DETAILED SOLUTIONS

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ESE 2025 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 20

Full Syllabus Test 2 : Paper-II

1. (c)	26. (d)	51. (a)	76. (b)	101. (b)	126. (d)
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16. (c)	41. (d)	66. (c)	91. (a)	116. (b)	141. (a)
17. (b)	42. (c)	67. (c)	92. (c)	117. (c)	142. (a)
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19. (c)	44. (b)	69. (c)	94. (c)	119. (d)	144. (c)
20. (d)	45. (b)	70. (a)	95. (d)	120. (b)	145. (a)
21. (c)	46. (d)	71. (c)	96. (b)	121. (c)	146. (b)
22. (c)	47. (d)	72. (a)	97. (a)	122. (d)	147. (a)
23. (b)	48. (c)	73. (d)	98. (d)	123. (d)	148. (a)
24. (a)	49. (d)	74. (d)	99. (b)	124. (d)	149. (a)
25. (c)	50. (a)	75. (b)	100. (c)	125. (b)	150. (b)

DETAILED EXPLANATIONS

1. (c)

Loops are,

$$L_1 = -G_1G_2G_3G_4G_5G_6H_3$$
$$L_2 = -G_2G_3G_4G_5H_2$$
$$L_3 = -G_4H_4$$
$$L_4 = -G_2G_7H_2$$
$$L_5 = -G_8H_1$$
$$L_6 = -G_5G_6H_1$$
$$L_7 = -G_1G_2G_3G_4G_8H_3$$
$$L_8 = -G_1G_2G_7G_6H_3$$

Out of which, pair of non-touching loops are,

- $-G_4H_4$ and $-G_2G_7H_2$ (L_3 and L_4)
- $-G_2G_7H_2$ and $-G_8H_1$ (L_4 and L_5)
- $-G_4H_4$ and $-G_1G_2G_7G_6H_3$ (L_3 and L_8)

Hence, there are three pairs of non-touching loops.

2. (d)

Step 1: Compute binary representation of the magnitude of the number.

2	450
2	225 – 0
2	112 – 1
2	56 – 0
2	28 – 0
2	14 – 0
2	7 – 0
2	3 – 1
	1 – 1

Using sign-bit, 450 is represented as $(0111000010)_2$.

$$(450)_{10} = (111000010)_2$$

Step 2: Take 2's complement of binary representation.

$$+450 = 111000010$$
$$-450 = 1000111110$$

Since the options given correspond to 12 bits, we repeat the sign bit to extend the number of bits. Thus, we have

$$-450 = (1110\ 0011\ 1110)_2 = (E3E)_H$$

3. (d)

The following are the services provided by OS:

- Interface between user and hardware.
- Program execution
- Protection and security
- I/O operations

- Controlling of the system
- Memory management
- File system manipulation
- Accounting information
- CPU scheduling

4. (b)

- For a real-valued signal, the Fourier series coefficients exhibit conjugate symmetry i.e. $C_n = C_n^*$ or we can write, $C_n = C_{-n}^*$.
- If the signal is real and even, its Fourier series coefficients are purely real and even. We have, $C_{-n} = C_n^* = C_n$.
- If the signal is real and odd, its Fourier series coefficients are purely imaginary and odd. We have, $C_{-n} = C_n^* = -C_n$.

Hence, A → 3, B → 4, C → 1, D → 2.

5. (b)

When μ > 1, the negative peaks of the modulated waveform cross zero, leading to overmodulation which distorts the envelope of the modulated signal. This causes distortion in the demodulated signal, making it unreadable.

6. (b)

Absolute instruments are those that provide the value of the measured quantity in terms of physical constants and do not require calibration against a standard. Some examples include:

1. Tangent Galvanometer – Measures current using tangent of the deflection angle.
2. Rayleigh's Current Balance – Measures electric current using force between conductors.
3. Absolute Pressure Gauge – Measures pressure using a known reference (e.g., barometer).
4. Electrometer – Measures electric charge or potential using electrostatic principles.
5. Standard Cell – Provides a reference voltage based on electrochemical properties.

These instruments are primarily used in laboratories for high-precision measurements.

Secondary instruments are those that require calibration against a standard instrument and provide a direct reading of the measured quantity. Some examples include:

1. Ammeter – Measures electric current.
2. Voltmeter – Measures voltage across two points.
3. Wattmeter – Measures electrical power in a circuit.
4. Thermometer – Measures temperature using thermal expansion or electrical resistance.
5. Pressure Gauge – Measures pressure relative to atmospheric or absolute pressure.
6. Energy Meter – Measures electrical energy consumption in kWh.

These instruments are widely used in industrial, commercial, and domestic applications.

