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ESE- 2018 (Prelims) - Offline Test Series-Test-15

ELECTRICAL ENGINEERING

SUBJECT: POWER SYSTEMS, POWER ELECTRONICS & DRIVES, AND **SYSTEMS & SIGNAL PROCESSING** SOLUTIONS

01 Ans: (d)

Sol: $x(t) = \cos t + \sin \sqrt{3}t$

 $T_1 = \frac{2\pi}{1} = 2\pi$

$$\Gamma_2 = \frac{2\pi}{\sqrt{3}} = \frac{2\pi}{\sqrt{3}}$$

$$\frac{T_1}{T_2} = \frac{2\pi}{\frac{2\pi}{\sqrt{3}}} = \sqrt{3} \implies \text{irrational number}$$

 \therefore x(t) is non-periodic

02. Ans: (c)

Sol:
$$y(t) = \sum_{k=-\infty}^{\infty} x(t) \,\delta(t - kT_s)$$

 $y(t) = \dots + x(t) \,\delta(t+T_s) + x(t) \,\delta(t) + x(t)$
 $\delta(t-T_s) + \dots$
The choice system is linear, time variant

The above system is linear, time variant.

Sol:
$$\int_{-\infty}^{\infty} e^{-t} \, \delta'(t) dt = \frac{-d}{dt} \left[e^{-t} \right]_{t=0} = e^{-t} \Big|_{t=0} = 1$$

04. Ans: (c)
Sol:
$$x(\infty) = \lim_{Z \to 1} (z-1)X(z) = \lim_{Z \to 1} \frac{z+1}{3(z+0.9)}$$
$$= \frac{2}{3(1.9)} = 0.3508$$

05. Ans: (a)

Sol:
$$H(z) = \frac{z}{z+1}$$

 $H_{inv}(z) = \frac{z+1}{z} = \frac{Y(z)}{X(z)} = 1 + z^{-1}$
 $Y(z) = X(z) + z^{-1}X(z)$
 $y(n) = x(n) + x(n-1)$



06. Ans: (a)

Sol: From the given data the transfer function is

$$H(z) = \frac{k}{\left(z - 2\right)\left(z - \frac{1}{2}\right)}$$

Non-anticipative means causal and it is possible only when ROC $|z| > 2 \Rightarrow$ Right sided.

07. Ans: (d)

08. Ans: (c)

Sol: x(n) = 1, $0 \le n \le N-1$

= 0, otherwise .2π N-1N-1

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-j\frac{2\pi}{N}nk} = \sum_{n=0}^{N-1} e^{-j\frac{2\pi}{N}nk} = \frac{1 - e^{-j2\pi k}}{1 - e^{-j\frac{2\pi}{N}k}}$$
$$X(0) = 0, \ k \neq 0$$
$$X(0) = N, \ k = 0$$
$$X(k) = N\delta(k)$$

09. Ans: (c)

Sol: y(n)-ay(n-1) = x(n)

$$H(z) = \frac{Y(z)}{X(z)} = \frac{1}{1 - az^{-1}}$$

 $h(n) = (a)^n u(n)$

10. Ans: (d)

11. Ans: (c)

Sol: Using area property

Area of
$$(e^{-\pi t^2})$$
 × Area of $(e^{-\pi t^2})$ = Area of $(Ae^{-\frac{\pi t^2}{2}})$
Area of $(e^{-at^2}) = \int_{-\infty}^{\infty} e^{-at^2} dt = \sqrt{\frac{\pi}{a}}$
 $\sqrt{\frac{\pi}{\pi}} \times \sqrt{\frac{\pi}{\pi}} = A \sqrt{\frac{\pi}{\frac{\pi}{2}}} \Rightarrow A = \frac{1}{\sqrt{2}}$

12. Ans: (a)

Sol: $r_{xh}(\tau) = x(\tau) * h(-\tau) = e^{-\tau}u(\tau) * e^{\tau}u(-\tau)$ Apply Fourier transform

$$S_{XH}(\omega) = \frac{1}{(1+j\omega)(1-j\omega)} = \frac{1}{2} \left\lfloor \frac{2}{\omega^2 + 1} \right\rfloor \xleftarrow{I.F.T}{2} e^{-|t|}$$

13. Ans: (b)

Sol: Ex: x(t) = u(t+1) u(1-t) = rect (t/2) is an energy signal but u(t+1) and u(1-t) are individually power signals. So statement (3) is FALSE.

14. Ans: (b)

Sol: The exponential Fourier series coefficient of $\mathbf{x}(t)$

is
$$C_0 = \frac{2}{\pi}$$
, $C_n = \frac{2}{\pi (1 - 4n^2)}$

Fundamental frequency is 250 Hz (not 125 Hz)

So the ideal filter will retain the d.c component in the output.



