TEST ID: 302

ACE
Engineering Academy
Head Office : Sree Sindhi Guru Sangat Sabha Association, # 4-1-1236/1/A, King Koti, Abids, Hyderabad – 500001.
Ph: 040-23234418, 040-23234419, 040-23234420, 040 - 24750437
Hyderabad | Delhi | Bhopal | Pune | Bhubaneswar | Lucknow | Patna | Bengaluru | Chennai | Vijayawada | Vizag | Tirupati | Kukatpally | Kolkata | Ahmedabad

ESE- 2019 (Prelims) - Offline Test Series Test-3

ELECTRICAL ENGINEERING

SUBJECT: Electrical Machines & Systems and Signal Processing

SOLUTIONS

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01. Ans: (c)

Sol: ⇒ With hot-rolled steel laminations

$\phi_{max} = [B_{m1}] \times A_1 = 1.2\ A_1$

$$A_1 = \frac{\phi_{max}}{1.2}$$

⇒ With CRGO laminations

$\phi_{max} = 1.6\ A_2$

$$A_2 = \frac{\phi_{max}}{1.6}$$

$$\frac{\text{weight of the CRGO } (W_2)}{\text{Weight of the hot rolled core} (W_1)}$$

$$= \frac{(\text{Core volume})_2 (\text{Density})}{(\text{Core volume})}$$

$$= \frac{A_2 (\text{Height of lim b})}{A_1 (\text{Height of lim b})}$$

$$= \frac{\frac{\phi_{max}}{1.6}}{\frac{\phi_{max}}{1.2}} = \frac{1.2}{1.6} = \frac{3}{4}$$

$$W_2 = \frac{3}{4} W_1$$

$$\%\ \text{savings} = \frac{W_1 - W_2}{W_1} \times 100$$

$$= \frac{100 - 75}{100} \times 100 = 25\%$$

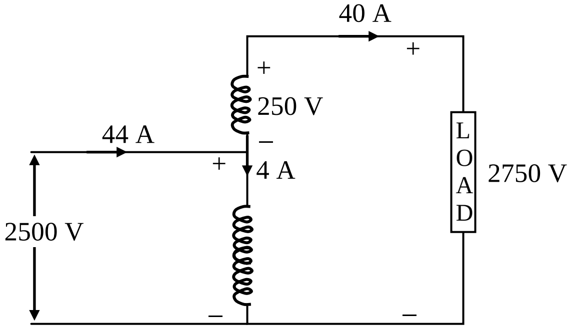
02. Ans: (d)

Sol: The coefficient of coupling of the transformer can be increased by

1. Increasing the window height.
2. Arranging the primary and secondary windings concentrically
3. Sandwiching the primary and secondary windings
4. Using shell type construction

03. Ans: (c)

Sol:



I_L rated = $\frac{10000}{250}$ = 40 A

$I_{H\ rated}$ = $\frac{10000}{2500}$ = 4 A

kVA auto transformer = 2500 × 44

= 2500(40 + 4)

= 100 k + 10 k

= 110 kVA

kVA transformed = 250 × 40 = 10 kVA

kVA conducted = 110 K – 10 K = 100 kVA

04. Ans: (b)

Sol: Transformation ratio K = $\frac{2000}{2500}$ = 0.8

Voltage Regulation of auto transformer

= (1 – K) × voltage regulation of two winging transformer

= (1 –0.8) × 10

= 2%

05. Ans: (b)

Sol:
1. The equivalent leakage impedance in ohms should be inversely proportional to their respective kVA ratings.
2. The transformer with greater leakage impedance angle operates at lower pf as compared to others with lower leakage impedance angle.

06. Ans: (a)

Sol: Full load current = $\frac{10K}{2500}$ = 4 A

Ohmic losses at full load current

$P_{SC} = 45\left(\frac{4}{3}\right)^2$ = 80 watts

The voltage applied to HV winding to get 4 A current through it = $\frac{4}{3}\times 60$ = 80 V

Maximum percentage regulation

Percentage Z = $\frac{80}{2500}\times 100$

= $\frac{80}{25}$ = 3.2%

Percentage resistance

$= \frac{\text{Full load copper losses}}{\text{kVA rating}} \times 100$

$= \frac{80}{10K} \times 100$

= 0.8%

07. Ans: (a)

Sol: $X = \sqrt{\frac{P_i}{P_{Cu}}}$

$= \sqrt{\frac{100}{400}}$

= 0.5

% Efficiency

$$= \frac{X(\text{kVA rating})\times \text{pf}}{X(\text{kVA rating})\times \text{pf} + \text{losses}}\times 100$$

$$= \frac{0.5(10k)\times 0.8}{0.5(10k)0.8+200}\times 100$$

$$= \frac{4k}{4.2k} \times 100 = 95.3\%$$

08. Ans: (d)

Sol: $P_i = P_h + P_e$

$= K_1 \times f + K_2 \times f^2$

$\frac{P_i}{f} = K_1 + K_2 f$

$\frac{300}{50} = K_1 + K_2 \times 50$ ………….. (1)

$\frac{420}{60} = K_1 + K_2 \times 60$ ………….. (2)

