratio. The fault current is 3000 A. The relay has the characteristics as shown in the following table.

PSM	2	4	5	8	10	20
Time for unity TMS (in sec)	10	5	4	3	2.8	2.4

[(CO3)(Apply/IOCQ)]

7 + 5 = 12

7. (a) What do you mean by Universal Torque Equation? Using this equation derive the operating characteristics of (i) Reactance relay, (ii) Mho relay.

[(CO3) (Understand/LOCQ)]

(b) In a 440 kV, 3-phase, 50 Hz long transmission line, synchronous impedance of alternator (Z_S) = 5Ω; line impedance (Z_L) = 15 Ω and load impedance (Z_{Load}) = 200 Ω. If the current measured from CT be 60 kA, then determine whether the distance relay will operate or not. Also determine the location of fault.

[(CO3) (Evaluate/HOCQ)]

(1 + 2 + 2) + 7 = 12

Group – E

8. (a) Define the following terms in a Circuit Breaker:
   (i) Restriking voltage
   (ii) Recovery voltage
   (iii) RRRV. *[(CO4) (Understand/LOCQ)]*

   (b) A 11 kV, 500 MVA circuit breaker suddenly closes on to a fault. Determine
   (i) the symmetrical breaking current
   (ii) the asymmetrical breaking current assuming 30% dc component
   (iii) the making current. *[(CO4) (Evaluate/HOCQ)]*

(2 + 2 + 2) + 6 = 12

9. (a) What is the difference between system grounding and equipment grounding? What is effectively grounded system? Explain. *[(CO4)(Apply/IOCQ)]*

   (b) A 50 Hz overhead line has line to earth capacitance of 1.2 μF. It is decided to use an earth fault neutralizer. Determine the reactance to neutralize the capacitance of (i) 100 % of the line length and (ii) 80 % of the line length. *[(CO4) (Apply/IOCQ)]*

(4 + 4) + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	20.83	44.79	34.38

Course Outcome:

After the completion of the course students will be able to

1. To analyze different types of power system faults.
2. To analyze the load flow problems and stability in power system.
3. To discuss the basic principles of Power System relaying and the different protection schemes for various power system components.
4. To discuss the basic principle of Circuit Breaking and grounding.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*