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TEST SERIES

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ESE-2017 : Prelims Exam

UPSC Engineering Services Examination

ELECTRICAL ENGINEERING

Answer Key & Solutions

Test 3: Part Syllabus Technical

Power Systems

1. (c)
2. (d)
3. (d)
4. (b)
5. (d)
6. (c)
7. (a)
8. (c)
9. (a)
10. (c)
11. (c)
12. (a)
13. (c)
14. (a)
15. (a)
16. (b)
17. (d)
18. (b)
19. (d)
20. (c)
21. (c)
22. (b)
23. (c)
24. (d)
25. (a)
26. (d)
27. (c)
28. (d)
29. (d)
30. (c)
31. (d)
32. (b)
33. (d)
34. (c)
35. (c)
36. (c)
37. (c)
38. (a)
39. (b)
40. (d)
41. (a)
42. (b)
43. (c)
44. (b)
45. (b)
46. (d)
47. (c)
48. (d)
49. (d)
50. (a)
51. (b)
52. (d)
53. (d)
54. (d)
55. (d)
56. (b)
57. (d)
58. (b)
59. (a)
60. (d)
61. (b)
62. (b)
63. (a)
64. (b)
65. (a)
66. (a)
67. (a)
68. (b)
69. (a)
70. (c)
71. (d)
72. (a)
73. (a)
74. (a)
75. (a)

DETAILED EXPLANATIONS

1. (c)

$$\text{Load factor} = \frac{\text{Average demand}}{\text{Maximum demand}}$$

$$0.60 = \frac{\text{Average demand}}{25}$$

$$\text{Average demand} = 15 \text{ MW}$$

$$\text{Plant capacity factor} = \frac{\text{Average demand}}{\text{Installed capacity}}$$

$$0.50 = \frac{15}{\text{Installed capacity}}$$

$$\text{Installed capacity} = \frac{15}{0.50} = 30 \text{ MW}$$

The energy corresponding to installed capacity per day

$$= 30 \times 24 = 720 \text{ MWh}$$

2. (d)

Pollutants that emit from coal based power plants are

(i) SO_2 (oxides of Sulphur)

(ii) NO_x (oxides of Nitrogen), NO_2 is a major concern as a pollutant

(iii) CO, CO_2 (oxides of Carbon)

(iv) Hydrocarbons during the oxidation process in Combustion chamber.

4. (b)

Nuclear power stations have very high capital cost and very low fuel cost. Thus they are considered as base load power stations.

5. (d)

$$P_{\text{wind}} = 0.5 \rho A v^3 \text{ W}$$

Where,

ρ = air density (kg/m^3)

v = wind speed in km/h

A = swept area (m^2)

7. (a)

$$\text{Total load, } P_{G_1} + P_{G_2} = 250 \text{ MW}$$

For optimum load sharing,

$$\frac{dC_1}{dP_{G_1}} = \frac{dC_2}{dP_{G_2}}$$

$$0.20P_{G_1} + 40.0 = 0.25P_{G_2} + 30.0$$

$$5P_{G_1} - 4P_{G_1} = 200 \qquad \text{...(i)}$$

$$P_{G_1} + P_{G_2} = 250 \qquad \text{...(ii)}$$

On solving equations (i) and (ii), we obtain

$$P_{G_1} = \frac{350}{3}\text{ MW}$$

and

$$P_{G_2} = \frac{400}{3}\text{ MW}$$

9. (a)

For economic operation of power system, the incremental cost of production of individual units should be equal to λ.

i.e.

$$\frac{dC_1}{dP_{G_1}} = \frac{dC_2}{dP_{G_2}} = \ldots\ldots = \frac{dC_n}{dP_{G_n}} = \lambda$$

10. (c)

Diversity factor:

The ratio of the individual maximum demands of all the consumers supplied by it to the maximum demand of the power station.

$$\text{Diversity factor} = \frac{\text{Sum of individual maximum demands}}{\text{Maximum demand of power station}}$$

12. (a)

The distance between the phase conductors in underground cable is very small as the result of which proximity effect is dominant.