7. (d)

Short Jump (SJMP) → It uses bit signed offset [Range within –128 to +127 Bytes from the current program counter]

Absolute Jump (AJMP) → The 64 KB memory is divided into 32 parts; known as pages each consisting of 2 KB of memory. Absolute jump is performed inside a page only. It uses 11-bit address. [Range within 2^{11} Bytes = 2 K Bytes of the page]
Long Jump (LJMP) → It uses 16-bit address [Range within 2^{16} Bytes = 64 K Bytes]

8. (d)

Different methods used to start a synchronous motors are,

1. **Using Pony motors:** Synchronous motors can be started by using small pony motors like a small induction motor.
2. **Using Damper Windings:** When a three-phase supply is connected to the stator, the synchronous motor with damper winding will start as a three-phase induction motor.
3. **Using small DC machine:** In this method, DC motor is used in place of induction motor to start a synchronous motor.

Note: Use of flywheels is one of the techniques used to reduce hunting. The flywheel increases the inertia of the rotor and helps in maintaining the rotor speed constant.

9. (b)

$$V_{out} = A_0[V_{in1} - V_{in2}]$$
$$V_{out} = A_0[V_{in} - V_{out}]$$
$$\frac{V_{out}}{V_{in}} = \frac{A_0}{1+A_0} = \frac{1000}{1+1000} = 0.999$$
$$\Rightarrow \quad V_{out} = 0.999 \text{ V}$$

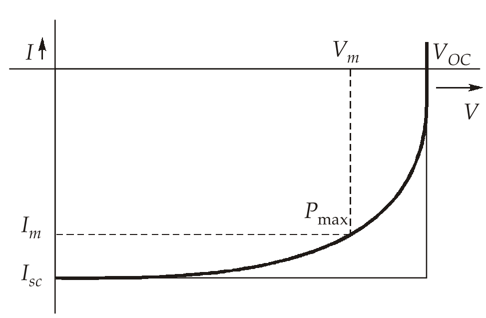
10. (d)

- During the execution of a program, memory accesses tend to cluster in certain areas of memory for a period of time. This locality can be temporal (referencing the same memory locations repeatedly within a short time) or spatial (referencing memory locations that are physically close to each other).
- As per heuristic 90-10 rule, 90 % of program execution time is spent executing 10% of code. This is a specific manifestation of the temporal locality of reference. Cache memory is designed to effectively store and provide fast access to this frequently executed 10% of the code.

Hence, all the given statements are correct.

11. (b)

For a solar cell, I-V characteristics are as below:



$$\text{Fill factor (FF)} = \frac{V_m I_m}{V_{OC} I_{sc}} = \frac{P_m}{V_{OC} I_{sc}} = \frac{\text{Area of inner rectangle}}{\text{Area of outer rectangle}}$$

$$\therefore \quad \text{F.F} = \frac{3}{4} = 0.75$$

12. (b)

$$\text{DC gain of the system} = \lim_{s\to 0} T(s)$$

$$= \frac{5k}{5} = k \quad \text{...(i)}$$

Now open loop transfer function of the system is given as

$$G(s)H(s) = \frac{T(s)}{1-T(s)} = \frac{k(s+5)}{[s(s+3)+(s+1)(s+5)]-k(s+5)}$$

Now, $$\text{open loop DC gain} = \lim_{s\to 0} G(s)H(s) = \frac{5k}{5-5k}$$

As, $$\frac{5k}{5-5k} = 1$$

$$5k = 5 - 5k$$

$$10k = 5$$

$$k = 0.5$$

Now from equation (i), DC gain of the system is $\lim_{s\to 0} T(s) = k = 0.5$

13. (a)

$$\text{Conversion efficiency, } \eta = \frac{\text{AC signal power supplied to load}}{\text{DC power drawn from biasing supply}}$$

$$\%\eta = \frac{P_{AC}}{P_{DC}} \times 100$$

Thus, η should be as high as possible.

Now, $$\text{Figure of merit, } F = \frac{P_{D\max}}{P_{AC\max}} = \frac{\text{maximum power dissipation in transistor}}{\text{maximum AC power supplied to load}}$$

Figure of merit should be as low as possible for better performance.

14. (d)

Non-pipelined processor:

$$\text{Execution time for '}n\text{' instructions} = t_n = \text{CPI} * \text{Cycle time} * n = \frac{8n}{5\times 10^9} = \frac{8}{5}n\times 10^{-9}$$

Pipelined processor:

For a pipelined processor, CPI = 1.

$$\text{Execution time for '}n\text{' instructions} = t_p = \text{CPI} * \text{Cycle time} * n = \frac{n}{2.5\times 10^9} = \frac{2}{5}n\times 10^{-9}$$

$\therefore$ $$\text{speed up} = \frac{t_n}{t_p}$$

$$= \frac{\left(\frac{8}{5}n \times 10^{-9}\right)}{\left(\frac{2}{5}n \times 10^{-9}\right)} = \frac{\left(\frac{8}{5}\right)}{\left(\frac{2}{5}\right)} = 4$$

15. (d)

Let, $$X(s) = \frac{2}{s^2}(\sinh(sT))$$

$$= \frac{2}{s^2}\left[\frac{e^{sT} - e^{-sT}}{2}\right] = \frac{e^{sT}}{s^2} - \frac{e^{-sT}}{s^2}$$

Taking inverse Laplace transform,

$$x(t) = r(t + T) - r(t - T)$$

16. (c)

We know that,

$$S_{\text{NBFM}}(t) = A_c \cos(2\pi f_c t) + \frac{A_c\beta}{2}\cos 2\pi(f_c + f_m)t - \frac{A_c\beta}{2}\cos(2\pi(f_c - f_m)t)$$

$$S_{\text{AM}}(\text{t}) = A_c \cos(2\pi f_c t) + \frac{A_c\mu}{2}\cos 2\pi(f_c + f_m)t + \frac{A_c\mu}{2}\cos(2\pi(f_c + f_m)t)$$

Thus, NBFM signal is similar to AM except 180° phase shift at lower side band (LSB).