Date of Exam : 20th Jan 2018

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15. Ans: (c)
Sol:
$$tu(t-2) - 2u(t) = (t-2+2)u(t-2) - 2u(t)$$

 $= -2u(t) + 2u(t-2) + r(t-2)$

16. Ans: (a) Sol: $\cos^{2}(\omega_{0}t) u(t) = \frac{1 + \cos 2\omega_{0}t}{2} u(t)$ $= \frac{1}{2}u(t) + \frac{1}{2}\cos 2\omega_{0}t u(t)$ $= \frac{1}{2s} + \frac{1}{2}\frac{s}{4\omega_{0}^{2} + s^{2}}$ $= \frac{1}{2}\left[\frac{4\omega_{0}^{2} + s^{2} + s^{2}}{s(4\omega_{0}^{2} + s^{2})}\right] = \frac{1}{2} \times \frac{4\omega_{0}^{2} + 2s^{2}}{s(4\omega_{0}^{2} + s^{2})}$ $= \frac{2\omega_{0}^{2} + s^{2}}{s(4\omega_{0}^{2} + s^{2})}$ 17. Ans: (b) Sol:





18. Ans: (b)

Sol: P: Delta function Fourier transform is constant function $\rightarrow 3$.

Q: Gate function Fourier transform is sampling function $\rightarrow 4$.

R: Gaussian function Fourier transform is Gaussian function $\rightarrow 2$.

S: Sinusoidal function Fourier transform is Delta function $\rightarrow 3$.

19. Ans: (c)

→ The ON state voltage drop of SCR is 1-1.5 V and for GTO 2-3 V

 \rightarrow GTO can be used for more switching frequency than that of SCR

 \rightarrow The GTO can be turned off by applying a negative gate-cathode voltage, therefore causing a sufficiently large negative gate current to flow.(i.e., large magnitude for small duration)

 \therefore So, options 1, 2 and 4 are true

20. Ans: (b)

Sol: At the instant of switch is closed



$$i = \frac{240}{6} \left[1 - e^{\frac{-6t}{4.8 \times 10^{-6}}} \right]$$
$$\frac{di}{dt} = \frac{240}{6} \left[e^{\frac{-6t}{4.8 \times 10^{-6}}} \right] \times \frac{6}{4.8 \times 10^{-6}}$$

At t = 0,
$$\left(\frac{di}{dt}\right)_{max} = \frac{240}{4.8 \times 10^{-6}} = 50 \text{ A} / \mu \text{ sec}$$

Voltage across SCR is given by $V = R_s i$

$$\left(\frac{\mathrm{dV}}{\mathrm{dt}}\right)_{\mathrm{max}} = 2 \times \left(\frac{\mathrm{di}}{\mathrm{dt}}\right)_{\mathrm{max}}$$
$$= 100 \, \mathrm{V/usec}$$

21. Ans: (a)

Power MOSFET is a low voltage, High current, power semiconductor device. It has positive temperature Coefficient gives the power MOSFET a good power handling capability as well as parallel operation is also possible. As the temperature of FET increases, The mobility of charge carriers decreases. so Thermal runaway is not possible in FET.

22. Ans: (a)

23. Ans: (d)





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As we know in centre tap full wave $1-\phi$ rectifier circuit PIV of each diodes 2 V_m \therefore PIV = $2\sqrt{2} \times 100$ V = 282.8 V

24. Ans: (a)

Sol:
$$\Rightarrow V_0 = \frac{2V_m}{\pi} \cos \alpha$$
$$V_0 = \frac{2 \times 240\sqrt{2}}{\pi} \cos 60^\circ$$
$$= 108V$$
$$V_0 = I_0 (R_L + 0.75) + E$$
$$108 = 100 + 5 (R + 0.75)$$
$$R = 1.6 - 0.75$$
$$R = 0.85\Omega$$

25. Ans: (a)

Sol: $I_0 = 60A$

$$I_{T_{avg}} = \frac{I_0 \times \frac{2\pi}{3}}{2\pi} = 20A$$
$$P_T = V_D \times I_{T_{avg}} = 20 \times 1.5$$
$$= 30W$$

26. Ans: (b)

Sol: Inversion Mode

$$I_{0} = \frac{E - (-V_{0})}{R} = \frac{E + V_{0}}{R}$$
$$10 \times 1.5 = 144 + \frac{2 \times 240\sqrt{2}}{\pi} \cos \alpha$$

$$\cos \alpha = \frac{-129.6}{216} = -0.6$$

 $\alpha = 126.86^{\circ}$

27. Ans: (c)

Sol: output ripple frequency = supply frequency × number of pulses in a cycle $= 50 \times 6$ = 300 Hz