13. (c)

Capacitance from phase to neutral is given as

$$C_n = \frac{q_n}{V_{an}} = \frac{2\pi \in}{ln\left(\frac{D_m}{r}\right)}\text{ F/m}$$

$$= \frac{2\pi \in}{10^{-3}ln\left(\frac{D_m}{r}\right)}\text{ F/km}$$

14. (a)

Geometric mean radius = GMR = D_s

$$D_s = \sqrt[4]{D_{aa}.D_{ab}.D_{ac}.D_{ad}}$$

$$= \sqrt[4]{r' \times 2r \times 2r \times 2\sqrt{2} \times r}$$

$$D_s = r\sqrt[4]{8.8}$$

15. (a)

Due to Skin effect, $r_{ac} = 0.7788\, r_{dc}$

⇒ $R_{ac} > R_{DC}$

$$Z_s = \text{Surge impedance} = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{L}{C}}$$

16. (b)

If it is a synchronous generator then we have:

- (i) field excitation
- (ii) prime mover input/excitation

If it is a synchronous motor then we have:

- (i) field excitation
- (ii) stator excitation

17. (d)

$$\text{Stress} = \frac{\text{Tensile load}}{\text{Area of cross section}}$$

$$= \frac{120 \times 10^3}{12 \times 10^{-4}} = 10^8 \text{ N/m}^2$$

$$= 10^5 \text{ KN/m}^2$$

19. (d)

$$\text{Velocity of propagation, } v = 3 \times 10^8 \text{ m/sec}$$

$$\text{Electrical line length} = \beta l = \frac{6^\circ \times \pi}{180^\circ} \text{ rad}$$

$$\text{Velocity} = v = \lambda f$$

$$\lambda = \frac{2\pi}{\beta}$$

$$v = \frac{2\pi f}{\beta}$$

$$\beta = \frac{2\pi f}{v}$$

We have,

$$l = \frac{6\pi}{180 \times \beta}$$

$$l = \frac{6\pi \times v}{180 \times 2\pi \times f}$$

$$\text{length of the line, } l = \frac{6\pi \times 3 \times 10^8}{180 \times 2\pi \times 50} = 100 \text{ km}$$

21. (c)

Corona effects can be minimized in a transmission line by using large diameter conductors which may be accomplished by using hollow conductors.

22. (b)

Impedance of an ideal transmission line is surge impedance. The impedance of a line for which capacitive VAR is equal to the inductive VAR is called surge impedance. On the other hand, impedance of a practical transmission line is called characteristic impedance.

23. (c)

If we increase the spacing between the phase conductors, the line capacitance decreases.

25. (a)

Let ΔV = Voltage fluctuation

ΔQ = Reactive power variation (i.e. the size of the compensator)

$S_{s/c}$ = System short circuit capacity

Then, $$\Delta V = \frac{\Delta Q}{S_{s/c}}$$

or, $$\Delta Q = \Delta V \times S_{s/c}$$
$$= \pm(0.05 \times 5000)$$
$$= \pm 250 \text{ MVAR}$$

∴ The capacity of the static VAR compensator is 250 MVAR.

26. (d)

A synchronous condenser is an overexcited synchronous motor running at no-load under wide variation of excitation.

27. (c)

$$\text{Admittance} = \frac{1}{\text{impedance}}$$
$$= \frac{1}{3+j4} = \frac{1}{3+j4} \times \frac{3-j4}{3-j4}$$
$$\text{Admittance} = \frac{3-j4}{25} \mho$$
$$\text{Conductance} = \frac{3}{25}$$

(Real part we have to take)

30. (c)

Steady state stability limit is enhanced by providing auxiliary stability controllers to damp low frequency oscillations. Hence, statement-5 is not correct.

32. (b)

Since the generators are in parallel, they will operate at same frequency at steady load.

Let,

load on generator 1 (200 MW) = x MW

load on generator 2 (400 MW) = $(600 - x)$ MW

Reduction in frequency = Δf

Then, $$\frac{\Delta f}{x} = \frac{0.04 \times 50}{200}$$

$$\frac{\Delta f}{600 - x} = \frac{0.05 \times 50}{400}$$

Also, Equating $\Delta f = \frac{0.04 \times 50}{200}(x) = \frac{0.05 \times 50}{400}(600 - x)$, we have

$x \approx 231$ MW (load on generator 1)

$$\therefore \quad \text{System frequency} = 50 - \left(\frac{0.04 \times 50}{200}\right) \times 231$$

$$= 47.69 \text{ Hz}$$

33. (d)

Turbine power will increase 100 MW for a 0.03 p.u. or 1.5 Hz drop in frequency.
Thus, we have regulation parameter

$$= R = \frac{-1.5}{100} = -0.015 \text{ Hz/MW}$$

For a frequency change of $\Delta f = -0.2$ Hz, the turbine power will experience a static charge of

$$\Delta P_t = -\frac{1}{0.015} \times (-0.2)$$

$$= 13.33 \text{ MW}$$

34. (c)

A sudden short circuit in an ac power system causes a rise in current in the short circuited phase.