$(2) - (1) \Rightarrow 10K_2 = 1$

$K_2 = \frac{1}{10}$ and $K_1 = 1$

$P_i = K_1 \times (40) + K_2 \times (40)^2$

$= 200$ W

09. Ans: (d)

Sol: The following are effects of armature reaction

1. Distortion of main field flux
2. Increased iron losses
3. Delayed commutation
4. cost of the field winding increases

10. Ans: (b)

Sol: $I_a = I_L + I_f$

$I_f = \frac{V_t}{R_f} = \frac{250}{125} = 2A$

$I_a = 148 + 2 = 150A$

Total AT per pole $= \frac{Z}{2P} \times \frac{I_a}{A}$

$= \frac{480 \times 150}{2 \times 6 \times 2} = 3000$

$\theta_e = \frac{P}{2} \times \theta_m$

$= \frac{6}{2} \times 5 = 15°$

Demagnetizing AT per pole

$= \frac{2\theta_e}{180} \times$ Total AT per pole

$= 2 \times \frac{15}{180} \times 3000 = 500$

11. Ans: (b)

Sol: The following are reasons to failed to build-up of voltage at no load in shunt generator

(1) High field circuit resistance

(2) Field connection reversed

(3) No residual magnetism

(4) Speed is Less than critical speed.

12. Ans: (a)

Sol: Generating Mode

$I_a = I_L + I_f = 48+2=50A$

$E_g = V_t + I_a R_a$

$= 250 + 50 \times 0.5$

$= 275$ V

Motoring Mode

$I_a = I_L - I_f$

$= 52-2$

$= 50A$

$E_b = V_t - I_a R_a$

$= 250 - 50 \times 0.5$

$= 225$ V

$$\frac{N_m}{N_g} = \frac{E_b}{E_g}$$

$$= \frac{225}{275} = \frac{9}{11} = 0.818$$

13. Ans: (c)

Sol: Critical filed resistance is directly propositional to speed

$$\frac{X}{1000} = \frac{90}{150}$$

$X = 600$ rpm

14. Ans: (a)

Sol: Case 1

$I_a = I_L - I_f$

$$= 105 - \frac{250}{50} = 100$$

$E_{g1} = V_t - I_a R_a = 250 - 100 \times 0.5 = 200$

$T = \text{constant} = K_a \times I_a$

$I_a = \text{constant}$

Case II

$$\frac{E_{g2}}{E_{g1}} = \frac{N_2}{N_1}$$

$$E_{g2} = \frac{N_2}{N_1} E_{g1} = \frac{750}{1000} \times 200 = 150\text{V}$$

$E_{g2} = V_t - I_a (R_a + R_{ext}) = 150$

$250 - 100\ (0.5 + R_{ext}) = 150$

$R_{ext} = 0.5$

15. Ans: (c)

Sol: At No load

Input power = $250 \times 6 = 1500$W

= constant losses + No load copper loss

$I_{a0} = I_L - I_F = 6 - 2 = 4$A

No load copper losses = $(I_{a0})^2 \times R_a$

$= 4^2 \times 0.5 = 8$W

Constant loss = 1500 – 8 = 1492

At Full Load

Input power = 250×52

$= 250\ (50+2)$

$= 12500 + 500$

= 13 KW

$I_a = 50$A

Load Copper Losses = $I_a^2 \times R_a$

$= 50^2 \times 0.5$

$= 2500 \times 0.5$

= 1250W

Total Losses = 1250+1492

= 2742 W

$P_{out} = 13k - 2742$

=10258W

$$\text{Efficiency} = \frac{10258}{13000} \times 100$$

= 78%

16. Ans: (c)

Sol: $P_{em} = E_b \times I_a = (V_t - I_a R_a)\, I_a$

$$\frac{\partial P_{em}}{\partial I_a} = 0$$

$V_t - 2I_a R_a = 0$

$I_a R_a = \frac{V_t}{2} = 125$

$E_b = V_t - I_a R_a$

$= 250 - 125$

$= 125V$

17. Ans: (d)

Sol: characteristics of the servo motor

1. Torque speed characteristics are linear
2. High torque/inertia ratio
3. Fast response
4. Quick reversal
5. Cannot overloaded

18. Ans: (c)

Sol: Step angle

$$= \frac{360°}{\text{Number of steps per revolution}}$$

$$= \frac{360°}{200} = 1.8°$$

19. Ans: (d)

Sol: In the actual process of converting electrical energy to mechanical energy (or vice versa) is independent of

1. The loss of energy in either the electrical or mechanical systems
2. The energy stored in electric or magnetic fields which are not in common to both systems.
3. The energy stored in the mechanical systems

20. Ans: (a)

Sol: $y_b = \frac{2C}{P} \pm K$ = coil sides per pole $\pm K$ = odd

2C = number of coil sides

P = number of poles

K = number (integer or fraction)

$$y_b = \frac{2 \times 40}{6} \pm K$$

$$= \frac{40}{3} \pm K$$

$$= \frac{40}{3} - \frac{1}{3} = 13$$

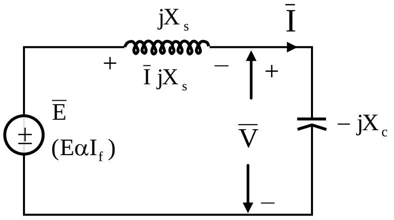
$y_b - y_f = \pm 2$

$y_f = 13 - 2 = 11$ for progressive

$y_f = 13 + 2 = 15$ for retrogressive

21. Ans: (b)

Sol: The per phase equivalent circuit and phasor diagram corresponding to the problem are shown in figs. 1 and 2 respectively.