17. (b)

If a potentiometer has N turns of wire, then each turn represents a fraction $1/N$ of the total resistance and therefore, $1/N$ of the total voltage across the potentiometer. The resolution of a wirewound potentiometer with N number of turns is thus, $1/N$. Thus, for a resolution of 0.02%,

$$\text{Number of turns required} = \frac{1}{\text{resolution}}$$

$$= \frac{1}{\left(\frac{0.02}{100}\right)} = \frac{100 \times 100}{2} = 5000 \text{ turns}$$

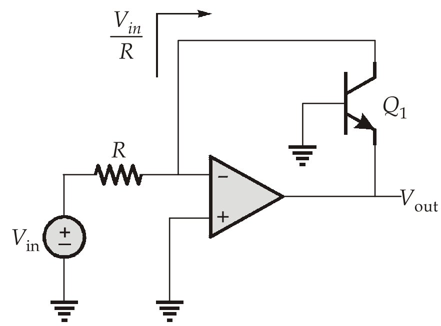
18. (b)

In the 8085 microprocessor, data transfer instructions and branching instructions do not affect the flag register content.

19. (c)

- Modern data loggers mostly use digital storage and processing.
- Voltmeters use Analog-to-digital (A-D) conversion to display voltage in digital form.
- Servo-type recoders generally have better frequency response than galvanometric recoders.
- Digital transducers provide better readability and ergonomic benefits in data presentation.

20. (d)



The collector current, $I_c = \frac{V_{in}}{R} = I_s \exp\left(\frac{V_{BE}}{V_T}\right)$

$V_{BE} = V_T \ln\left(\frac{V_{in}/R}{I_s}\right)$, where I_s is saturation current of BJT.

Also, $V_{out} = -V_{BE}$

$\therefore$ $V_{out} = -V_T \ln\left(\frac{V_{in}}{RI_s}\right)$

$\Rightarrow$ $V_{out} \propto \ln\left(\frac{V_{in}}{RI_s}\right)$

21. (c)

We know that,

$$\text{Gain Margin, GM} = \frac{K_{\text{marginal}}}{K_{\text{desired}}} = \frac{40}{K_{\text{desired}}} \quad ...(i)$$

In dB, $\text{GM(dB)} = 20 \log \text{GM} = 4$

$$\log \text{GM} = \frac{4}{20}$$

$$\log \text{GM} = 0.2$$

$$\text{GM} = 10^{0.2} = 1.58 \quad ...(ii)$$

From equation (i) and (ii), we get

$$\frac{40}{K_{\text{desired}}} = 1.58 \quad \Rightarrow \quad K_{\text{desired}} \approx 25$$

22. (c)

- $+V_{CC}$ and $-V_{EE}$ helps in establishing the correct bias voltages and currents for active region operation in both transistors of the differential pair.
- The negative supply, $-V_{EE}$ is crucial for setting the emitter voltage to a level that allows the base-emitter junctions of both transistors to be forward-biased when the input signals are near zero or have a certain common-mode voltage.

Thus, both the statements are correct.

23. (b)

In IC fabrication, patterning involves precisely defining and transferring intricate circuit designs onto silicon wafers through a series of processes including deposition of oxide, pattern transfer onto the oxide through lithography, followed by etching of the oxide.

24. (a)

The auto-correlation of discrete time sequence $x[n]$ is given by

$$R_{xx} = x[n] * x[-n]$$

The convolution in time domain leads to multiplication in frequency domain. Further, using the time reversal property $x(-n) \leftrightarrow X(1/z)$. We get,

$$R_{xx}(z) = X(z)\cdot X\left(\frac{1}{z}\right)$$

$$= \left(\frac{1}{1-\frac{1}{2}z^{-1}}\right)\cdot\left(\frac{1}{1-\frac{1}{2}z}\right)$$

$$= \frac{1}{1-\frac{1}{2}(z+z^{-1})+\left(\frac{1}{2}\right)^2} = \frac{1}{1-0.5(z+z^{-1})+0.25}$$

25. (c)

We know that,

The power contained in first order side bands of FM signal is,

$$P_1 = \frac{A_c^2}{2}J_1^2(\beta)+\frac{A_c^2}{2}J_{-1}^2(\beta)$$

Since $J_{-n}(\beta) = (-1)^n\, J_n(\beta)$. We get,

$$P_1 = A_c^2 J_1^2(\beta) = A_c^2 J_1^2(2.4)$$

$$P_1 = 0.25A_c^2 \text{ Watt}$$

Percentage power in first order sidebands = $\frac{P_1}{P_T}\times 100$

where P_T is the power of FM signal = $\frac{A_c^2}{2R}$

$$= \frac{0.25A_c^2}{\frac{A_c^2}{2}}\times 100 = 50\%$$

26. (d)

Gating signal determines the length of time during which the counters are allowed to totalize the pulses separated by the period of the original input signal.

