DETAILED SOLUTIONS

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## ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

## ELECTRICAL ENGINEERING

## Test 14

**Section A :** Systems and Signal Processing + Communication Systems [All Topics]
**Section B :** BEE-1 + Analog Electronics-1 + Electrical & Electronic Measurements-1 [Part Syllabus]
**Section C :** Power Electronics and Drives-2 [Part Syllabus]

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

## DETAILED EXPLANATIONS
### Section A : Systems and Signal Processing + Communication Systems

**1. (b)**

Average power of $x(t)$, $P_x = \dfrac{1}{T_x}\displaystyle\int_{-T_x/2}^{T_x/2} |x(t)|^2\, dt = \dfrac{1}{4}\int_0^2 \left(\dfrac{A}{2}t\right)^2 dt = \dfrac{A^2}{16}\int_0^2 t^2 dt$

$$= \frac{A^2}{16}\left(\frac{t^3}{3}\right)_0^2 = \frac{A^2}{6}$$

Let, $y(t) = x(3t + 6)$.

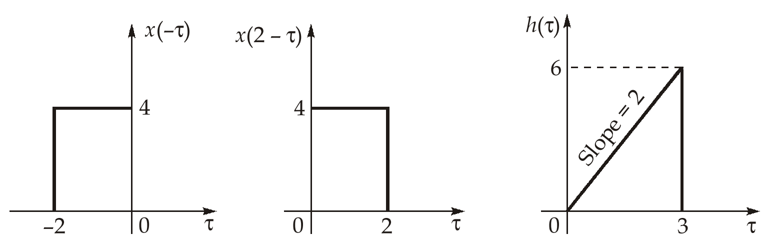
Since, $x(t)$ is a periodic signal, time scaling or shifting operations do not affect its average power.

So, $$P_y = P_x = \frac{A^2}{6}$$

**2. (c)**

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

$$y(2) = \int_{-\infty}^{2} x(2-\tau)h(\tau)\,d\tau$$




So, $$y(2) = \int_0^2 4(2\tau)\,d\tau = 8\left[\frac{\tau^2}{2}\right]_0^2 = 16$$

**3. (c)**

The series interconnection of two non-linear systems also can be a linear system depending on the individual systems.

**4. (a)**

The given signal $x(t)$ can be expressed as,

$$x(t) = 2u(t) + r(t-2) - r(t-4) - 4u(t-4)$$

$$r(t) = tu(t)$$

So, $$x(t) = 2u(t) + (t-2)u(t-2) - (t-4)u(t-4) - 4u(t-4)$$

$$= 2u(t) + (t-2)u(t-2) - tu(t-4) + 4u(t-4) - 4u(t-4)$$

$$= 2u(t) + (t-2)u(t-2) - tu(t-4)$$

Given that, $$x(t) = 2u(t) + (t-2)u(t-2) - (t-t_0)u(t-4)$$

So, $$t_0 = 0$$

**5. (c)**

1. $\cos\left(\frac{\pi}{3}n\right)+\sin\left(\frac{\pi}{3}n\right)\Rightarrow$ periodic

$$\text{Period} = \frac{2\pi\times 3}{\pi}=6$$

2. $\cos\left(\frac{1}{2}n\right)+\cos\left(\frac{1}{3}n\right)\Rightarrow$ non-periodic

3. $\text{Even }\{\cos(4\pi t)u(t)\} = \frac{\cos(4\pi t)\,u(t)+\cos(-4\pi t)u(-t)}{2} = \frac{\cos 4\pi t}{2}\Rightarrow$ Periodic

4. $\text{Even }\{\sin(4\pi t)u(t)\} = \frac{\sin(4\pi t)u(t)+\sin(-4\pi t)u(-t)}{2}\Rightarrow$ not periodic

**6. (d)**

- If $x(t)$ is periodic with time period $T$, then $y(t) = x(2t)$ will be periodic with time period $T/2$.
- Sum of two discrete time periodic signals is always periodic.

