This question paper contains 3 printed pages.

3300 *Your Roll No.* .....

B. Tech. (E) / IV **J**

Paper EEE–402— SWITCHGEAR AND PROTECTION

Time : 3 hours *Maximum Marks* : 70

(Write your Roll No. on the top immediately on receipt of this question-paper.)

Attempt any five questions.
All questions carry equal marks.

Assume missing data, suitably, if any.

1. (*a*) Describe the construction, principle of operation and applications of (*i*) Rod gaps; (*ii*) Expulsion gap; and (*iii*) Valve type lightning arrester. 9

   (*b*) A 25 MVA, 13·2 kV alternator with solidly grounded neutral has a sub-transient reactance of 0·25 p.u. The Negative and Zero sequence reactances are 0·35 and 0·19 p.u. respectively. A single line-to-ground fault occurs at the terminals of an unloaded alternator. Determine the fault current. 5

2. (*a*) Differentiate between (*i*) a lightning arrester and a lightning conductor, and (*ii*) a surge diverter and a surge absorber. 6

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(*b*) A 30 MVA, 33 kV, 3-phase alternator has internal reactance of 4% and negligible resistance. Find the external reactance per phase to be connected in series with the alternator so that steady current on short circuit does not exceed 10 times the full-load current. 6

(*b*) Draw the zero-sequence network of a generator, when the neutral is solidly grounded; grounded with Z_n and ungrounded. 2

3. (*a*) A generator rated 100 MVA, 20 kV has $X_1 = X_2 = 20\%$ and $X_0 = 5\%$. Its neutral is grounded through a reactor of 0·32 ohms. The generator is operating at rated voltage with load and is disconnected from the system when a double-line-to-ground (L–L–G) fault occurs at its terminals. Find the sub-transient current in the faulted phase and line to line voltages. 6

(*b*) The line currents in amperes in phases *a*, *b* and *c* respectively are $500+j150$, $100-j600$ and $-300+j600$ referred to the same reference vector. Find the symmetrical components of current. 3

(*c*) Explain the process of Arc-development and its extinction in vacuum circuit breaker. 5

4. (*a*) In a short circuit test on a 132 kV, 3 phase system, the ckt. breaker gave the following results: p.f. of the fault 0·4, recovery voltage 0·95 of full-line value; the breaking current is symmetrical and the restriking transient has a neutral frequencey of 16

kHz. Determine the rate of rise of restriking voltage. Assume that fault is grounded. 6

(*b*) Explain the terms (*i*) Restriking Voltage; (*ii*) Recovery Voltage; and (*iii*) RRRV.

Derive an expression for the restriking voltage in terms of system voltage, inductance and capacitance, across a C.B. contact when a 3-phase fault takes place. Assume the neutral of the system to be solidly grounded. 8

5. (*a*) Describe the construction, principle of operation and application of SF_6 circuit breaker. How does this breaker essentially differ from an air blast breaker? 10

(*b*) What is tower-footing resistance? What are the methods to reduce this resistance? 4

6. (*a*) What is Universal Torque Equation? Using this equation derive the following characteristics: (*i*) impedance relay; (*ii*) reactance relay; (*iii*) mho relay. Draw the characteristics and indicate clearly the zones of operation and no-operation. 10

(*b*) What is meant by 3-zone protection? 4

7. (*a*) Explain clearly the V–I and polar characteristics of a directional relay. 6

(*b*) Classify and explain the over-current relays on the basis of the time of operation. 8

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