We have, Gating time, δ_A = 2 sec

$\Rightarrow$ Maximum possible error in the frequency measurement = $\frac{1}{2}$Hz

Measured frequency, A_a = 20 Hz

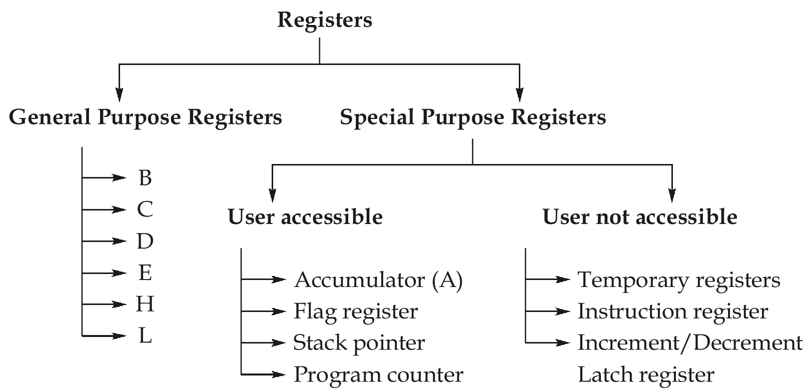
$$\%\text{Error} = \%\in_r = \frac{\left(\frac{1}{2}\right)}{20}\times 100 = 2.5\%$$

Now, accuracy of the system = $(100 - \in_r)\%$

$= (100 - 2.5)\% = 97.5\%$

27. (c)

'A' is not a General purpose register of the 8085 microprocessor. It the part of the arithmetic and logical unit (ALU) and stores the result after performing arithmetical or logical operations.



28. (d)

Given,

$e = 0.002$

$R = 6378$ km

$T = 12$ hrs

$\mu = 3.986 \times 10^{14}\ m^3/s^2$

According to Kepler's third law,

$$T^2 = \frac{4\pi^2 a^3}{\mu} \Rightarrow a^3 = \frac{\mu T^2}{4\pi^2}$$

$$a^3 = \frac{4\times 10^{14}\times(12\times 60\times 60)^2}{(2\pi)^2}$$

$$a = \left[\frac{4\times 10^{14}\times 4\times(6)^6\times 10^4}{4\pi^2}\right]^{1/3}$$

$$= \left(0.1\times 10^{18}\times 4(2\times 3)^6\right)^{1/3}$$

$$= 36\times 10^6\sqrt[3]{0.4}$$

$= 36 \times 10^6 \times 0.74$

$= 26.525 \times 10^3$ m

$\cong 26525$ km

29. (b)

For a current mirror,
$$I_1 = \frac{\left(\frac{W}{L}\right)_1}{\left(\frac{W}{L}\right)_{ref}} I_{ref}$$
$$I_1 = \left(\frac{20}{10}\right) \times 10 \text{ mA} = 20 \text{ mA}$$

30. (d)

Since the system has zero steady state error for unit step input and finite steady state error for unit ramp input, it indicates that the system is a Type 1 system i.e. one pole is present at origin. Hence, from the given options,
$$G(s)H(s) = \frac{s+A}{s(s+B)}$$
From the given data, we get Steady state error for unit ramp input is 0.25

i.e.,
$$e_{ss} = \frac{1}{k_v} = 0.25 \Rightarrow \quad k_v = 4$$
We know that,
$$k_v = \lim_{s\to 0} sG(s)H(s)$$
$$k_v = \lim_{s\to 0} s\frac{(s+A)}{s(s+B)}$$
$$k_v = \frac{A}{B} = 4$$
$$A = 4B$$
Therefore, option (d) is correct.

31. (d)

Properties of ideal operational amplifier:

- Open loop voltage gain is infinite, ($A_{OL} = \infty$)
- Input resistance is infinite, $R_i = \infty$
- Output resistance is zero, $R_0 = 0$; thus no loading effect.
- Bandwidth is infinite i.e. the op-amp can amplify signals of any frequency without attenuation.
- Zero offset i.e. it produces zero output voltage when the input differential voltage is zero.
- CMRR is infinite.
- Slew rate is infinite so that the output can change instantaneously with respect to input.