**7. (a)**

$$I = \int_{-\infty}^{\infty}\cos(2\pi t)e^{-t^2/2}\delta(1-2t)\,dt$$

$$= \int_{-\infty}^{\infty}\cos 2\pi t\; e^{-t^2/2}\,\frac{1}{2}\delta\left(t-\frac{1}{2}\right)dt$$

$\because\;\; f(t)\,\delta(t-t_0) = f(t_0)\delta(t-t_0)$ and area under impulse is 1,

$$I = \frac{1}{2}\times\cos\left(2\pi\times\frac{1}{2}\right)\times e^{-1/8} = -\frac{1}{2}e^{-1/8}$$

**9. (b)**

| Signal | Range |
|---|---|
| $x(t)$ | $t_1$ to $t_2$ |
| $h(t)$ | $t_3$ to $t_4$ |
| $y(t)$ | $(t_1+t_3)$ to $(t_2+t_4)$ |
| $x(2t-3)$ | $\left(\frac{t_1+3}{2}\right)$ to $\left(\frac{t_2+3}{2}\right)$ |
| $h(2t+4)$ | $\left(\frac{t_3-4}{2}\right)$ to $\left(\frac{t_4-4}{2}\right)$ |
| $x(2t-3)*h(2t+4)$ | $\left(\frac{t_1+t_3}{2}\right)-\frac{1}{2}$ to $\left(\frac{t_2+t_4}{2}\right)-\frac{1}{2}$ |

} assume ($x(t)$, $h(t)$)

$\Rightarrow$ 3 to 7 ($y(t)$)

$$t_1 + t_3 = 3 \quad\Rightarrow\quad \frac{t_1+t_3}{2}-\frac{1}{2}=1$$

$$t_2 + t_4 = 7 \quad\Rightarrow\quad \frac{t_2+t_4}{2}-\frac{1}{2}=3$$

**10. (d)**

Given, $$g(t) = \text{rect}(4t) * 4\delta(-2t) = 4\text{rect}(4t) * \delta(-2t)$$

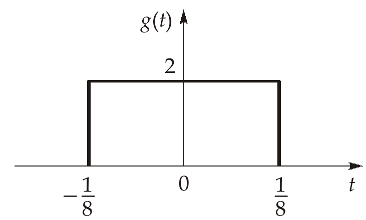
$$g(t) = 2\text{rect}(4t) \quad [\because \delta(-t) = \delta(t) \text{ and } \delta(2t) = \frac{1}{2}\delta(t)]$$

$$\text{rect}(t) \xleftrightarrow{\text{CTFT}} \text{sinc}(f)$$

$$2\text{rect}(t) \xleftrightarrow{\text{CTFT}} 2\text{sinc}(f)$$

$$2\text{rect}(4t) \xleftrightarrow{\text{CTFT}} 2 \times \frac{1}{4}\text{sinc}\left(\frac{f}{4}\right)$$

$$\therefore \quad 2\text{rect}(4t) \xleftrightarrow{\text{CTFT}} \frac{1}{2}\text{sinc}\left(\frac{f}{4}\right)$$




**11. (d)**

Let, $x_1(t) = te^{-2t}u(t)$.

$$x_1(t) = te^{-2t}u(t) \xleftrightarrow{\text{CTFT}} X_1(\omega) = \frac{1}{(2+j\omega)^2}$$

$$X(\omega) = \frac{j\omega}{(2+j\omega)^2} = j\omega X_1(\omega)$$

$$\frac{dy(t)}{dt} \xleftrightarrow{\text{CTFT}} j\omega Y(\omega)$$

So, $$x(t) = \frac{dx_1(t)}{dt} = \frac{d}{dt}[te^{-2t}u(t)]$$

$$= e^{-2t}u(t) - 2te^{-2t}u(t) + te^{-2t}\delta(t)$$

$$= (1 - 2t)e^{-2t}u(t) \qquad [\because te^{-2t}\delta(t) = 0]$$

**12. (d)**

The system has a pole at $z = \frac{1}{4}$. The ROC of a stable system should include the unit circle in the $z$-plane.

So, the required ROC is, $|z| > \frac{1}{4}$.