$\overline{E} = \overline{V} + \overline{I}jX_s$

Fig.1

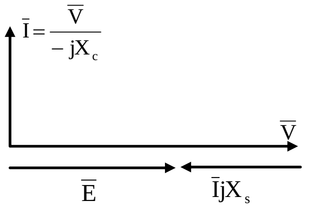


Fig.2

Assume that the terminal voltage V is always kept constant, by changing the field excitation when necessary. With $\bar{I}=0$ ($X_c=\infty$), the induced emf due to the field, E, equals V.

With $\bar{I}>0$, phasor diagram of fig. 2 indicates that the induced emf due to the field, E, decreases to less than V. Therefore, field excitation must have decreased. But the voltage across the load must still be V. So the difference (V-E) must have been induced by the armature mmf. Hence armature mmf aids the field mmf. This is called magnetizing action of the armature reaction.

22. Ans: (c)

Sol: 1. Short-circuit ratio:

The short-circuit ratio of a 3-phase alternator is defined as

$$\alpha_{sc}=\frac{\text{field excitation for rated voltage } V_r \text{ on OC}}{\text{field excitation for rated current } I_r \text{ on SC}}$$

$$=\frac{I_{foc}}{I_{fsc}}$$

Since it is the ratio of two field currents, it is dimensionless.

2. Synchronous reactance:

For some field current I_f, open-circuit voltage = $V_r\frac{I_f}{I_{foc}}$

(assuming a linear OCC).

For the same field current, short-circuit current = $I_r\left(\frac{I_f}{I_{fsc}}\right)$.

(SSC is always nearly linear).

$$\therefore\ X_s\text{ (unsaturated)}=\frac{V_rI_fI_{fsc}}{I_{foc}I_rI_f}$$

$$=\frac{(V_r)}{(I_r)}\frac{1}{\alpha_{sc}}$$

$$\alpha_{sc}=\frac{1}{X_s/(V_r/I_r)}$$

$$=\frac{1}{X_s\text{in pu}}$$

From the given data, X_s in per unit = $\frac{3}{7.26}$

$$\therefore\ \ \alpha_{sc}=\frac{7.26}{3}$$

$$=2.42$$

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23. Ans: (c)

Sol: V and Inverted V curves:

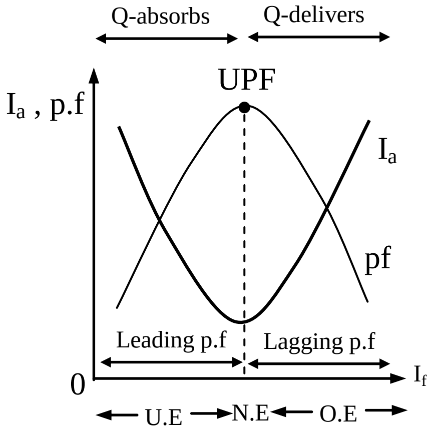


Fig. 2

A synchronous generator is operating with leading power factor, if field current increases, then armature current will decreases to minimum value and then increases

24. Ans: (a)

Sol: $X_s = 1.5\ \Omega$, $R_e = 0\ \Omega$

At no load, $\delta \approx 0$ and E =V.

$$P_{sy} = \frac{3EV}{X_s}\cos\delta \times \Delta\delta$$

$$\theta_e = \frac{P}{2}\theta_m = \frac{12}{2}\times 1^\circ = 6^\circ$$

$$= 6\times\frac{\pi}{180} = \frac{\pi}{30}\text{rad}$$

$$\Rightarrow P = \frac{3\delta V^2}{X_s} = \frac{3\times\frac{\pi}{30}\times\left(\frac{6000}{\sqrt{3}}\right)^2}{1.5}$$

= 2513 kW.

25. Ans: (a)

Sol: Direction of field current I_f on the rotor winding shows (by right hand rule) that the field poles are as in fig below.

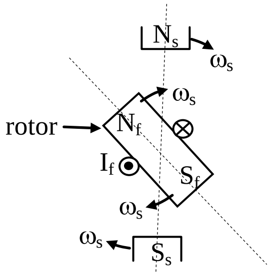


Fig.1

The rotor poles do rotate at ω_s r/s w.r.t stator. (They are, however, stationary w.r.t stator poles). (i) is true. N_s of stator and N_f of rotor repel each other. Hence the developed torque is in acw direction. Hence the rotor is being driven by a prime mover a against this developed torque. This represents generator action. (ii) is false.

26. Ans: (c)

Sol: i. VI cos θ = input to the motor

I^2r = copper losses

$\therefore$ We have VI $\cos\theta - I^2r = P_m$. = shaft output of motor + mechanical and iron losses in the motor.

