CLASS TEST

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POWER SYSTMS-1

ELECTRICAL ENGINEERING

Date of Test : 02/10/2023

ANSWER KEY

1.	(a)	7.	(b)	13.	(b)	19.	(c)	25.	(c)
2.	(a)	8.	(b)	14.	(c)	20.	(a)	26.	(a)
3.	(c)	9.	(a)	15.	(a)	21.	(b)	27.	(b)
4.	(a)	10.	(d)	16.	(c)	22.	(d)	28.	(b)
5.	(b)	11.	(d)	17.	(a)	23.	(c)	29.	(b)
6.	(a)	12.	(a)	18.	(a)	24.	(d)	30.	(a)

DETAILED EXPLANATIONS

1. (a)

Flow duration curve is a very convenient form of hydrograph for determining the available power at the site.

2. (a)

As the transformer is the most costliest equipment in the substation, lightning arrester is placed near to it.

3. (c)

The cost of generation in steam power plant is lesser than that of diesel power plant.

4. (a)

Pumped storage and diesel generating stations are peak load generating plants.

5. (b)

If x is the number of layers, then the total number of strands is obtained by,

$$N = (3x^2 - 3x + 1)$$
$$= 3(3^2) - (3 \times 3) + 1$$
$$= 27 - 9 + 1$$
$$N = 19$$

7. (b)

$$\text{Reactive power, } Q = \frac{V}{X} \cdot \Delta V$$
$$Q = \frac{1}{0.4} \times \frac{7\text{ kV}}{400\text{ kV}}$$
$$Q = 0.04375 \text{ p.u.} = 0.04375 \times 1000 \text{ MVA}$$
$$= 43.75 \text{ MVAR}$$

9. (a)

$$X_{L,\,sh} \text{ under no-load condition} = \frac{B}{1-A} = \frac{150\angle 90°}{1-0.9} = j1500\ \Omega$$
$$X_{L,\,sh} = 1500\angle 90°\ \Omega$$

10. (d)

$$\text{Loss tangent of the cable} = \tan\delta = \frac{\frac{V}{R_i}}{V\omega C_i} = \frac{I_i}{I_c}$$
$$\tan\delta = \frac{1}{\omega C_i R_i} = \frac{1}{2\pi f C_i R_i}$$
$$= \frac{1}{2\pi \times 50 \times 1 \times 10^{-6} \times 1 \times 10^{6}}$$
$$= \frac{1}{100\pi}$$

11. (d)

$$\text{Dielectric power loss} = P_L = 3 \times V_{ph}^2 \times \omega C_i \times \tan\delta$$
$$= 3 \times (100 \times 10^3)^2 \times 2\pi \times 50 \times 1 \times 10^{-6} \times 2 \times 10^{-4}$$
$$P_L = 600\,\pi\ \text{W/km}$$

12. (a)

The magnitude of surge transmitted through cable = V_t

$$V_t = V_i \cdot \frac{2Z_2}{Z_1 + Z_2} = 100 \times \left(\frac{2 \times 40}{440}\right) = 18.18\ \text{kV}$$

13. (b)

For a T-model,

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} 1 & \frac{Z_L}{2} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ Y_L & 1 \end{bmatrix} \begin{bmatrix} 1 & \frac{Z_L}{2} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$

$$= \begin{bmatrix} 1 + \frac{Z_L Y_L}{2} & Z_L\left(1 + \frac{Z_L Y_L}{4}\right) \\ Y_L & 1 + \frac{Z_L Y_L}{2} \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$

$$\frac{A-1}{C} = \frac{1 + \frac{Z_L Y_L}{2} - 1}{Y_L} = \frac{Z_L}{2}$$

$$\therefore \quad \frac{Z_L}{2} = \frac{A-1}{C}$$

14. (c)

$$K = \frac{C_m}{C_s} = 0.20$$
$$V_3 = V_1(K^2 + 3K + 1) = 11\ (0.2^2 + (3 \times 0.2) + 1)$$
$$V_3 = 18.04\ \text{kV}$$

15. (a)

$$\text{kVA}_1 = \frac{\text{kW}}{\cos\phi} = \frac{20}{1} = 20\ \text{kVA}$$

Similarly, $$\text{kVA}_2 = \frac{100}{0.707} = 141.4\ \text{kVA}$$

and, $$\text{kVA}_3 = \frac{50}{0.9} = 55.5\ \text{kVA}$$

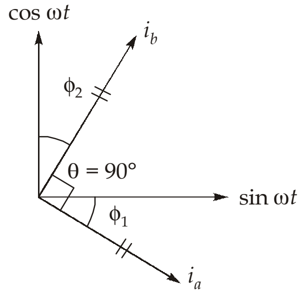
Now, $$\text{kVAR}_1 = \text{kVA}_1 \sin\phi_1 = 20 \times 0 = 0$$
$$\text{kVAR}_2 = \text{kVA}_2 \sin\phi_2 = 141.4 \times 0.707 = 100\ \text{kVAR}$$
$$\text{kVAR}_3 = \text{kVA}_3 \sin\phi_3 = 55.5 \times 0.436$$
$$= -24.2\ \text{kVAR} \quad \text{[Minus sign is taken since leading]}$$

