

CSM—29/24
PART—II/PAPER—VII
ELECTRICAL ENGINEERING
PAPER—II

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Time : 3 Hours

Full Marks : 250

*The question paper contains 18 (Eighteen) questions
in GROUP—A, (12) and GROUP—B, (06) together.*

GROUP—A

Candidates to attempt 10 (ten) questions within word limit of 250.

Each question carries 15 marks.

1. There is a parallel circuit having two branches. The current in one branch is $I_1 = 100 \pm 2 \text{ A}$ and in the other current is $I_2 = 200 \pm 5 \text{ A}$. Determine the value of the total current $I = I_1 + I_2$. First consider the errors in I_1 and I_2 as limiting errors. Then consider the errors as standard deviation error. Comment upon the results.
2. A three-phase 50 Hz transmission line is 400 km long. The voltage at the sending end is 220 kV. The line parameters are $R = 0.125 \text{ ohm/km}$, $X = 0.4 \text{ ohm/km}$ and $Y = 2.8 \times 10^{-6} \text{ mho/km}$. Find the following :

The sending end current and receiving end voltage when there is no load on the line.

The maximum permissible line length if the receiving end no-load voltage is not to exceed 235 kV.
3. For a unity feedback system, $G(s) = 200 / s(s+8)$ and $r(t) = 2t$, determine steady state error. If it is desired to reduce this existing error by 5%, then find the new value of the gain of the system.

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4. A synchronous generator of reactance 1.2 pu is connected to an infinite bus bar ($V = 1$ pu) through transformers and a line of total reactance of 0.6 pu. The generator no-load voltage is 1.2 pu and its inertia constant is 4 MW-s/MVA. The system frequency is 50 Hz. Calculate the frequency of natural oscillations if the generator is loaded to 50% and 80% of its maximum power limit.
5. Draw the configuration of Hay's bridge and obtain the bridge balance conditions. Show that if the Q value of an unknown inductor is high, the expression for the inductance value is independent of frequency. If the Q value is high, calculate the value of the inductor if the bridge component values at balance are as follows :

$$R_2 = R_3 = 1000 \text{ ohm}; C_4 = 0.02 \mu\text{F}.$$

6. Consider the system with the following open loop transfer function :

$$G(s)H(s) = K(s + z) / (s + p_1)(s + p_2)$$

Examine the root loci for the following three cases :

$$\text{Case 1: } z > p_1 > p_2$$

$$\text{Case 2: } p_1 > p_2 > z$$

$$\text{Case 3: } p_1 > z > p_2$$

7. Consider a pure Si crystal that has $\epsilon_r = 11.9$ and the density of the Si crystal is given as $5 \times 10^{28} \text{ m}^{-3}$. What is the electronic polarizability due to valence electrons per Si atom? Suppose that a Si crystal sample is polarized and has a voltage applied across it. By how much is the local field greater than the applied field?
8. A 40 MVA, 3-phase, 345/34.5 kV transformer is star/delta connected. Select the standard CT ratios on the two sides of the transformer for percentage differential protection of the transformer. Would an autotransformer be required? If so, what should be its current ratio?

9. Calculate the Nyquist rate and Nyquist interval for $x(t) = 10\cos(2000\pi t)\cos(1000\pi t)$. What will happen if sampling frequency is less than the highest frequency component present in the sampled signal? How is PAM different from PTM?

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10. What factors decide the limit of visibility in satellite? Considering an earth station at the equator, with the antenna pointing either west or east along the horizontal, calculate the limiting angle.

A satellite is orbiting in the equatorial plane with a period from perigee to perigee of 12 hrs. Given the eccentricity is 0.002. Calculate the semi-major axis. The earth's equatorial radius is 6378.1414 km.

11. What is the main feature of tidal cycle? Describe the working of a single basin tidal power plant. What are the advantages and limitations of tidal power generation?

12. Classify the various types of the overcurrent relays and give their applications along with characteristics.

What is meant by current chopping? What is the effect of current chopping and name the circuit breaker that deals with current chopping phenomena?

GROUP—B

Candidates to attempt 05 (five) questions within word limit of 300.

Each question carries 20 marks.

13. Explain the working of LVDT.

The output of an LVDT is connected to a 5 V voltmeter through an amplifier whose amplification factor is 250. An output of 2 mV appears across the terminals of LVDT when the core moves through a distance of 0.5 mm. Calculate the sensitivity of the LVDT and that of the whole setup. The milli-voltmeter scale has 100 divisions. The scale can be read to 1/5 of a division. Calculate the resolution of the instrument in mm.

14. Consider the system with the following open-loop transfer function :

$$G(s)H(s) = K(1 + sT_2) / s^2(1 + sT_1)$$

Draw Nyquist plots and determine the stability of the system for

$$T_1 = T_2$$

$$T_1 < T_2$$

$$T_1 > T_2$$

Explain how relative value of T_1 and T_2 affects stability.

15. In a short circuit on 132 kV, 3-phase system, the breaker gave the following results :

Power factor of the fault = 0.45

Recovery voltage = 0.9 time full line voltage

The breaking current is symmetrical and the restriking transient had a natural frequency of 15 kHz. Determine the Rate of Rise of Restriking Voltage (RRRV) for the following types of faults :

Grounded fault

Ungrounded fault

16. Calculate the drift mobility and the mean scattering time of conduction electrons in copper at room temperature, given that the conductivity of copper is $5.9 \times 10^5 \Omega^{-1} \text{cm}^{-1}$. The density of copper is 8.96g cm^{-3} and its atomic mass is 63.5gmol^{-1} .

If the mean speed of the conduction electrons in Cu is roughly $1.6 \times 10^6 \text{ms}^{-1}$, what is the mean free path between collisions?

17. Distinguish between block codes and convolution codes.

Determine which of the following (n, k) linear binary block codes are perfect codes :

(7, 4) code with a $d_{\min} = 3$.

(6, 3) code with a $d_{\min} = 3$.

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18. Briefly explain the CVD technique for deposition of polysilicon. Write the different steps involved in monolithic circuit formation. How is resist mask removed after etching and diffusion of impurities?

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