

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) A transformer rated for 500kVA, 11kV / 0.4kV has an reactance of 10% and is connected to an infinite bus. The fault level of the transformer is
 - (a) 500 Kva
 - (b) 500 MVA
 - (c) 20 MVA
 - (d) 5000 kVA
- (ii) 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
- (iii) 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) $j2.4$ pu
 - (b) $j0.8$ pu
 - (c) $j7.2$ pu
 - (d) $j0.24$ pu
- (iv) For 800 MJ stored energy in the rotor at synchronous speed, what is the inertia constant H for a 50 Hz, four pole turbo generator rated 100 MVA, 11 kV?
 - (a) 2.0 MJ/MVA
 - (b) 4.0 MJ/MVA
 - (c) 6.0 MJ/MVA
 - (d) 8.0 MJ/MVA
- (v) 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
- (vi) 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
- (vii) Mho relay is
 - (a) Voltage restrained overcurrent relay
 - (b) Voltage restrained directional relay
 - (c) Directional restrained overcurrent relay
 - (d) Directional restrained overvoltage relay

(viii) Plug setting of a relay can be changed by changing
 (a) Air gap (b) Backstop position
 (c) Number of ampere turns (d) All of these

(ix) The making capacity of a circuit breaker is generally:
 (a) Equal to the breaking capacity (b) Less than the breaking capacity
 (c) 2.55 times the breaking capacity (d) 1.55 times the breaking capacity

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

Fill in the blanks with the correct word

(xi) The severe most fault that may occur at the terminals of an alternator with solidly grounded neutral is _____.

(xii) The torque angle “ δ ” for which maximum power transfer takes place, is _____.

(xiii) Number of slack bus in a power system is _____.

(xiv) The inverse-time overcurrent relay has an operating time that _____ as the fault current increases.

(xv) SF6 circuit breakers are widely used in high-voltage applications because SF6 gas has excellent _____ properties.

Group - B

2. (a) State Fortescue's theorem for three phase unbalanced system. *[(CO1)(Remember/LOCQ)]*
 (b) What are the assumptions made in the analysis of unsymmetrical fault? *[(CO1)(Remember/LOCQ)]*
 (c) A symmetrical 3-phase short circuit occurs on the 22 kV bus-bars of the circuit shown as one line diagram in Fig. 1. Calculate the fault current and fault level. Assume the system was under no load condition before fault. Take 100 MVA as base MVA and transmission line voltage as base voltage at transmission line.

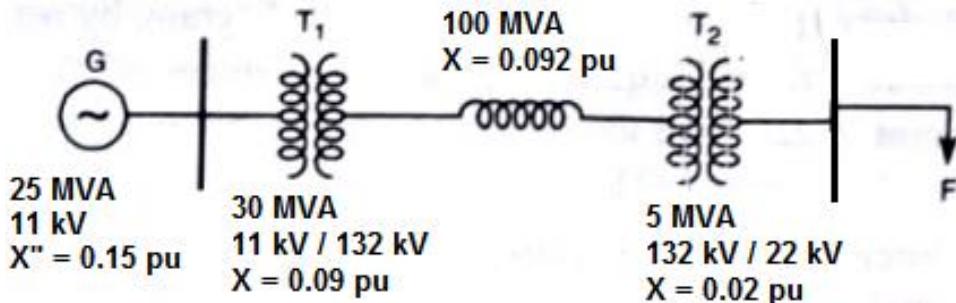


Fig. 1

[(CO1)(Apply/LOCQ)]
 $2 + 2 + 8 = 12$

3. (a) Sketch the positive, negative and zero sequence reactance networks for the power system of Fig. 2. The different sequence reactance of various components of the power system is given in the Table 1. *[(CO1)(Apply/HOCQ)]*

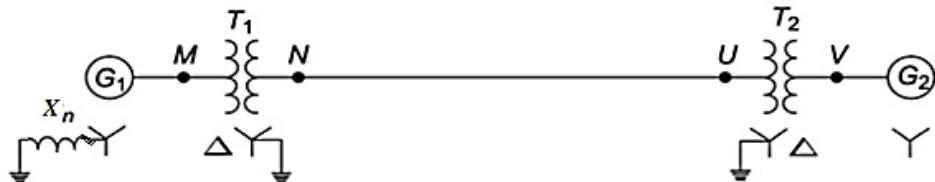


Fig. 2
Table 1

Component	Positive sequence reactance in p.u.	Negative sequence reactance in p.u.	Zero sequence reactance in p.u.	Neutral reactance in p.u.
G ₁	0.17	0.14	0.05	0.3
G ₂	0.17	0.14	0.05	-
T ₁	0.11	0.11	0.11	-
T ₂	0.11	0.11	0.11	-
Line	0.22	0.22	0.60	-

(b) A synchronous generator has following reactances:

$$X_1 = 60\%, X_2 = 25\%, X_0 = 15\%$$

- (i) Calculate the percentage reactance to be added in the generator neutral such that the current for L-G fault does not exceed 1 pu.
- (ii) Calculate the value of resistance to be connected in the neutral to achieve the same purpose.