28. Ans: (a)

Sol: Magnitude of reverse voltage across the scr, $V_{ml} = 230\sqrt{2} = 325.26V$

Circuit turn of time, $\omega t_c = \pi - \alpha$ (when $\alpha > \alpha$ 60°)

$$\omega t_{c} = \frac{\pi}{2}$$
$$t_{c} = \frac{\frac{\pi}{2}}{2\pi \times 60} = 4.16 \text{ m sec}$$

29. Ans: (c)
Sol:
$$K = \frac{2L}{RT} = \frac{2 \times 0.7 \times 10^{-3}}{1 \times 2000 \times 10^{-6}} = 0.7$$

 $K_{c_r} = (1 - D) = 0.7$
As $k = K_{c_r}$

So, nature of current flowing through inductor is Boundary of continuous and discontinuous in nature.



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- 30. Ans: (d)
- 31. Ans: (b)
- 32. Ans: (b)

Sol:
$$V_{01,rms} = \frac{4V_s}{\sqrt{2\pi}} = 108.04 V$$

 $I_{01,rms} = \frac{250}{\sqrt{2}}, \cos \phi$
 $= \cos 30^\circ = 0.866$
 $P_0 = V_{01,rms} I_{01,rms} . \cos \phi = 16.54 kW$

33. Ans: (a)

Sol: turn - on loss

$$= \left[\frac{\text{VI}}{6} \times \text{t}_{\text{on}}\right] \text{f}$$
$$= \frac{300 \times 200}{6} \times 1 \times 10^{-6} \times 10 \times 10^{3}$$
$$= 100 \text{W}$$
Conduction loss = 2.1 × 200 × 0.5

$$= 210 W$$

34. Ans: (a)

Sol:
$$\frac{V_0}{V_{ml}} = \frac{\frac{3V_{ml}}{\pi}\cos\alpha}{V_{ml}}$$

 $\Rightarrow \frac{3}{\pi}\cos\alpha = 0.9549\cos\alpha$



35. Ans: (b)

Sol: Half bridge inverter power delivered to load

$$\Rightarrow P_1 = \frac{V_{or}^2}{R} = \frac{V_{dc}^2}{4R}$$

Full bridge inverter power delivered to load

$$\Rightarrow P_2 = \frac{V_{or}^2}{R}$$
$$P_2 = 4P_1$$

36. Ans: (c)

Sol:
$$V_L = \frac{4V_s}{n\pi} \cdot \cos\left(\frac{n\pi}{6}\right) \cdot \sin\left[n(\omega t + \frac{\pi}{6})\right]$$

 $100 = \frac{4V_s}{\pi} \cdot \cos\left(\frac{\pi}{6}\right)}{\sqrt{2}}$
 $100 = 0.9 V_s \times \cos 30^\circ$
 $V_s = 128.3 V$

37. Ans: (d)

Sol:
$$V_{\ell 5} = \frac{3V_s}{5\pi} \cdot \sin\left[5\omega t + \frac{5\pi}{3}\right]$$

 $V_{\ell 5_{ms}} = \frac{\frac{3V_s}{5\pi}}{\sqrt{2}}$
 $= 0.954 \times 10 \times \sqrt{2}$
 $V_{5, rms} = 13.5 V$

38. Ans: (a)

:7:



$$\dot{\mathbf{i}}_{s} \right)_{rms} = \sqrt{\left[\left(\frac{\mathbf{V}_{s}}{3R} \right)^{2} \times \frac{\pi/3}{2\pi} \times 2 \right]} + \left[\left(\frac{2\mathbf{V}_{s}}{3R} \right)^{2} \times \frac{\pi/3}{2\pi} \right]$$

$$(i_s)_{rms} = \frac{V_s}{3R} = \frac{600}{3 \times 10} = 20A$$

39. Ans: (b)

Sol: In a AC voltage controller

Power factor =
$$\frac{V_{or}}{V_s}$$

Per unit power = $\frac{\text{actual power}}{\text{Rated power}}$

$$=\frac{\left(V_{or}\right)^2/R}{V_s^2/R}$$

$$\therefore \text{ Power factor } = \frac{V_{\text{or}}}{V_{\text{S}}} = \sqrt{\text{Per unit power}}$$

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All tests will be available till 12" February 2018



All tests will be available till 07th January 2018



All tests will be available till 25th December 2017

HIGHLIGHTS * *

- Detailed solutions are available.
- All India rank will be given for each test.
- Comparison with all India toppers of ACE students.