Note: This is also called the mechanical power developed by motor. Mechanical power developed does not include copper losses.

ii. Dividing both sides of the equation by r (resistance/ph) and writing

$I^2 = I^2\cos^2\theta + I^2\sin^2\theta$,

we get,

$$\frac{v}{r} I\cos\theta - I^2\cos^2\theta - I^2\sin^2\theta = \frac{P_m}{r}$$

Multiply both sides by (–1); and add $\frac{V^2}{4r^2}$ to both sides;

$$(I\cos\theta)^2 - 2\left(\frac{V}{2r}\right) I\cos\theta + \frac{V^2}{4r^2} + (I\sin\theta)^2 = \frac{V^2}{4r^2} - \frac{P_m}{r},$$

Let I cosθ = x, I sin θ = y. Then locus of the point B(x,y) for a constant P_m is a circle with center at $\left(x = \frac{v}{2r}, y = 0\right)$ and radius of $\sqrt{\frac{v^2}{4r^2} - \frac{P_m}{r}}$.

(This is called a power circle).

27. Ans: (a)

Sol: Power developed in synchronous machine

$$\Rightarrow P = \frac{EV}{X_s}.\sin\delta$$

$\Rightarrow P = P_{max}.\sin\delta$

$$\therefore P_{max} = \frac{EV}{X_s}$$

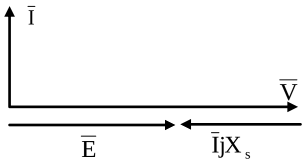
$\Rightarrow P_{max} \propto E, V$

$\Rightarrow P_{max} \propto I_f$ and V $[\because E \propto I_f]$

28. Ans: (d)

Sol: For the generator, we have $\bar{E} - \bar{I}jX_s = \bar{V}$.

i. Phasor diagram for a purely capacitive load:

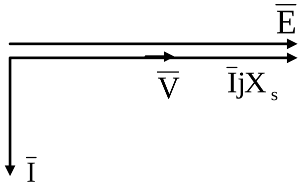


From the diagram, we can write V= X_sI + E.

V ~ I curve is a straight line, with a slope X_s, and an intercept on the V–axis of E. (E the induced emf is constant since excitation and speed are constant).

This corresponds to curve 2. (when I = 0, V = E. As I increases, V increases).

(ii) Phasor diagram for a purely inductive load:



From the diagram, we have

$$V = -\bar{I}X_s + E$$

V~I curve is a straight line with slope ($-X_s$), and I reaches a maximum of $\frac{E}{X_s}$ when V = 0 (short-circuit).

This corresponds curve 1 (when I = 0, V = E. As I increases, V decreases).

29. Ans: (c)

Sol: 1. Initial operation as synchronous motor:

Power received by the motor/phase = P

$$= \underbrace{\frac{EV}{X_d}\sin\delta}_{\text{Synchronous power}} + \underbrace{\frac{V^2}{2}\left(\frac{1}{X_q}-\frac{1}{X_d}\right)\sin 2\delta}_{\text{reluctance power}}$$

= Mechanical losses of the machine.

Since the mechanical losses are likely to be small compared to the rated power of the machine, δ will be very small.

2. Excitation reduced to zero:

E becomes zero (residual magnetism of rotor poles is neglected). But the reluctance power is not zero. (It does not depend on E). δ will now increase till the reluctance power just supplies the mechanical losses. The machine is likely to run as a reluctance motor at synchronous speed.

[Note: δ is the angle between $\overline{E}\,\&\,\overline{V}$. When E is zero, the question arises as to how δ is to be defined. We can take it as the angle between the stator mmf axis and the rotor axis].

30. Ans: (b)

Sol: Orders of the slot harmonics of stator (or rotor) are given by $\frac{2\times(\text{No.of slots})}{\text{No.of poles}} \pm 1$.

Here, number of slots of the stator = 36.

$$\frac{2\times 36}{4}+1=19;\quad \frac{2\times 36}{4}-1=17$$

Thus slot harmonics of stator mmf are of orders 17 and 19. (The 19th harmonic obtained by using the positive sign, rotate at $\frac{N_s}{19}$ in the same direction as the fundamental component of stator mmf, i.e., in clockwise direction. The harmonic obtained by using the negative sign rotates in the opposite direction ie., anti-clockwise).

31. Ans: (c)

Sol: 1. Since the rotor has 40 slots, slot harmonics of the rotor mmf are of orders $\frac{2\times 40}{4}\pm 1 = 21 \text{ and } 19$.

The 19th harmonic (which is obtained by using the negative sign) rotates at $\frac{1}{19}$ (synchronous speed corresponding to frequency of rotor currents in the anti-clockwise direction wrt the rotor).

2. If the stator supply frequency is f, frequency of rotor currents is $\frac{N_s - N}{N_s}f$.

For a frequency f, the synchronous speed is N_s in clockwise. For a frequency $\frac{N_s - N}{N_s}f$, the synchronous speed corresponding to rotor currents is (N_s–N) (cw).

3. Thus speed of the 19th harmonic of rotor mmf wrt rotor = $\frac{N_s - N}{19}$, in the anticlockwise direction.

32. Ans: (d)

Sol: 1. The normal speed drop due to increase in load is not called crawling. Steady running at a speed much smaller than the synchronous speed (usually at about $\frac{1}{7}^{\text{th}}$ the synchronous speed) is called crawling. **Statement 1 is false.**

2. Crawling can be produced by both harmonic induction torques and harmonic synchronous torques. **Statement 2 is true.**

3. If the crawling is due to harmonic induction torque, speed can vary with load. If it is due to harmonic synchronous torque, speed will remain constant. **Statement (3) is false.**

4. With rotor slots = stator slots, two harmonic synchronous torques of nearly equal magnitude and opposite directions can be produced, which can lead to cogging. **Statement (4) is true.**

33. Ans: (d)

Sol: Slip of the machine is grater than one means induction machine is working in braking mode. In this mode, the machine will draw electrical power from the supply mains.