Properties of practical operational amplifier:

- Open voltage gain, $A_{OL} = 10^6$
- Output Resistance, R_0 = (50 to 100) Ω
- Input resistance, R_i = 1 MΩ to 2 MΩ
- Non-zero offset
- CMRR = 10^6 or 120 dB
- Slew Rate = (0.5 to 1) volt/μsec

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32. (b)

Parameters	Constant Field scaling	Constant Voltage Scaling
Channel Width (W)	$1/s$	$1/s$
Channel length (L)	$1/s$	$1/s$
Gate Oxide Thickness (t_{ox})	$1/s$	$1/s$
Gate capcitance (C_g)	$1/s$	$1/s$
Power Dissipation (P)	$1/s^2$	s
Drain-Source Current (I_{DS})	$1/s$	s

33. (a)

Given, $$y[n] - ay[n-1] = x[n] - bx[n-1]$$

Take z-transform on both sides,

$$Y(z) - az^{-1}Y(z) = X(z) - bz^{-1}X(z)$$
$$Y(z)[1 - az^{-1}] = X(z)[1 - bz^{-1}]$$

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

$\Rightarrow$ For minimum phase, the poles and zeros of $H(z)$ must be inside the unit circle, thus $|a| < 1$ and $|b| < 1$.

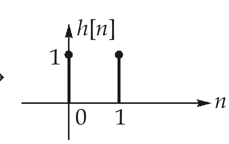
For causal and stable system the poles of $H(z)$ must be inside the unit circle, thus $|a| < 1$; any value of b.

All-pass filters have conjugate-reciprocal pole-zero pairs. Thus, if pole is at 'a', then zero shall be at

$$b = \frac{1}{a^*} = \frac{1}{a}$$

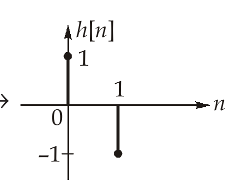
For $a = 0$, $b = 1$:

$$y[n] = x[n] + x[n-1] \Rightarrow H(z) = 1 + z^{-1} \rightarrow$$



For $a = 0$, $b = -1$:

$$y[n] = x[n] - x[n-1] \Rightarrow H(z) = 1 - z^{-1} \rightarrow$$



Thus, for $a = 0$ and $b = \pm 1$, the system has finite impulse response.

34. (a)

For third harmonic mixing, the intermediate frequency is given by

$$f_{IF} = 3f_{L0} - f_s$$
$$3f_{L0} = f_s - f_{IF}$$
$$3f_{L0} = (820 - 70)\text{ MHz}$$
$$f_{L0} = 250\text{ MHz}$$

35. (c)

- Hot wire instruments works on the principle that the length of the wire increases because of the heating effect of current flow through it. The deflection is proportional to the root mean square (RMS) value of the current, hence they can accurately measure both AC and DC currents, regardless of waveform or frequency.
- The hot wire instruments have many disadvantages like high power consumption, instability due to stretching of wire. That is why these instruments are obsolete now.

36. (c)

In the 8085 microprocessor, the H and L registers together form a 16-bit register pair known as the HL pair, which serves as the primary data pointer. It acts as a memory address pointer in instructions like MOV M, A, LXI H, STAX, LDAX, etc.

37. (a)

- In CDMA, all users share the same bandwidth but are distinguished by their unique spreading codes. However, as the number of users increases, cross-correlation between codes leads to Multiple Access Interference (MAI, degrading system performance.
- The processing gain is the ratio between the bandwidth of the spread signal to the bandwidth of the data signal, also referred to as the chip rate to data rate. higher chip rate leads to more bandwidth expansion, allowing for greater noise resistance. Thus, a high processing gain is crucial in satellite channels to overcome noise, interference, and improve detection.
- The near-far problem occurs when users closer to the satellite transmit with higher power than distant users, causing their signals to dominate. Power control ensures that all received signals at the satellite have nearly equal power levels, minimizing interference.
- Unlike FDMA, CDMA does not allocate a fixed bandwidth per user. Instead, all users share the entire bandwidth and are separated by unique spreading codes. This does not inherently reduce interference but rather spreads it across the spectrum.

38. (d)

For distortion in the output,

$$\left.\frac{dV_0}{dt}\right|_{\max} \leq \text{Slew rate}$$

For sinusoidal input $V_{in}\sin(\omega t)$, we have $V_0 = AV_{in}\sin(\omega t)$. For voltage buffer, $A = 1$. Thus,

$$\omega V_m \leq \text{Slew rate}$$

$$f \leq \frac{62.8 \times 10^6}{2\pi \times 10} = 1 \text{ MHz}$$

39. (d)

- By applying the Routh Hurwitz criterion to the characteristic equation of a system with a PID controller, the range of K can be determined for a stable system. This helps in selecting appropriate gain values for the PID controller.

- In root locus analysis, as the gain K is varied from zero to infinity, the roots of the characteristic equation move in the s-plane. The Routh-Hurwitz criterion is applied to find the specific values of K at which the roots cross the imaginary axis, leading to instability. This helps in determining the range of K for which the system is stable.
- Jury's stability criterion is a method used to determine the stability of discrete-time systems with characteristic equations in the z-domain. It is the discrete counterpart of the Routh-Hurwitz criterion used for continuous time signals. The Jury stability criterion requires that the system poles are located inside the unit circle centered at the origin, while the Routh-Hurwitz stability criterion requires that the poles are in the left half of the complex plane.

Hence, all the given statements are correct.

40. (b)

- In class B amplifier, transistor is operates in either cut-off region or saturation region i.e., operating point is at extreme ends of load line. As a result, amplifier quiescent power dissipation of transistor is zero and thereby it offers better efficiency.