[(CO1)(Apply/IOCQ)]

$$(2 + 2 + 3) + 5 = 12$$

Group - C

4. (a) Explain the equal-area criterion for the stability of an alternator supplying infinite busbar via an inductive interconnector. [(CO2)(Apply/IOCQ)]

(b) A two-pole, 50 Hz, 60 MVA turbo-generator has a moment of inertia of 9×10^3 kg-m². Calculate

- (i) the kinetic energy in MJ at rated speed,
- (ii) the inertia constants M and H,
- (iii) the inertia constant on 50 MVA base.

[(CO2)(Analyse/HOCQ)]

$$6 + 6 = 12$$

5. (a) What are the advantages and disadvantages of Newton-Raphson method over Gauss-Seidel method in load flow analysis. [(CO2)(Understand/LOCQ)]

(b) Find the bus admittance matrix for the given 3-bus system of Fig. 3 below. (all the impedances and reactances are given in ohm). [(CO2)(Apply/IOCQ)]

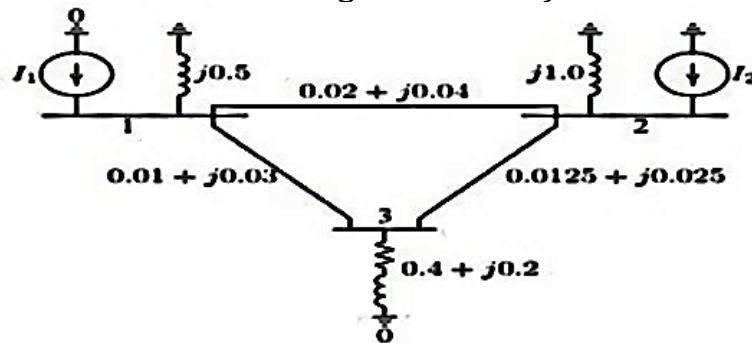


Fig. 3

$$5 + 7 = 12$$

Group - D

6. (a) Determine the time of operation of an Over current relay of current rating 5A and having a relay current setting of 125%. Time setting is 0.9. It is connected to a supply circuit through a C.T. of 200/5 ratio. The fault current is 1000 A.

PSM	2	4	5	8	10	20
Operating Time(sec)	10	5	4	3	2.8	2.4

[(CO3)(Evaluate/HOCQ)]

(b) Using universal torque equation, derive and draw the operating characteristics of
 (i) Impedance relay and (ii) Reactance relay.

[(CO3)(Apply/IOCQ)]

6 + 6 = 12

7. (a) A 3-phase, 132 kV/11 kV power transformer is connected in star-delta. The transformer is protected by Mertz-Price circulating current system. CTs on LV side have a ratio of 200/5. How to connect the CTs on HV side and what will be CT ratio on HV side.

[(CO3)(Explain/HOCQ)]

(b) 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?

[(CO3)(Understand/LOCQ)]

6 + (2 + 1 + 3) = 12

Group - E

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

[(CO4)(Understand/LOCQ)]

(b) A three-phase circuit breaker is rated at 1250 A, 2000 MVA, 33 kV, 4- second. Determine

(i) The rated normal current, (ii) The rated symmetrical breaking current,
 (iii) Making current and (iv) Short-time rating

[(CO4)(Evaluate/HOCQ)]

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

9. (a) Briefly describe the following grounding in power system.
 (i) Solid grounding (ii) Resistance grounding

[(CO4)(Understand/LOCQ)]

(b) An 11 kV, 50 Hz alternator is connected to a system which has inductance and capacitance per phase of 10 mH and 0.01 μ F respectively. Determine (i) the maximum voltage across the breaker contacts, (ii) frequency of transient oscillation, (iii) the average RRRV and (iv) the maximum RRRV.

[(CO4)(Evaluate/HOCQ)]

(3 + 3) + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	27	32	37