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40. Ans: (a)

Sol:
$$\frac{N}{2N} = \frac{2\frac{V_m}{\pi}\cos\alpha}{\frac{V_m}{\pi}[1+\cos\alpha]} \Rightarrow 1+\cos\alpha = 4\cos\alpha$$

 $\Rightarrow \cos\alpha = 1/3$
 $\Rightarrow \alpha = 70.528^0$

41. Ans: (a)

Sol: Rated Shunt Compensation=VI tana

 $= 205 \times 105 \tan 45^{\circ}$

 $= 21.6 \, \text{kVAR}$

Power factor, $\cos \alpha = \cos 45^0 = 0.707$

42. Ans: (a)

Sol: Given data, Maximum demand = 50 MW, Load factor = 80%, plant capacity factor = 50% \therefore Load factor = <u>average load</u> maximum demand \Rightarrow average load = 0.8×50 MW = 40 MW \therefore Plant capacity factor = $\frac{\text{average demand}}{\text{installed capacity}}$

 \Rightarrow Installed capacity = $\frac{40}{0.5}$ = 80 MW

Then, reserve capacity of the plant



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= installed capacity – maximum demand = 80 - 50 = 30 MW

43. Ans: (c)

Sol: Run of the river type: It is a type of hydro electric plant where little or no water storage is provided.

Pondage type: It is a medium head hydro electric plant. It has small amount of water storage. They may be used in run of the river hydro electric plant in lean period.

Reservoir type: It is a high head plant consisting of a large dam.

44. Ans: (d)

Sol: Nuclear plants have a high capital cost in comparison to running cost, therefore, they are generally used as base load plant therefore statement-1 is wrong.

The rate of nuclear reaction can be lowered by small margin so that load on the nuclear power plant can be reduced by only a small margin below its fall load value. Tripping of lines may lead to shutting down of the plant itself.

Therefore statement-II is wrong.

45. Ans: (a)

Sol: Given data,

$$\frac{\mathrm{dC}_1}{\mathrm{dP}_1} = 0.2 \, \mathrm{P}_1 + 40$$

 $\frac{dC_2}{dP_2} = 0.4 P_2 + 30$ And $P_1 + P_2 = 220$ (1) For optional economic operation, $\frac{dC_1}{dP_1} = \frac{dC_2}{dP_2}$ $\Rightarrow 0.2 P_1 + 40 = 0.4 P_2 + 30$ $\Rightarrow P_1 - 2P_2 = -50$ (2) Now from equation (1) – equation (2) $3P_2 = 270 \Rightarrow P_2 = 90 \text{ MW}$ And $P_1 = 130 \text{ MW}$

46. Ans: (d)

:9:

Sol: After infinite reflections, steady state is achieved (see the diagram)



Now, voltage at the receiving end would be, $V_{R}(1+0.4) - (0.4+0.16) + (0.16+0.064)....$ $\Rightarrow V_{R} = (1 + 0.4) [1+(0.4)^{2} + \{(0.4) + (0.4)^{3} + \}]$ $\Rightarrow V_{R} = (1+0.4) \left[\frac{1}{1-(0.4)^{2}} - \frac{(0.4)}{1-(0.4)^{2}} \right]$



$$\Rightarrow V_{R} = 1.4 \left[\frac{1 - 0.4}{1 - (0.4)^{2}} \right]$$
$$\Rightarrow V_{R} = 1.4 \left[\frac{0.6}{(1 + 0.4)(1 - 0.4)} \right]$$
$$= 1.4 \left[\frac{0.6}{1.4 \times 0.6} \right]$$
$$= 1V$$

47. Ans: (c)

Sol: The nominal pH value of water is equal to 8.5, which is to be maintained in steam raising thermal power station.

48. Ans: (b)

49. Ans: (a)

Sol: Given data,

 $v(t) = 100 \cos \omega t$, Z = 1.25∠60°Ω Then, i(t) = $\frac{100}{1.25} \cos(\omega t - 60^\circ)$ = 80 cos($\omega t - 60^\circ$)

50. Ans: (a)

51. Ans: (c)

Sol: The design of overhead line insulator is based on peak voltage.



$$V_{\rm m} = \sqrt{2} V_{\rm ph} \, (\rm rms)$$
$$= \sqrt{2} \frac{\rm V}{\sqrt{3}}$$

52. Ans: (b)

Sol: Standard representation of lightening impulse wave is

 $V/t_r/t_f$

Where, V is the crest value of the voltage

t_r is the rise time

t_f is the fall time.