41. (d)

Non-pipelined processor:

$$\text{Cycle time} = 400 + 500 + 450 + 650 + 150$$
$$= 2150 \text{ ps}$$

Pipelined processor:

$$\text{Cycle time} = \text{Max}(400, 500, 450, 650, 150) + [\text{Buffer Delay}]$$
$$= (650 + 10)$$
$$= 660 \text{ ps}$$

$\therefore$ Ratio of cycle times of Non-pipelined processor to the pipelined processor

$$= \frac{2150}{660} \simeq 3.258$$

42. (c)

We know, if "z_0" is the complex zero with $|z_0| \neq 1$, then the locations of zeros of a linear phase 4th order FIR filter are,

$$z_0, z_0^{-1}, z_0^*, (z_0^{-1})^*$$

For $z = \frac{1}{4}e^{j\pi/4}$, the other possible zeros are $z = \frac{1}{4}e^{-j\pi/4}, 4e^{j\pi/4}$ and $4e^{-j\pi/4}$

43. (a)

In communication systems, noise refers to any unwanted signal that interferes with the transmission and reception of the intended message. Noise can be categorized into different types based on its source and nature:

1. **Thermal Noise (Johnson-Nyquist Noise):**
   - Caused by the random motion of electrons in conductors due to temperature.
   - Present in all electronic devices and communication channels.
   - Increases with temperature and bandwidth.
   - Can be minimized using cooling techniques.

2. **Shot Noise:**
   - Arises due to the discrete nature of charge carriers (electrons and holes) in semiconductor devices.
   - Common in diodes and transistors, affecting low-current circuits.
   - Can be reduced using proper circuit design and filtering.
3. **Flicker Noise (1/*f* Noise):**
   - Observed at low frequencies, typically below 1 kHz.
   - Its power spectrum follows an inverse frequency dependence (hence the name 1/f noise).
   - Occurs in semiconductors and vacuum tubes.
   - Can be minimized by using high-frequency operation.
4. **Gaussian Noise:**
   - A statistical model where noise follows a normal distribution.
   - Used in theoretical analysis of communication systems.
   - Managed using signal processing techniques like matched filtering.

44. (b)

The Gauge factor of the strain gauge is given as

$$GF = \frac{\Delta R / R}{\Delta l / l}$$

Given, $GF = 2.1; \quad \Delta R = 0.012\ \Omega$

$R = 200\ \Omega,\ l = 0.2$ m

Substituting the values, we get

$$2.1 = \left(\frac{0.012}{200}\right) \times \left(\frac{0.2}{\Delta l}\right)$$

$$\Delta l = 5.714 \times 10^{-6} \text{ m}$$

45. (b)

MVI A, A7H ; $A \leftarrow$ A7H (1 0 1 0 0 1 1 1)

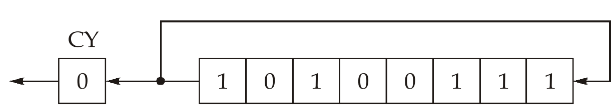
ORA A ;

$$\begin{array}{r} 10100111 \\ 10100111 \\ \hline \boxed{CY = 0} \quad 10100111 \end{array}$$

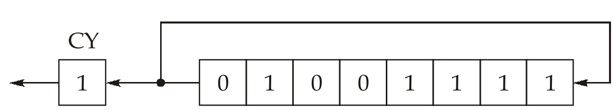
$A \leftarrow$ A 7 H (1 0 1 0 0 1 1 1)

RLC ; Rotate Accumulator left without carry.

Before execution of RLC



After execution of RLC



$A \leftarrow$ 4 FH (0 1 0 0 1 1 1 1)

46. (d)

Let 'h' be the height of the reflected layer. Since the radio waves travel at the speed of light in free space, we have

$$h = \frac{cT}{2} \text{ meters}$$

where, $T = 8$ milliseconds $= 8 \times 10^{-3}$ seconds

$c = 3 \times 10^{8}$ m/s

Therefore,
$$h = \frac{3\times10^{8}\times8\times10^{-3}}{2} \text{ meters}$$
$$= 12 \times 10^{5} \text{ meters}$$
$$h = 1200 \text{ km}$$

47. (d)

$$\text{CMRR} = 20\log_{10}\left(\frac{A_{DM}}{A_{CM}}\right)$$
$$= 20\log_{10}(A_{DM}) - 20\log_{10}(A_{CM})$$
$$= 48 \text{ dB} - 2 \text{ dB}$$
$$= 46 \text{ dB}$$

48. (c)

Two materials are differentiated by their permeability in case of magnetic materials and permittivity in case of electric materials. Thus, a boundary of separation between two magnetic materials is identified by change in permeability.

49. (d)

- A tuned circuit is capable of amplifying a signal over a narrow band of frequencies that are centered at resonant frequency. Thus, they have a narrow bandwidth compared to the untuned amplifier.
- For tuned amplifier, voltage gain is proportional to load impedance. As in tuned amplifier load is LC circuit which depends on frequency. Thus, $A_V \propto Z_L$ and is maximum at resonant frequency.