37. (c)

For static devices like transmission lines and transformers:

$$Z_1 = Z_2$$

and $$Z_0 > Z_1 \text{ or } Z_2$$

39. (b)

$$Z_1 = j(X_s - X_m) = \text{Positive sequence impedance.}$$
$$Z_2 = j(X_s - X_m) = \text{Negative sequence impedance.}$$
$$Z_0 = j(X_s + 2X_m) = \text{Zero sequence impedance.}$$

40. (d)

Three phase fault current is given as

$$(I_f)_{3-\phi} = \frac{V_3^0}{Z_{33}} = \frac{1}{j0.3}$$

$$= -j\,3.33 \text{ p.u.}$$

43. (c)

$$\text{Stored energy} = G \times H = 800 \text{ MJ}$$
$$P_a = 80 - 50 = 30 \text{ MW}$$
$$= M\frac{d^2\delta}{dt^2}$$

$$M = \frac{GH}{180f} = \frac{800}{180 \times 50} = \frac{4}{45} \text{ MJ-s/ele. deg}$$

Now, acceleration of rotor is, $\alpha = \frac{d^2\delta}{dt^2} = \frac{30 \times 45}{4}$

$$= 337.5 \text{ ele. deg/s}^2$$

44. (b)

Kinetic energy = GH

If Kinetic energy is constant then $G \propto \frac{1}{H}$

$\therefore$ $$\frac{G_1}{G_2} = \frac{H_2}{H_1}$$

or, $$\frac{100}{50} = \frac{H_2}{5}$$

$$H_2 = 10 \text{ MJ/MVA}$$

45. (b)

For transient stability limit, the fault in the system must be before t reaches t_{cr} (critical clearing time) and δ reaches δ_{cr} (critical clearing angle)

48. (d)

The diagonal element Y_{22} of Y_{bus} is obtained by,

$$Y_{22} = y_{12} + y_{23} + y_{20}$$

$$= \frac{1}{Z_{12}} + \frac{1}{Z_{23}} + \frac{1}{Z_{20}}$$

$$= \frac{1}{j0.1} + \frac{1}{j0.1} + \frac{1}{-j20}$$

$$= -j19.95 \text{ p.u.}$$

53. (d)

In general for a n bus system having p-number of pV buses the size of the Jacobian matrix will be

$$= (2n - 2 - p) \times (2n - 2 - p)$$

$$= (2 \times 15 - 2 - 3) \times (2 \times 15 - 2 - 3)$$

$$= 25 \times 25$$

57. (d)

$$Z_1(\text{actual}) = Z_{\text{pu.}} Z_{\text{base}}$$

$$= 0.05 \times \frac{400 \times 400}{250} = 32 \ \Omega$$

58. (b)

$$V_t = 100 \times \frac{2 \times 50}{450} = 22.22 \text{ kV}$$

62. (b)

Synchronizing power coefficient,

$$S_p = \left.\frac{dP_e}{d\delta}\right|_{\delta=\delta_0} = P_{\max}\cos\delta_0$$

63. (a)

Insulation resistance is inversely proportional to length of the line

$$R \propto \frac{1}{l}$$

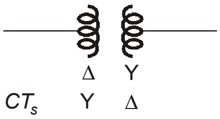
$$\frac{R_1}{R_2} = \frac{l_2}{l_1}$$

$$\frac{200}{R_2} = \frac{5}{1}$$

$$R_2 = 40\ \text{M}\Omega$$

64. (b)

They should be opposite in nature.



Secondaries of CT_s

65. (a)

$$I_S = CV_r + DI_R$$

$$V_r = 220/\sqrt{3}\ ,\ I_r = 0$$

$$\therefore \quad I_S = 0.5\times10^{-4}\times\frac{220}{\sqrt{3}}\times10^3$$

$$I_S = \frac{11}{\sqrt{3}}A$$

66. (a)

Nuclear power plants are generally base load power plants due to which they are mostly suited for constant loads.

69. (a)

Maximum true power transferred through a line is

$$P_{\max} = \frac{|V_S||V_R|}{|X|}$$

$$P_{\max} \propto |\ V_S\ |\ |\ V_R\ |$$

70. (c)

Corona losses have no effect due to transposition of conductors.

73. (a)

Reactance relay is more suitable for the protection of short lines because it is practically unaffected by arc resistance which may be large compared with the line impedance as a result of which more of the line can be protected at high speed using a reactance relay. Hence, both statement (I) and statement (II) are individually true and statement (II) is the correct explanation of statement (I).

74. (a)

Mho relay is normally used for protection of heavily loaded (EHV/UHV) long transmission lines as its threshold characteristic in Z-plane is a circle passing through the origin, and its diameter is Z_R. Because of this, the threshold characteristic is quite compact enclosing faulty area compactly and hence, there is less chance to operate during power swing and also it is directional.

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