**13. (d)**

$$H(e^{j\omega}) = \frac{1+e^{j2\omega}}{0.50+e^{j2\omega}}$$

$H(e^{j\omega}) = 0$, for $2\omega = (2n + 1)\pi$ ; $\quad n = 0, 1, 2, 3, ......$

The relation between analog frequency "$f$" and digital frequency "$\omega$" is,

$$\omega = 2\pi\frac{f}{f_s} \; ; \quad f_s = \text{sampling frequency}$$

To reject the analog noise of 50 Hz,

$$2\pi\frac{50}{f_s} = (2n+1)\frac{\pi}{2}$$

$$f_s = \frac{200}{(2n+1)} \text{ Hz} = 200 \text{ Hz}, 66.67 \text{ Hz}, 40 \text{ Hz}, ....$$

Among the given options, $f_s$ = 200 Hz can be selected.

**14. (c)**

The transfer function from the given direct form implementation is,

$$H(z) = \frac{a}{1-abz^{-1}-acz^{-2}} = \frac{1}{1-2z^{-1}+3z^{-2}}$$

$$a = 1$$

$$ab = 2 \Rightarrow b = 2$$

$$ac = -3 \Rightarrow c = -3$$

**15. (d)**

$$y(n) = x_1(n) \circledast x_2(n) = \{\underset{\uparrow}{1}, 2, 2, 0\} \circledast \{\underset{\uparrow}{1}, 2, 3, 4\}$$

$$y(n) = [1\ 2\ 2\ 0]\begin{bmatrix}1 & 2 & 3 & 4\\4 & 1 & 2 & 3\\3 & 4 & 1 & 2\\2 & 3 & 4 & 1\end{bmatrix} = [15\ 12\ 9\ 14]$$

So, $$y(n) = \{\underset{\uparrow}{15}, 12, 9, 14\}$$

**16. (d)**

The Fourier series expansion of a periodic signal is also periodic.

Among the given signals, $x_4(t)$ is not a periodic signal.

**17. (d)**

$$x(t) \xleftrightarrow{\text{CTFT}} X(f)$$

$$x(t+4) \xleftrightarrow{\text{CTFT}} X(f)\ e^{+j8\pi f}$$

$$x(2t+4) \xleftrightarrow{\text{CTFT}} \frac{1}{2}X\left(\frac{f}{2}\right)e^{+j4\pi f}$$

**18. (c)**

$$x(n) = \left(\frac{1}{5}\right)^{|n|} - (2)^n u(n) = \left(\frac{1}{5}\right)^{-n} u(-n-1) + \left(\frac{1}{5}\right)^{n} u(n) - (2)^n u(n)$$

$$= (5)^n u(-n-1) + \left(\frac{1}{5}\right)^{n} u(n) - (2)^n u(n)$$

$(5)^n u(-n-1) \Rightarrow \text{ROC}: |z| < 5$

$\left(\frac{1}{5}\right)^n u(n) \Rightarrow \text{ROC}: |z| > \frac{1}{5}$

$(2)^n u(n) \Rightarrow \text{ROC}: |z| > 2$

So, the ROC of the sequence $x(n)$ can be given as, $\left\{(|z|<5) \cap \left(|z|>\frac{1}{5}\right) \cap (|z|>2)\right\} = 2<|z|<5$.

**19. (d)**

If $x(n) = \delta(n)$, then $y(n) = h(n)$ = unit impulse response.

So, for the given system,

$$h(n) = \sum_{k=-\infty}^{n+5} \delta(k) = \begin{cases} 0\,; & \text{for } n < -5 \\ 1\,; & \text{for } n \geq -5 \end{cases}$$

$$h(n) = \{1, 1, 1, 1, 1, \underset{\uparrow}{1}, 1, 1, 1, .....\}$$

$$h(n) \neq 0 \text{ for } n < 0 \Rightarrow \text{Non causal}$$

$$\sum_{n=-\infty}^{\infty} |h(n)| = \infty \Rightarrow \text{unstable}$$

So, the given system is neither stable nor causal.