Therefore, all the statements are correct.

50. (a)

If a system is built from N components, each of which must work, then the yield of the system Y_t is the product of the Y_c of the components.

$\therefore$
$$Y_t = Y_c^N$$

For a 32-core processor, if each core has yield of 0.8, then

$$\text{Yield of chip} = (0.8)^{32}$$

51. (a)

$$\text{Density of iron, } \rho = \frac{\text{Mass of atoms in unit cell}}{\text{Total volume of unit cell}} = \frac{nA_{Fe}}{V_C N_A}$$

For BCC: n = 2 atoms/unit cell, $4R = \sqrt{3}a$, where R is the radius of an atom and a is the edge length of the unit cell.

$$\therefore \quad \text{Volume of unit cell, } V_C = a^3 = \left(\frac{4R}{\sqrt{3}}\right)^3$$

$$\Rightarrow \quad \rho = \frac{2A_{Fe}}{\left(\frac{4R}{\sqrt{3}}\right)^3 N_A}$$

$$= \frac{(2\text{ atoms/unit cell})(60.23\text{ g/mol})}{\left(\frac{4\times 0.5\times 10^{-7}\,cm}{\sqrt{3}}\right)^3 /\text{unit cell}\times 6.023\times 10^{23}\text{ atoms/mol}}$$

$$= \frac{3\sqrt{3}}{40}\text{g/cm}^3$$

52. (a)

- In magnetic disk, data is recorded on concentric rings on the surface of the platters called tracks. Seek time refers to the duration it takes for a disk's read/write head to move to the specific track where data is stored.
- The tracks are further divided into sectors, which hold a block of data that is read or written at one time. Rotational latency is the time it takes for the desired sector of a disk to rotate under the read/write head.

53. (a)

Given, $x[n] = u[n+1] - u[n-2]$

$$\Rightarrow \quad x[n] = \begin{cases} 1; & |n| \le 1 \\ 0; & |n| > 1 \end{cases}$$

We know,

$$x[n] = \begin{cases} 1; & |n| \le N_1 \\ 0; & |n| > N_1 \end{cases} \longleftrightarrow X(e^{j\omega}) = \frac{\sin\left(\omega\left(N_1 + \frac{1}{2}\right)\right)}{\sin\left(\frac{\omega}{2}\right)}$$

Here, $N_1 = 1$

$$\Rightarrow \quad X(e^{j\omega}) = \frac{\sin\left(\omega\left(1+\frac{1}{2}\right)\right)}{\sin\left(\frac{\omega}{2}\right)} = \frac{\sin\left(\frac{3\omega}{2}\right)}{\sin\left(\frac{\omega}{2}\right)}$$

54. (b)

- Vestigial sideband (VSB) modulation is a type of amplitude modulation (AM) in which one side band is partially suppressed instead of being fully removed. It is a compromise between double sideband (DSB) and single sideband (SSB) modulation, used mainly in television broadcasting (NTSC and PAL television systems) and data transmission (some modem technology)
- If a carrier component is transmitted (like in VSB-AM used for TV signals), an envelope detector can be used to extract the original message.
- It is easier to implement than SSB because Filter design is easy as high accuracy is not needed but complex as compared to DSB.

Thus, all the statements are correct.

55. (c)

- **Fidelity:** Fidelity is defined as the degree to which a measurement system indicates changes in the measured quantity without any dynamic error.
- **Sensitivity:** Sensitivity is defined as the ratio of change in output to the corresponding change in input. It determines how much the output changes for a given input change.
- **Resolution:** Resolution is defined as the smallest change in input that an instrument can detect and display. It determines, how finely an instrument can distinguish between two close values.
- **Precision:** Precision is the measure of the spread of the incident errors. It reflects how consistently repeated measurements cluster around each other.

56. (b)

8254 is a programmable interval/timer counter.

Control Word Register:

SC_1	SC_0	RW_1	RW_0	M_2	M_1	M_0	BCD
D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0

8254 can operate in six different modes. The values of M_2, M_1, M_0 are used to decide the operating mode of 8254:

M_2	M_1	M_0	
0	0	0	Mode 0 : Interrupt on terminal count
0	0	1	Mode 1 : Hardware Retriggerable one-shot
X	1	0	Mode 2 : Rate generator
X	1	1	Mode 3 : Square wave generator
1	0	0	Mode 4 : Software triggered strobe
1	0	1	Mode 5 : Hardware triggered strobe

57. (a)

Given,
$$I_{a1} = 20\text{A} \rightarrow \tau_1 = 250 \text{ Nm}$$
$$I_{a2} = 40\text{A} \rightarrow \tau_2 = ?$$

For DC motor, Torque $\tau \propto \phi I_a$. For a DC series motor, flux ϕ is directly proportional to armature current I_a. Thus,

$$\tau \propto I_a^2$$

$$\Rightarrow \quad \frac{\tau_1}{\tau_2} = \frac{(I_{a1})^2}{(I_{a2})^2}$$

$$\Rightarrow \quad \tau_2 = 250 \times \left(\frac{40}{20}\right)^2$$

$$\Rightarrow \quad \tau_2 = 250 \times (2)^2$$

$$\Rightarrow \quad \tau_2 = 1000 \text{ Nm}$$

58. (b)

% Voltage Regulation for a half wave rectifier is given as

$$\% \text{ voltage regulation} = \frac{R_f}{R_L} \times 100 = \frac{10}{500} \times 100 = 2\%$$

59. (a)

- We know that auto-correlation function, $R_X(\tau)$ is maximum at $\tau = 0$ i.e. $R_X(\tau) \geq R_X(\tau)$.
- The autocorrelation of a periodic function with period T is, itself, periodic with the same period i.e. $R_X(T + \tau) = R_X(\tau)$.