The magnitude of resultant kVAR is,

$$= 100 - 24.2$$
$$= 75.8\ \text{kVAR}$$

16. (c)

According to phasor diagram of a two phase system,



For balanced two phase system,

$$\theta = 90°$$

$$\therefore \quad \phi_1 = \phi_2$$

17. (a)

Given, Operating torque, $T_o = aVI\cos(\phi - \alpha)$

Restraining torque, $T_r = bV^2$

For relay to operate, $T_o > T_r$

$$aVI\cos(\phi - \alpha) > bV^2$$

$$Y\cos(\phi - \alpha) > \frac{b}{a}$$

$$\frac{a}{b} > \frac{1}{Y\cos(\phi - \alpha)}$$

18. (a)

The C.T. secondary current, $I_S = \dfrac{I_P}{n}$

Where, $n = \dfrac{500}{5}$

$$\therefore \quad I_S = 7500 \times \frac{5}{500} = 75 \text{ A}$$

Relay current setting = 125% of 5A = 1.25 × 5 = 6.25 A

$$\therefore \quad \text{Plug setting multiplier (PSM)} = \frac{75}{6.25} = 12$$

Using data in characterstic table

Operating time corresponding to PSM = 12 is 2.8 sec (at TMS = 1)

Operating time of relay = 2.8 sec × 0.4 = 1.12 sec.

19. (c)

$$\text{Diversity factor} = \frac{\Sigma \text{ Individual maximum demand of consumers}}{\text{Maximum load of the system}}$$

20. (a)

$$\lambda = \frac{2\pi}{\beta} = \frac{2\pi}{0.00127} = 4947.39 \text{ km}$$

$$\text{Ratio} = \frac{\text{line length}}{\text{wave length}} = \frac{300 \text{ km}}{4947.39 \text{ km}} = 0.0606$$

$$\%\text{ratio} = 6.06\%$$

21. (b)

$$\text{Given, } V_s = 120 \text{ kV},$$
$$V_r = 110 \text{ kV}$$
$$A = 0.96$$
$$\alpha = 10°,$$
$$B = 100$$
$$\beta = 80°$$

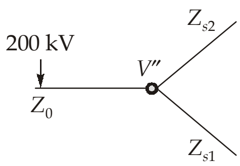
Maximum power transmitted is given by,

$$P_{max} = \frac{V_s \cdot V_r}{B} - \frac{AV_r^2}{B}\cos(\beta - \alpha)$$
$$= \frac{110 \times 120}{100} - \frac{0.96 \times (110)^2}{100}\cos(80° - 10°)$$
$$P_{max} = 92.27 \text{ MW}$$

22. (d)

$$K = \frac{C}{5C} = 0.2$$
$$V_3 = V_1(1 + 3K + K^2)$$
$$= V_1(1 + (3 \times 0.2) + (0.2)^2)$$
$$V_3 = 1.64\ V_1$$

23. (c)



$$\frac{V''}{V} = \frac{\frac{2}{Z_0}}{\frac{1}{Z_0} + \frac{1}{Z_{s1}} + \frac{1}{Z_{s2}}} = \frac{\frac{2}{500}}{\frac{1}{500} + \frac{1}{1000} + \frac{1}{600}}$$
$$\frac{V''}{200 \times 10^3} = \frac{6}{7} = 0.8571$$
$$V'' = 0.8571 \times 200 \times 10^3$$
$$V'' = 171.42 \text{ kV}$$

24. (d)

$$P_{transmitted} = VI \qquad \text{for 2-wire DC system}$$
$$= \text{constant}$$

$\Rightarrow$ $$V_1 I_1 = V_2 I_2$$

or $$\frac{I_1}{I_2} = \frac{V_2}{V_1} = 2$$

$$P_{loss} = I^2 R_{line} = \text{Constant}$$

$\Rightarrow$ $$I_1^2 R_1 = I_2^2 R_2$$

or $$\frac{R_2}{R_1} = \left(\frac{I_1}{I_2}\right)^2 = 4$$

$\therefore$ $$R_2 = 4R_1$$

Since conduction length is same (given),

$\therefore$ $$R \;\alpha\; \frac{1}{A}$$

or, $$R \;\alpha\; \frac{1}{\text{Conductor material}}$$

Thus, $$(\text{Conductor material})_2 = \frac{1}{4}(\text{Conductor material})_1$$