34. Ans: (c)

Sol: $\frac{T_{st}}{T_{FL}} = \left(\frac{I_{st}}{I_{FL}}\right)^2 s_{FL}$

From data ⇒ $T_{st} = T_{FL}$;

$$\Rightarrow \left(\frac{I_{st}}{I_{FL}}\right)^2 = \frac{1}{0.06} \approx 16$$

$$\Rightarrow I_{st} = 4I_{fL}$$

35. Ans: (d)

Sol: As the rotor resistance increase, hence total circuit resistance increased. So stator current will decrease.

For constant torque load, slip $\propto R_2$

⇒ As R_2 increases, slip also increases.

36. Ans: (d)

Sol: Suitability of the characteristics of the motor for a given application, cost, and size are some of the important considerations in selecting a motor for a given application. The usual practice is listed below:

Domestic pumps use 1-phase induction motors. Stepper motors are used in computer numerical control. Universal motors are used in a hand-drilling machines. Brushless dc motors are used in fast-acting servo drives.

Thus, the correct pairing would be

A- 4, B-3, C-2, D-1.

37. Ans: (c)

Sol: X_m , the magnetizing reactance per phase of an induction motor

$$= \omega \times \frac{\text{flux linkage / phase due to airgap flux}}{\text{phase current}}.$$

Magnetizing reactance can be shown to be proportional to $\frac{N^2 R \ell_a}{\ell_g}\omega$.

Where N = the number of turns/phase,

R = the radius of the stator bore,

ℓ_a = the axial length, and

ℓ_g = the radial length of the air-gap.

For a machine of given ratings, $N^2 R \ell_a$ can be considered approximately constant. Hence X_m is influenced most by ℓ_g.

38. Ans: (a)

Sol: In a 3 – ph induction motor,

$$T_{st} = \text{Starting torque} = \frac{3V^2 r_2}{\omega_s\left[r_2^2 + x_2^2\right]} \quad \text{……... (1)}$$

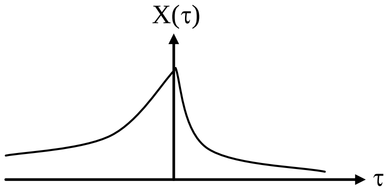
$$\approx \frac{3V^2}{\omega_s x_2{}^2} r_2$$

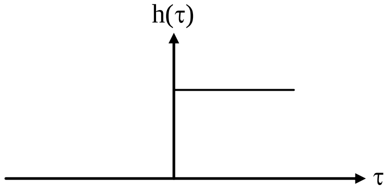
[Usually x_2 is substantially larger than r_2 in induction machines and hence r_2 is neglected in the denominator of (1)].

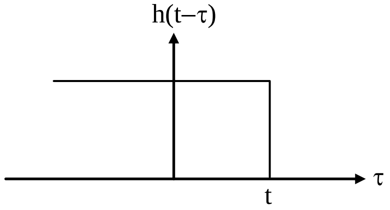
Thus a high starting torque is obtained by increasing r_2 the rotor resistance.

39. Ans: (b)

Sol: $y(t) = \int_{-\infty}^{t} x(\tau)\ h(t-\tau)d\tau$







t < 0

$$y(t) = \int_{\infty}^{t} e^{2t}dt = \left.\frac{e^{2t}}{2}\right|_{-\infty}^{t} = \frac{e^{2t}}{2}$$

40. Ans: (c)

Sol: y(0) = x(0) h(0) = 1 h(0) = 1

h(0) = 1

y(1) = x(0) h(1) + x(1) h(0)

= 1 h(1) + 0 h(0) = h(1) = 2

h(1) = 2

41. Ans: (d)

Sol: 1. The power signals has finite power and infinite energy

2. The energy signal has finite energy and zero power
3. All periodic signals are power signals
4. All infinite duration signals are may not power signals

42. Ans: (c)

Sol: 1. $x_1(t) \rightarrow y_1(t) = t\,x_1(t) + 2$

$x_2(t) \rightarrow y_2(t) = t\,x_2(t) + 2$

$x_3(t) = a\,x_1(t) + b\,x_2(t) \rightarrow y_3(t)$

$= t(a\,x_1(t) + b\,x_2(t)) + 2$

$\neq a y_1(t) + b y_2(t)$

Hence non-linear

2. $y(t - t_0) = (t - t_0)\,x(t - t_0) + 2$

$x_2(t) = x(t - t_0) \rightarrow y_2(t)$

$= t\,x(t - t_0) + 2$

$\neq y(t - t_0)$

Hence time variant

43. Ans: (d)

Sol: Given $y(n) = \sum_{k=-\infty}^{|2n|} x(k)$

$$y(-1) = \sum_{k=-\infty}^{2} x(k)$$

Present output depends on future input. So, system is non-causal.

For a bounded input u(n) system produces unbounded output(ramp). So, system is unstable.