**20. (a)**

Let, $$y = \sum_{k=1}^{3} x[k]\delta[1-k] = \sum_{k=1}^{3} (4-k)\delta[1-k]$$

$$= \sum_{k=1}^{3} 3 \times \delta[1-k]$$ ...from multiplication property of impulse

$$= 3 \times 1 = 3$$

**21. (b)**

$$y[n] = \delta[n+1] - \frac{3}{2}\delta[n] - \delta[n-1]$$

$$x[n] = \delta[n] + \frac{1}{2}\delta[n-1]$$

$$H(z) = \frac{Y(z)}{X(z)} = \frac{z - \frac{3}{2} - z^{-1}}{1 + \frac{1}{2}z^{-1}} = \frac{z^2 - \frac{3}{2}z - 1}{z + \frac{1}{2}} = \frac{\left(z+\frac{1}{2}\right)(z-2)}{\left(z+\frac{1}{2}\right)}$$

$H(z) = (z - 2)$ $\Rightarrow$ All zero system

$h[n] = \delta[n + 1] - 2\delta[n]$ $\Rightarrow$ Finite length

$h(n)$ is finite length sequence and $H(z)$ has only zeros $\Rightarrow$ System is FIR filter

As the system is FIR, it is always stable

Impulse response is non-zero for $n = -1 \Rightarrow$ Non-causal

**22. (b)**

Since $x(n)$ is causal,

$$x(0) = \lim_{z \to \infty} X(z) = \lim_{z^{-1} \to 0} X(z)$$

$$= \lim_{z^{-1} \to 0} \frac{3(2-3z^{-1})}{(3-z^{-1})(2-z^{-1})} = \frac{3\times 2}{3\times 2} = 1$$

**23. (c)**

$$y(n) = x(n) * h(n)$$

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $x(n) \Rightarrow$ | $\underset{\bullet}{1}$ | 2 | 3 | 4 | | | |
| $h(n) \Rightarrow$ | $\underset{\bullet}{5}$ | 6 | 7 | 8 | | | |
| | $\underset{\bullet}{5}$ | 6 | 7 | 8 | | | |
| | | 10 | 12 | 14 | 16 | | |
| | | | 15 | 18 | 21 | 24 | |
| | | | | 20 | 24 | 28 | 32 |
| $x(n) * h(n) \Rightarrow$ | $\underset{\bullet}{5}$ | 16 | 34 | 60 | 61 | 52 | 32 |

$$y(n) = \{\underset{\uparrow}{5}, 16, 34, 60, 61, 52, 32\}$$

So, $\quad y(3) = 60$

**24. (c)**

$$\frac{\pi}{j}[\delta(\omega-1)-\delta(\omega+1)] \xrightarrow{IFT} \sin t$$

$$2[\delta(\omega-1)-\delta(\omega+1)] \xrightarrow{IFT} \frac{2j}{\pi}\sin t$$

$$3[\delta(\omega-2\pi)+\delta(\omega+2\pi)] \xrightarrow{IFT} \frac{3}{\pi}\cos 2\pi t$$

So, correct answer is (c).

**25. (c)**

$$x(t) = s(t)A\cos(\omega_c t + 30°)$$

$$= A^2[\cos(\omega_c t + 30°)\cos(\omega_c t)]m(t)$$

$$= \frac{A^2}{2}[\cos(2\omega_c t + 30°) + \cos 30°]m(t)$$

After passing through LPF, we get,

$$y(t) = \frac{A^2}{2}\cos(30°)\, m(t) = \frac{\sqrt{3}A^2}{4} m(t)$$

Average power of $y(t)$,

$$P_y = \left(\frac{\sqrt{3}}{4}A^2\right)^2 P_m = \frac{3A^4}{16}P_m$$

**26. (a)**

$$(BW)_{FM} = \left(1+\frac{\Delta f}{f_m}\right)(2f_m) = \left(1+\frac{A_m k_f}{f_m}\right)(2f_m)$$

$$(BW)_{PM} = (1 + A_m k_p)\ (2f_m)$$

When only $f_m$ is increased, $(BW)_{PM}$ will be increased by higher factor than that of $(BW)_{FM}$.

