SECTION A

*Answer any **THREE** questions from this section.*

1. (a) State **three** general requirements of any power protection system. (3 marks)

(b) (i) With aid of a diagram, describe the graded time protection in power systems.

(ii) Explain **three** disadvantages of the protection system in (b) (i). (12 marks)

(c) Draw a labelled equivalent circuit diagram of a magnetic core balance protection scheme. (5 marks)

2. (a) State **four** types of power line faults. (4 marks)

(b) With aid of phasor diagrams, explain the following:

(i) positive phase sequence;
(ii) negative phase sequence;
(iii) zero phase sequence. (6 marks)

(c) Determine the values of the positive phase sequence of symmetrical components of a system of currents; $I_R = 300\angle 0°$, $I_Y = 400\angle 240°$ and $I_B = 200\angle 90°$. The phase sequence is RYB. (10 marks)

3. (a) State **three** classifications of transmission lines. (3 marks)

(b) With respect to overhead transmission lines:

(i) Explain the term 'voltage surge';

(ii) Outline **three** causes of voltage surges. (5 marks)

(c) With aid of a diagram, explain the operation of the Peterson coil. (7 marks)

(d) An overhead transmission line having an inductance of 1.28 mH per km and a capacitance of 0.00602 μF per km is connected in series with an underground cable having an inductance of 0.167 mH per km and a capacitance of 0.201 μF per km. Determine the surge velocities in:

(i) transmission line;
(ii) underground cable. (5 marks)

4. (a) State **four** types of conductor vibrations. (4 marks)

(b) Explain the importance of the synchronous phase modifier in transmission lines. (3 marks)

(c) An overhead transmission line hangs in the form of a catenary

$y = C\cosh\frac{x}{c}$, where $C = 1025$ m and x is half the span.

The span is 205 m and the conductor mass is 1.39 kg per metre.

Determine the:

(i) length of the conductor;
(ii) sag.

(11 marks)

(d) State **two** advantages of miniature circuit breakers over high rupturing capacity fuses. (2 marks)

5. (a) Explain 'steady state stability' with reference to power systems. (3 marks)

(b) (i) Describe the phenomena of corona in overhead transmission lines.

(ii) Outline **three** factors affecting corona.

(6 marks)

(c) A three phase 275 KV, 50 Hz transmission line is 40 km long. It consists of three conductors each of diameter 2.05 cm symmetrically spaced 2.66 m between centres. The barometric pressure is 76 cm of mercury and the temperature is $8°C$. The irregularity factor is 0.72. Determine the total corona power loss in the line. (11 marks)

SECTION B

*Answer any **TWO** questions from this section.*

6. (a) State **two** properties of a uniform plane wave. (2 marks)

(b) Using Maxwell's equations, derive the wave equation in free space for:

(i) $\bar{E}$;
(ii) $\bar{H}$

(10 marks)

(c) (i) Derive a relationship for $\bar{E}$ and $\bar{H}$ components for a uniform plane wave travelling in x-direction.

(ii) A TEM wave has an electric field intensity of 1 $\mu V/M$ and travels in a lossless media of relative permittivity of 5. Determine the magnetic field intensity.

(8 marks)

7. (a) Distinguish between wave propagation and wave polarization in electromagnetic fields.

(4 marks)

(b) For a wave propagating in a conducting medium, show that:

$\beta = \frac{\omega\mu\delta}{2\alpha}$, where

β = Phase constant (wave number)

μ = Absolute permeability

δ = Conductivity of medium

α = Attenuation constant

ω = Angular velocity

(7 marks)

(c) Derive Poynting's equation for the total power dissipated per unit volume in a wave.

(9 marks)

8. (a) Write the word statements for each of the Maxwell's equations in time varying fields.

(8 marks)

(b) State:

(i) **two** sources of electromagnetic radiations (EM);
(ii) **one** application for each of the following EM radiations:

(I) x-rays;
(II) Gamma-rays.

(4 marks)

(c) Verify Gauss divergence Theorem for a vector field

$D = \rho^2 Cos^2\phi\hat{a}_\rho + Z\sin\phi\hat{a}_\phi$

over any closed surface bounded by $\rho = 4,\ 0 \leq Z \leq 1$

(8 marks)

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