44. Ans: (b)

Sol: $\delta(at+b) = \frac{1}{|a|}\delta\left(t+\frac{b}{a}\right)$

$$\int_{-4}^{2}\cos(2\pi t)\delta(2t+1)dt = \frac{1}{2}\int_{-4}^{2}\cos(2\pi t)\delta\left(t+\frac{1}{2}\right)dt$$

From SIFTING property

$$\int_{t_1}^{t_2} x(t)\delta(t-t_0)dt = x(t_0)\ ; \quad t_1 \le t_0 \le t_2$$

$= 0$ otherwise

$$\int_{-4}^{2}\cos(2\pi t)\delta(2t+1)dt = \frac{1}{2}\cos(2\pi t)\Big|_{t=-\frac{1}{2}}$$

$$= \frac{1}{2}\cos(\pi)$$

$$= -\frac{1}{2}$$

45. Ans: (c)

Sol: A signal is called energy signal if energy is finite and power is zero.

A signal is called power signal if power is finite and energy is infinite.

In the given statement 1, 2 and 3 are true

But statement (4) is false. Because $u(t+2)u(2-t) = \text{rect}\left(\frac{t}{4}\right)$ is an energy signal.

46. Ans: (a)

Sol: Given $C_n = \frac{1-\cos n\pi}{(n\pi)^2}$.

$$C_{-n} = \frac{1-\cos n\pi}{(n\pi)^2} = C_n$$

$C_{-n} = C_n$. So, $x(-t) = x(t)$

So, x(t) is even signal.

47. Ans: (b)

Sol: Given signal is odd signal hence contains only sine terms

48. Ans: (d)

Sol: 1. If the signal is real then $C_K = C^*_{-K}$

2. If the signal is even then $C_K = C_{-K}$

3. If the signal is odd then $C_K = -C_{-K}$

4. Average power of the signal = $\sum_{K=-\infty}^{\infty} |C_K|^2$

49. Ans: (c)

Sol: $x(t) \rightarrow C_K$

$$x(t-1) \rightarrow C_K\, e^{\frac{-jK\pi}{2}}$$

$$x(t-1) - \frac{1}{2} \rightarrow C_K$$

$$= \begin{cases} \frac{1}{K\pi} \sin\left(\frac{K\pi}{2}\right) e^{-\frac{jK\pi}{2}} & ; K \neq 0 \\ -\frac{1}{2} & ; K = 0 \end{cases}$$

50. Ans: (c)

Sol: A. $\text{Re}\{x(n)\} \leftrightarrow X_e(e^{j\omega})$

B. $j\text{Img}\{x(n)\} \leftrightarrow X_0(e^{j\omega})$

C. $x_e(n) \leftrightarrow \text{Re}\{X(e^{j\omega})\}$

D. $x_0(n) \leftrightarrow j\text{Img}\{X(e^{j\omega})\}$

51. Ans: (a)

Sol: Fourier transform pair is

$$e^{-\alpha|t|} \leftrightarrow \frac{2\alpha}{\alpha^2+\omega^2}$$

Inverse Fourier transform is

$$x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(\omega)e^{j\omega t}d\omega$$

$$x(0) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(\omega)d\omega$$

Assume $X(\omega) = \frac{2\alpha}{\alpha^2+\omega^2}$, $x(t) = e^{-\alpha|t|}$

$$\int_{-\infty}^{\infty} \frac{2\alpha}{\omega^2+\alpha^2}d\omega = 2\pi x(0)$$

$$\int_{-\infty}^{\infty} \frac{1}{\omega^2+\alpha^2}d\omega = \frac{\pi}{\alpha}e^{-\alpha|0|} = \frac{\pi}{\alpha}$$

52. Ans: (a)

Sol: Fourier transform of impulse signal is Constant.

Fourier transform of rectangular function is Sinc function

Fourier transform of constant is impulse function.

Fourier transform of Gaussian pulse is also Gaussian pulse.

53. Ans: (c)

Sol: A system is called minimum phase system, if all poles and zeros are lies on the left side of s-plane. A system is called stable if all poles lies on the left side of s-plane. So, Minimum phase systems are always stable and have smallest group delay. So, statement 1 is true.

A system is called mixed phase system, if one or more zeros lies on the right side of s-plane. So, statement 2 is false.

A system is called maximum phase system, if all zeros are lies on the right side of s-plane.

So, statement 3 is true

For system to be both causal & stable, all poles have negative real parts in the s-plane.

So, statement 4 is true

54. Ans: (a)

Sol: $$X(j\omega) = \int_{-\infty}^{\infty} x(t)e^{-j\omega t}dt$$

$$= \int_{-T_1}^{T_1} e^{-j\omega t}dt$$

$$= \frac{e^{-j\omega T_1} - e^{j\omega T_1}}{-j\omega}$$

$$= \frac{2}{\omega}\sin(\omega T_1)$$

$$= \frac{2T_1 \sin\left[\pi\left(\frac{\omega T_1}{\pi}\right)\right]}{\pi\left(\frac{\omega T_1}{\pi}\right)}$$

$$= 2T_1 \sin c\left(\frac{\omega T_1}{\pi}\right)$$

55. Ans: (b)

Sol: Given signal is the periodic signal and Fourier series coefficient $C_1 = 1$ and $C_k = 0$ For $K_0 \neq 0$.