So, $$\text{Material saving} = \frac{3}{4}\ (\text{Conductor material})_1$$

$\therefore$ $$\text{Percentage material saving} = \frac{3}{4}\times 100 = 75\%$$

25. (c)

Reactive power of capacitor,

$$Q_C \propto V^2\omega$$
$$Q_C \propto V^2 f$$

$$\therefore \text{ Reactive power supplied} = \left(\frac{1.1\times 33}{33}\right)^2 \times \left(\frac{0.85\times f}{f}\right)\times 100$$
$$= 102.85 \text{ MVAR}$$

26. (a)

Number of units, $n = 3$

Ratio of shunt capacitance to self capacitance,

$$K = \frac{0.15C}{C} = 0.15$$

Voltage across bottom most unit,

$$V_3 = \text{safe working voltage of the unit} = 20 \text{ kV}$$

So voltage across top most unit,

$$V_1 = \frac{V_3}{1+3K+K^2} = \frac{20}{1+3(0.15)+(0.15)^2} = \frac{20}{1.4725}$$
$$V_1 = 13.58 \text{ kV}$$

Voltage across middle unit,

$$V_2 = V_1(1 + K)$$
$$= (13.58 \text{ kV})\ (1 + 0.15)$$
$$= 15.617 \text{ kV}$$

Maximum safe working voltage of the string,

$$V = V_1 + V_2 + V_3$$
$$= 13.58 + 15.617 + 20$$
$$V = 49.197 \text{ kV}$$

$$\text{String efficiency} = \frac{V}{nV_n}\times 100 = \frac{49.197}{3\times 20}\times 100 = 81.995 \approx 82\%$$

27. (b)

Taking moments of all currents at A,

$$I_B \times 600 = 200 \times 400 + 75 \times 150 + 50 \times 100$$

$$\Rightarrow \quad I_B = 160.4 \text{ Amp}$$

$$\therefore \quad I_A = (200 + 50 + 75) - 160.4 = 164.6 \text{ Amp}$$

Therefore, location of point of minimum potential is 320.8 meters from end B.

The potential drop up to the minimum potential is

$$= 2 \times \frac{0.05}{1000}\left[(164.6 \times 100) + (114.6 \times 50) + (39.6 \times 50) + \frac{39.6}{2} \times 39.6\right]$$

$$= 2.5 \text{ Volts}$$

$$V_{min} = 220 - 2.5 = 217.5 \text{ Volts}$$

28. (b)

$$C_A = 0.90 \ \mu\text{F/km},$$

$$C_B = 0.40 \ \mu\text{F/km}$$

$$C_1 = \frac{1}{3}C_A = 0.3 \ \mu\text{F/km}$$

$$C_2 = \frac{1}{2}(0.4 - 0.3) = 0.05 \ \mu\text{F/km}$$

$$C_n = C_1 + 3C_2 = 0.3 + 3 \times 0.05 = 0.45 \ \mu\text{F/km}$$

For 20 km, $= 20 \times 0.45 = 9.0 \ \mu\text{F}$ for 20 km

29. (b)

On a per phase basis,

$$V_R = 6351 \text{ V}$$

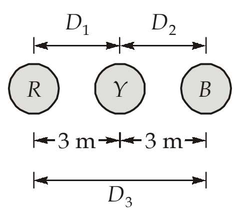
$$V_S = (1 + 0.05)\,6351 = 6668.6 \text{ V}$$

$$Z = \sqrt{(0.3)^2 + (0.4)^2} = 0.5 \ \Omega$$

$$P_{max} = \frac{V_R^2}{Z^2}\left(\frac{ZV_S}{V_R} - R\right) = \left(\frac{6351}{0.5}\right)^2\left(\frac{0.5 \times 6668.6}{6351} - 0.3\right) = 36.3 \text{ MW/phase}$$

Total maximum power $= 3 \times 36.3 = 108.9$ MW

30. (a)



$$\text{Inductance, } L = \frac{\mu_0}{2\pi}\ln\left(\frac{d}{r'}\right) = \frac{\mu_0}{2\pi}\ln\left(\frac{(D_1 D_2 D_3)^{1/3}}{r'}\right)$$

$$= 2 \times 10^{-7} \ln\left(\frac{(3 \times 3 \times 6)^{\frac{1}{3}}}{0.7788 \times \frac{10^{-2}}{2}}\right)$$

$$L = 1.375 \text{ mH/km/phase}$$

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