**27. (b)**

The standard form of an FM signal can be given as,

$$s(t) = A_c \cos\left[2\pi f_c t + 2\pi k_f \int_{-\infty}^{t} m(t)\,dt\right]$$

The maximum phase deviation of the FM signal can be given as,

$$\Delta\phi_{max} = 2\pi k_f \left|\int_{-\infty}^{t} m(t)\,dt\right|_{max}$$

Since $m(t)$ has only positive values,

$$\left|\int_{-\infty}^{t} m(t)\,dt\right|_{max} = \text{Area under } m(t) = 4 \times 2 = 8 \text{ V-sec}$$

$$\Delta\phi_{max} = 2\pi k_f \left|\int_{-\infty}^{t} m(t)\,dt\right|_{max}$$

$$= 2\pi(0.5 \text{ Hz/V})\ (8 \text{ V-sec}) \text{ rad} = 2\pi(0.5)\ (8) \text{ rad} = 8\pi \text{ rad}$$

**28. (b)**

Given, $x(t) = 10\cos(20\pi t + \pi t^2)$

$\theta(t) = 20\pi t + \pi t^2$

Instantaneous frequency, $f_i = \dfrac{1}{2\pi}\dfrac{d\theta(t)}{dt} = \dfrac{1}{2\pi}[20\pi + 2\pi t]\text{ Hz}$

$= (10 + t)$ Hz

At $t = 50$ sec, $f_i = 60$ Hz

**29. (b)**

The given modulated signal is an AM signal.

$$s(t) = (2.5 + 5\cos\omega_m t)\cos\omega_c t = 2.5(1 + 2\cos\omega_m t)\cos\omega_c t$$

So, the modulation index of the given AM signal is,

$$\mu = 2$$

As $\mu > 1$, synchronous detector is more suitable.

**30. (c)**

Modulation is not required to increase the signal power. Simple amplification also can increase the signal power.

**31. (d)**

- Detection or demodulation provides means of recovering message signal from a modulated wave. In fact, detection is the inverse of modulation.
- Mixer is a non-linear device which generates the sum and difference frequencies. Hence, mixer is involved in frequency conversion.
- IF amplifier is a tuned voltage amplifier.

**32. (d)**

- Channel capacity is the **maximum** rate at which the data can be transmitted through a channel without errors.
- Capacity of a channel can be increased by increasing channel bandwidth as well as by increasing signal to noise ratio.

$$C = B\log_2\left(1+\frac{S}{N}\right)$$

**33. (c)**

Number of voice channels,

$$N = 24$$

Sampling rate, $f_s = 8$ kHz

Number of bits/sample, $n = 8$

Number of message bits for each frame = 24 × 8 = 192 bits/frame

Number of bits/frame after adding sync bits = 193 bits/frame

Frame rate = Individual sampling rate = 8000 frames/second

Resultant data rate, $R_b$ = 193 × 8 kbps = 1544 kbps.

**34. (d)**

- Digital communication systems give better noise performance than any analog communication system.
- So, among the given choices, PCM provides better noise performance.

**35. (b)**

For AM; with μ = 1, 66.6% of AM power distributed to carrier.

$$\%P_{\text{save}} = \frac{P_c}{P_t}\times 100 = \frac{2}{2+\mu^2}\times 100\% = \frac{2}{2+1}\times 100 = 66.67\%$$

**36. (b)**

PAM, PPM, PWM are analog modulation technique.

**38. (d)**

$$I_t = I_c\sqrt{1+\frac{\mu^2}{2}}$$

Given that, $I_t = 5$ A and $I_c = 4$ A

$$\mu^2 = 2\left[\left(\frac{I_t}{I_c}\right)^2 - 1\right]$$

$$\mu = \sqrt{2\left[\frac{25}{16} - 1\right]} = \frac{3}{4}\sqrt{2} = \frac{3 \times 1.414}{4} = \frac{4.242}{4} = 1.06$$

**39. (b)**

For FM signal, $\beta$ = Maximum phase deviation

= 3 radians

**Note :** Unit of modulation index of a single-tone FM signal is radian by default.

**40. (b)**

$$(BW)_{FM} = (1 + \beta)(2f_m) = \left(1 + \frac{A_m k_f}{f_m}\right)(2f_m)$$

Let, $$B_1 = \left(1 + \frac{A_{m1} k_f}{f_{m1}}\right)(2f_{m1})$$

Given, $f_{m2} = 2f_{m1}$

$A_{m2} = 2A_{m1}$

Now, $$B_2 = \left(1 + \frac{A_{m2} k_f}{f_{m2}}\right)(2f_{m2}) = \left(1 + \frac{A_{m1} k_f}{f_{m1}}\right)(2 \times 2f_{m1}) = 2B_1$$