For the periodic signal Fourier transform

$$X(j\omega) = 2\pi\sum_{K=-\infty}^{\infty} C_K\delta(\omega - K\omega_0)$$

$$= 2\pi\delta(\omega - \omega_0)$$

56. Ans: (c)

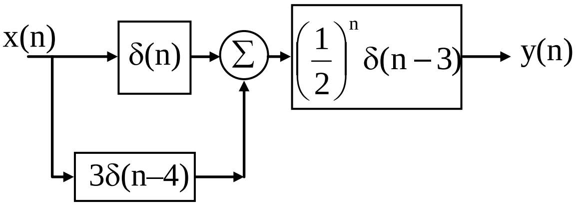
Sol: Using parseval's theorem

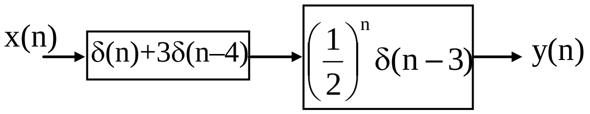
$$\int_{-\infty}^{\infty}|X(\omega)|^2 d\omega = 2\pi\int_{-\infty}^{\infty} x^2(t)dt$$

$$= 2\pi\left[\frac{2}{3} + \frac{2}{3}\right] = \frac{8\pi}{3}$$

57. Ans: (d)

Sol:





$$h(n) = [\delta(n) + 3\delta(n-4)] * \left[\left(\frac{1}{2}\right)^n \delta(n-3)\right]$$

$$h(n) = \left[\left(\frac{1}{2}\right)^n \delta(n-3) + 3\left(\frac{1}{2}\right)^{n-4} \delta(n-7)\right]$$

$$h(3) = \left(\frac{1}{2}\right)^3 \delta(0) + 3\left(\frac{1}{2}\right)^{-1} \delta(-4)$$

$$h(3) = \frac{1}{8}$$

58. Ans: (a)

Sol: A. x(n) = $\{1, 2, \underset{\uparrow}{2}, 1\}$. It is a finite duration both sided sequence. So, ROC is $0 < |z| < \infty$.

B. It is a finite duration right sided sequence, So, ROC is $|z| > 0$.

C. It is a finite duration left sided sequence, So, ROC is $|z| < \infty$.

D. The sequence is x(n) =δ(n) and the z-transform equal to 1 and ROC is entire z-plane.

59. Ans: (a)

Sol: (1) Number of stages in flow graph are $\log_2 N$.

So, statement (1) is wrong

(2) Number of butterflies in each stage are $\frac{N}{2}$.

(3) Number of complex multiplications are $\frac{N}{2}\log_2 N$.

(4) Number of complex additions are $N\log_2 N$.

(5) Inputs are bit reversal order, outputs are normal order.

So, statement (5) is false

60. Ans: (b)

Sol: There is a non-linear relation ship between analog and digital frequency in bilinear transformation method.

So, statement (2) is false, remaining all are true.

61. Ans: (b)

Sol: $$L[x(t)] = \frac{\int_0^T x(t)e^{-St}dt}{1-e^{-ST}}$$

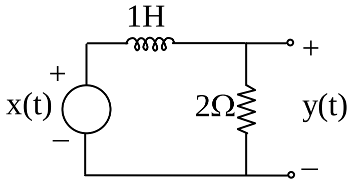
$$= \frac{\int_0^2 e^{-St}dt}{1-e^{-4S}}$$

$$= \frac{1-e^{-2S}}{\left(1-e^{-4S}\right)S}$$

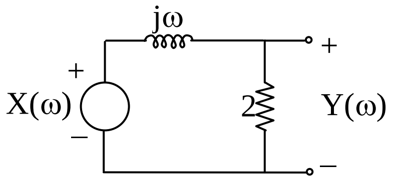
$$= \frac{1}{S\left(1+e^{-2S}\right)}$$

62. Ans: (a)

Sol: Given circuit is



Apply Fourier transform to above circuit. Then



$$Y(\omega)=\frac{2X(\omega)}{2+j\omega}$$

$$H(\omega)=\frac{Y(\omega)}{X(\omega)}=\frac{2}{2+j\omega}$$

Given x(t) = t e^{-2t} u(t)

$$X(\omega)=\frac{1}{(2+j\omega)^2}$$

$$Y(\omega)=X(\omega)H(\omega)=\frac{2}{(2+j\omega)^3}$$

$$t^n e^{-at}u(t)\leftrightarrow\frac{n!}{(j\omega+a)^{n+1}}$$

$$y(t)=t^2e^{-2t}u(t)$$

62. Ans: (b)

Sol: From multiplication of exponential in time domain property.

$$x(n)\leftrightarrow X(z)$$

$$(a)^n x(n)\leftrightarrow X(z/a)$$

$$(j)^n x(n)\leftrightarrow X(z/j)$$

From the given data

$$X(z)=\frac{k}{\left(z-\frac{3j}{2}\right)\left(z+\frac{3j}{2}\right)}=\frac{k}{z^2+\frac{9}{4}}$$

$$X\left(\frac{z}{j}\right)=\frac{k}{\left(\frac{z}{j}\right)^2+\frac{9}{4}}=\frac{k}{-z^2+\frac{9}{4}}=\frac{-k}{z^2-\frac{9}{4}}$$

Poles of $X\left(\frac{z}{j}\right)$ are $z^2-\frac{9}{4}=0$, $z=\pm\frac{3}{2}$

64. Ans: (c)

Sol: S_1: $e^{jn\frac{\pi}{2}}\rightarrow e^{jn\frac{\pi}{2}}u(n)$

For an LTI system if input is $Ae^{j\omega_0 n}$ then output is of the form $AH(e^{j\omega_0})e^{j\omega_0 n}$.