53. Ans: (a)

Sol: In sending end capacitor model no charging current component flows in the line impedance, so voltage drop is more and resultant sending end voltage is more for given receiving end voltage at lagging load condition.

54. Ans: (c)

Sol: P_{max} is more if 'X' of line is low

$$X = 2\pi fL,$$
 $L = 2 \times 10^{-7} ln \left(\frac{GMD}{GMR}\right)$

To get more P_{max} , GMD should be low and GMR should be high.

55. Ans: (c)

Sol: In lossless long line model No load power

loss is
$$\frac{I_c^2 R}{3}$$

56. Ans: (a)

Sol:

r

Self GMD =
$$\sqrt{r \times 2r}$$

= $\sqrt{0.7788r \times 2r}$
= 1.248 cm (\therefore r = 1cm)

57. Ans: (b)

Sol: $A = D = \cos\beta l$, $B = jZ_c \sin\beta l$, $C = j\frac{1}{Z_c}\sin\beta l$ As frequency increases, $\beta = \omega \sqrt{LC} \Rightarrow \beta^{\uparrow}$ So $|A| \downarrow |B| \uparrow |C| \uparrow |D| \downarrow$

58. Ans: (c)

Sol:
$$X_{p.u (LV)} = 0.121 \times \frac{400}{(22)^2}$$

= 0.1
 $X_{p.u(HV)} = X_{p.u (LV)}$
= 0.1
 $X_{p.u (HV)New} = X_{p.uHVold} \frac{MVA_{new}}{MVA_{old}} \left(\frac{kV_{old}}{kV_{new}}\right)^2$

$$=0.1 \times \frac{100}{400} \times \left(\frac{220}{230}\right)^2$$
$$= 0.0228$$

59. Ans: (c)

Sol: For LLG fault, $I_{positive} = I_{negative} + I_{zero}$

Hence given data satisfies the above condition.

60. Ans: (a)

- **Sol:** String efficiency in suspension type insulator can be improved by the following methods:
 - 1. using a longer cross arm
 - 2. using a guard ring
 - 3. using graded insulator discs
- 61. Ans: (b)

Sol:
$$M = \frac{SH}{\pi f} = \frac{100 \times 8}{3.14 \times 50}$$

= 5.09 MJ-sec/Elec rad

$$M = \frac{5.09}{2} = 2.54 \text{ MJ-sec/ Mech rad.}$$

62. Ans: (c)

Sol:





= 1

$$\begin{bmatrix} A_{eq} & B_{eq} \\ C_{eq} & D_{eq} \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 1/jx_r & 1 \end{bmatrix}$$
$$\Rightarrow A_{eq} = |A| + \frac{|B|}{x_r} \quad as \quad A_{eq}$$
$$\Rightarrow |A| + \frac{|B|}{x_r} = 1 \Rightarrow x_r = \frac{|B|}{1 - |A|}$$
For $\Delta \Rightarrow x_r(\Delta) = 3 \times \frac{|B|}{1 - |A|}$

Sol: $\frac{dp}{d\delta} = 3\cos\delta$, $\frac{dp}{d\delta}\Big|_{\delta=60^\circ} = 3 \times \cos60^\circ = 1.5 \text{ p.u}$

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64. Ans: (b)

Sol:
$$V_{a0} = -I_{a0} (Z_0 + 3Z_n)$$

 $Z_0 + 3Z_n = \frac{V_{a0}}{-I_{a0}} = \frac{-0.3}{+j2} = j0.$

 $Z_n = 0.033 p.u$

65. Ans: (b)

Sol: ARV = K₁ K₂ K₃. V_{max} sin ϕ = 0.9×1×1× $\frac{66}{\sqrt{3}}$ × $\sqrt{2}$ × $\sqrt{1-(0.25)^2}$ = 46.96 kV

66. Ans: (a)

67. Ans: (b)

Sol: If the fault is away from the relay, then the impedance seen by the relay is more.

68. Ans: (a)

69. Ans: (a)

70. Ans: (a)

71. Ans: (a)

Sol: Secondary cells are rechargeable in comparison to primary cells that are not rechargeable.

Hence, life of secondary cell is more than a primary cell.

The main reason for the rechargeable property of secondary cells is the reversible redone reaction given power input also the component are least degraded during such reversible reaction.

72. Ans: (a)

Sol: For discontinuous mode of operation the ripple content will be high and Average value of output voltage is more as compared with continuous mode output average value.

73. Ans: (b)

Sol:
$$H(S)_{APF} = \frac{s - \alpha}{s + \alpha}$$

75. Ans: (d)

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