**41. (b)**

The antenna current of an AM transmitter can be given as,

$$I_t = I_c\sqrt{1 + \frac{\mu^2}{2}}$$

Given that, $I_t = (1.1)\, I_c$

So, $$1.1 = \sqrt{1 + \frac{\mu^2}{2}}$$

$$\frac{\mu^2}{2} = (1.1)^2 - 1$$

$$\mu^2 = 2(0.21) = 0.42$$

$$\mu = \sqrt{0.42} \simeq 0.648 = 0.65$$

**42. (c)**

For a memoryless LTI system,

$\Rightarrow$ $h(n) = b_0\, \delta(n)$

taking $Z$-transform we get,

$H(z) = b_0$

which has no poles or no zeroes.

**43. (d)**

Power distributed among the sidebands and carrier components of a frequency modulated signal is a strong function of the modulation index.

Statement (II) is correct.

**44. (a)**

Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).

**45. (a)**

Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).

## Section B : BEE-1 + Analog Electronics-1 + Electrical & Electronic Measurements-1

**46. (a)**

Since band gap order is Ge < Si < GaAs

∴ Since band gap in GaAs is higher an electron in valence band of GaAs must gain more energy than one in Si to enter conduction band.

**47. (b)**

For negative cycle,

$$V_0 = 5 - 0.7 = 4.3 \text{ V}$$

For positive cycle,

$$V_0 = V_c + V_i$$

$$-20 + V_c + 0.7 - 5 = 0$$

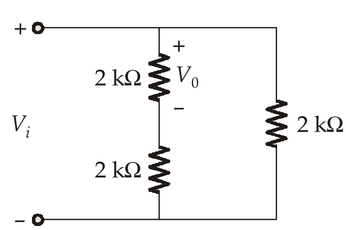
$$V_c = 24.3 \text{ V}$$

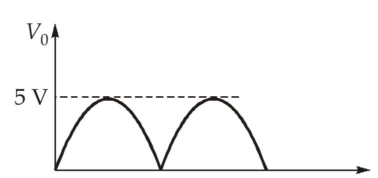
$$\therefore \quad V_0 = 10 + 24.3$$

$$= 34.3 \text{ V}$$

**48. (b)**

For positive region of $V_i$,




$$\therefore \quad V_{dc} = \frac{2}{\pi}V_m = \frac{2}{\pi}\times 5 = 3.18 \text{ V}$$

**49. (a)**

$$C_{\text{Diffusion}} \propto \tau_T$$

Also,
$$C_T = \frac{C_{j0}}{\left(1+\frac{V_R}{V_0}\right)^m}$$

With increase in $V_R$, $C_T$ will decrease.
Hence statement-2 is wrong.

**50. (d)**

- $|V_{BE}|$ decreases about 2.5 mV per degree Celsius (°C) increase in temperature.
- Higher the stability factor, more sensitive is the network to variation in that parameter.

**51. (b)**

Output of the circuit,

$$V_0 = -\left(\frac{R_f}{R_2}V_2 - \frac{R_f}{R_3}\frac{R_f}{R_1}V_1\right)$$

Hence acts as a voltage subtracter.

**52. (a)**

$$\omega_{0L} = \frac{1}{R_1C_1} = \frac{1}{10\times10^3\times0.1\times10^{-6}} = 1000 \text{ rad/sec}$$

$$f_{0L} = \frac{1000}{2\pi} = 159.15 \text{ Hz}$$

$$\omega_{0H} = \frac{1}{R_2C_2} = \frac{1}{10\times10^3\times0.002\times10^{-6}}$$

$$= \frac{1000}{0.02}\times100 = 50 \text{ K rad/sec}$$

$$f_{0H} = \frac{50\times1000}{2\pi} = 7957.75 \text{ Hz}$$

**53. (a)**

Reactance of pressure coil,

$$\omega L = 2\pi \times 50 \times 5 \times 10^{-3}$$
$$\omega L = 1.57\ \Omega$$