So,

S_1 is not LTI system

S_2: $e^{j\frac{n\pi}{2}}\rightarrow e^{j\frac{3\pi}{2}n}$, input and output frequencies are not same, so it is not LTI system.

S_3: $e^{j\frac{n\pi}{2}}\rightarrow 2e^{j\frac{5\pi}{2}n}=2e^{j\frac{\pi}{2}n}$, input and output frequencies are same, so it is an LTI system.

65. Ans: (b)

Sol: Assume $Y(k)=X^2(k)$

Apply IDFT

$y(n) = x(n)$ circular convolution $x(n)$

$$y(n) = \begin{bmatrix} 1 & 1 & -1 & 0 \\ 0 & 1 & 1 & -1 \\ -1 & 0 & 1 & 1 \\ 1 & -1 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ -1 \\ 1 \end{bmatrix}$$

$y(n) = \{2, -2, -1, 2\}$

66. Ans: (a)

Sol: The field winding of a single-phase synchronous machine (acting as a motor or as a generator) receives a dc excitation current, just like a 3-phase synchronous machine. When the rotor is rotating, a single-phase voltage is induced in the single phase winding present. The phase winding then delivers an ac current (generator action) or receives an ac current (motor action). In either case, the phase current flowing through the winding produces two rotating mmfs, rotating in opposite directions at synchronous speed (just like in a single phase induction motor). The rotor itself is rotating at synchronous speed.

The mmf component rotating in the same direction as the rotor is stationary w.r.t the rotor and does not induce any voltage in the field winding.

The mmf component rotating in opposite direction to the rotor however, causes a double frequency ac component of current in the field.

Both statements are correct. Statement-II explains statement-I.

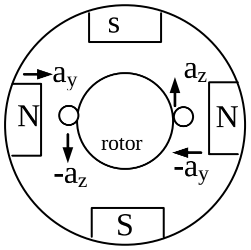
67. Ans: (c)

Sol: Given induction machine with a 4-pole stator and a 2-pole wound rotor.

Since the rotor winding is wound for 2 poles, each rotor phase can be represented by one full-pitched coil with a coil span of 180^o mech (which is the same as 180^o elec for 2 poles).

Direction of emf induced in coil-side 1 is given by that of $(-a_z \times a_y) = a_x$ (from Lorentz's force law).

Direction of emf induced in coil-side 1 is given by that of $(a_z \times -a_y) = a_x$ again.



These two emfs cancel each other and there is no current. This is true at every instant for every rotor phase and so there is no torque developed, and the rotor does not rotate.

However, if the rotor is replaced by a cage rotor, there will be normal rotation since cage winding automatically adjusts itself to have the same number of poles as the rotor.

'Statement-I' is true and 'Statement-II' is clearly false.

68. Ans: (b)

Sol: Statement I: 3 point starter is not used for the above rated speed control of the DC shunt motor

Statement II: 3 point starter is used to protect the DC shunt motor from accidental open circuit of field winding

Statement II is not correct explanation of statement I

69. Ans: (a)

Sol: DC series motor should not operate at light and no load condition, because series motor under no load condition will operate dangerously at very High speed.

70. Ans: (a)

Sol: Statement I: Concentric and interleaving winding will be used in the construction of the core type transformer

Statement II: By using the concentric and interleaving winding we can reduce the leakage flux, amount of the insulation required and amount of the copper required.

Both statements are correct and statement II is correct explanation of statement I.

71. Ans: (b)

Sol: Statement I: The speed of the self excited DC shunt motor is almost constant by changing the terminal voltage. Because flux is proportional to terminal voltage.

Statement II: The speed of the DC shunt motor can be increased by increasing the field circuit resistance. Because flux decreases, back emf is almost constant hence speed increases.

72. Ans: (a)

Sol: Statement I: In the parallel operation of the transformers, the transformer which has lower pu impedance on the common base will share more amount of the load.

Statement II: In the parallel operation the impedance of the transformer should be inversely proportional to kVA rating of transformer.

Both statements are correct and statement II is correct explanation of statement I.

73. Ans: (b)

Sol: Both are dirichlet conditions for existence of Fourier series. But there is no relation between each other.

74. Ans: (c)

Sol: FIR filters are always stable, because all poles lies inside the unit circle. So, Statement (I) is true.

FIR filters have linear phase only when it is symmetric/anti symmetric. i.e, $h(n) = h(N-1-n)$ or $h(n) = -h(N-1-n)$, So, Statement (II) is false.

75. Ans: (b)

Sol: Sampling in one domain makes the signal to be periodic in the other domain. So, statement I is correct. According to multiplication in time domain property, multiplication in one domain is the convolution in the other domain. So, statement II is correct.

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