Pressure coil phase angle,

$$\tan\beta = \frac{1.57}{3000}$$

$$\beta = \frac{1.57}{3000} \qquad (\because \tan\beta = \beta \text{ for very low values of } \beta)$$

$$\beta = 5.23 \times 10^{-4}$$

$\therefore$ error with zero p.f. $= VI \sin\phi \tan\beta$

$= 100 \times 10 \times 1 \times 5.23 \times 10^{-4}$

$= 0.523$ W

**55. (b)**

Voltage in parallel is same,

$$\therefore \quad (1 - 100 \times 10^{-6})R_{sh} = (100 \times 10^{-6} \times 100)$$

$$R_{sh} = \frac{10^{-2}}{0.9999}\Omega \approx 1 \times 10^{-2}\ \Omega = 10 \times 10^{-3}\ \Omega$$

$$= 10\ \text{m}\Omega$$

**56. (d)**

For measurement of high voltages of the order of kilo volts, electrostatic voltmeters are used.

**57. (d)**

For, $V_0 = 0$, bridge must be balanced

$$R\left(R + \frac{1}{j\omega C}\right) = R(R + j\omega L)$$

$$R\left(R - \frac{j}{\omega C}\right) = R[R + j\omega L]$$

$$R^2 - \frac{R}{\omega C}j = R^2 + jR\omega L$$

comparing the imaginary parts as real parts are already equal

$$\frac{-R}{\omega C} = R\omega L$$

$$\omega^2 = \frac{-1}{LC}$$

$$\omega = \frac{j}{\sqrt{LC}}$$

Frequency is coming to be imaginary which is impossible. Hence $V_0$ can not be made zero.

**58. (c)**

$Q$-point is not totally independent of $\beta$ but less sensitive to $\beta$ or temperature variations then encountered for fixed bias or emitter biased configuration.

**59. (c)**

The scale of shunt type ohmmeter is highly cramped for high value of resistance.

**60. (a)**

The deflection torque is small due to low power factor even when current and pressure coils are fully excited.

## Section C : Power Electronics and Drives-2

**62. (a)**

$$I_{LB} = \frac{D}{2fL}(V_S - V_0)$$

$$= \frac{V_s}{2fL}D(1-D)$$

**63. (b)**

Available output is less in the linear range of PWM.

**64. (c)**

With constant $V_d$ and $D$, output power will decrease in discontinuous mode.

$$p_0 = p_d$$

output voltage increases as the inductor discharge faster.

**65. (c)**

With parasitic elements,

$$V_0 = \frac{V_s(1-D)}{\left[\frac{r_L}{R} + (1-D)^2\right]}$$

$\therefore$ $D = 0;$ $V_0 = V_S \frac{R}{r_L}$

$D = 1;$ $V_0 = 0$

**66. (c)**

In dc-dc converter, switch duty ratio controls only the dc output voltage.

**67. (d)**

$$\text{Switch utilization ratio} = \frac{V_{01}I_{0\text{max}}}{qV_T I_T}$$

where for full bridge inverter,

$$V_T = V_{d\text{max}}$$

$$I_T = \sqrt{2}\, I_{0\text{max}}$$

$$= \frac{200 \times 10}{4 \times 325 \times \sqrt{2} \times 10} = 0.1087 \approx 0.11$$

**68. (c)**

In 3-$\phi$ inverters, only odd harmonics exists as side bands, centered around $m_f$ and its multiples, provided $m_f$ to be odd, here $m_f$ is chosen to be an odd multiple of 3.

**70. (a)**

Static Scherbius drive offers speed control below and above synchronous speed.

**72. (b)**

For natural turn-off, peak resonant current $\left(\frac{V_s}{Z_0} \text{ or } V_s\sqrt{\frac{C}{L}}\right)$ must be greater than load current $I_0$.

**73. (a)**

PWM with unipolar switching has harmonics at sidebands at twice the switching frequency in single phase inverter. The voltage waveform $V_{AN}$ and $V_{BN}$ are displaced by 180° of the fundamental frequency with respect to each other. Therefore the harmonic component at the switching frequency in $V_{AN}$ and $V_{BN}$ have the same phase. This results in cancellation of harmonic component at the switching frequency in the output voltage $V_0 = V_{AN} - V_{BN}$.

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