Since, it is given that, $R_X(T_0) = R_X(0)$, thus the autocorrelation function is periodic with period T_0.

$\therefore$ $R_X(KT_0) = R_X(0)$ for all integers value of K

60. (a)

Without any current through current coil, disc of the energy meter has a tendency to slowly rotate due to the supply voltage exciting its pressure coil. This is called creeping.

61. (b)

RST 6.5 and RST 5.5 are level triggered interrupts.

Priority	Interrupts	Trigger	Vector Address
1st	TRAP	Level & Edge	0024 H
2nd	RST 7.5	Edge	003C H
3rd	RST 6.5	Level	0034 H
4th	RST 5.5	Level	002C H
5th	INTR	Level	------

62. (a)

- The first Fresnel zone plays the most critical role in signal propagation. If at least 60% of the first Fresnel zone is clear, diffraction losses are minimized, ensuring a strong received signal.
- The radius of the n^{th} Fresnel zone is given by:

$$r_n = \sqrt{\frac{n\lambda d_1 d_2}{d_1 + d_2}}$$

Since the radius r_n increases with distance d_1, d_2, larger link distances lead to larger Fresnel zones.

- The wavelength λ is inversely proportional to frequency f since:

$$\lambda = \frac{c}{f}$$

Hence, Fresnel zone radius depends on the operating frequency.

- Although the first Fresnel zone is the most critical, obstructions in the second or third Fresnel zones can still cause diffraction and phase shifts leading to constructive or destructive interference, while their impact is lower than the first Fresnel zone.

63. (b)

Darlington amplifier provides high current gain β (equal to the product of current gain of individual transistors) and high input impedance. Thus, Leakage of one transistor is amplified by other. So, it has large leakage current.

64. (c)

The valid homogeneous wave equations are

$$\nabla^2 E = \frac{1}{c^2}\frac{\partial^2 E}{\partial t^2}$$

$$\nabla^2 H = \frac{1}{c^2}\frac{\partial^2 H}{\partial t^2}$$

65. (a)

The circuit given is double tuned amplifier.

We know that the bandwidth of double tuned amplifier is given as

$$\text{Bandwidth, BW} = \frac{3.1 f_0}{Q}$$

where f_0 is resonating frequency

$$f_0 = \frac{1}{2\pi\sqrt{L_1 C_1}} = \frac{1}{2\pi\sqrt{L_2 C_2}}$$

and Q is quality factor

Thus,

$$\text{BW} = \frac{3.1\times 1}{2\pi\sqrt{5\times 3\times 10^{-9}}\times 10}$$

$$\text{BW} = 402.84 \text{ Hz}$$

66. (c)

Scale of Integration	Gate Count	Transistor Count	Examples
SSI	<10	<100	7400 and 4000 series logic gate ICs.
MSI	10-100	100-500	4-bit adder, 16-bit shift register.
LSI	100-10000	500-20000	4004, 8080, 8085 microprocessors.
VLSI	>10000	>20000	32-bit microprocessors.

67. (c)

We first position the origin of the coordinate system at the tail of the direction vector; then in terms of this new coordinate system,

Projections	$\frac{a}{3}$	$-b$	$-c$
Projections in terms of a, b and c	$\frac{1}{3}$	-1	-1
Reduction to integers	1	-3	-3
Enclosure	$\left[1\ \bar{3}\ \bar{3}\right]$		

68. (b)

For the given circuit,

$$Y_{11} = (Y_A + Y_C)\,\mho;\ Y_{12} = Y_{21} = -Y_C\,\mho;\ Y_{22} = (Y_B + Y_C)\,\mho$$

On substituting the given data, we get

$$X = (2 + Y_C)\,\mho \quad \text{...(i)}$$

$$Y_{12} = Y_{21}\,\mho = -Y_C = -Y \quad \Rightarrow \quad Y_C = Y\,\mho \quad \text{...(ii)}$$

$$Y = (0 + Y_C)\,\mho = Y_C\,\mho \quad \text{...(iii)}$$

Now, from equation (i) and (ii), we get

$$X = 2 + Y$$

$$X - Y = 2 \quad \text{...(iv)}$$

$\because$ $X + Y = 14$ and $X - Y = 2$; on solving we get

$$X = 8;\ Y = 6$$

From equation (ii), we have $Y_C = Y = 6$

Therefore, option (b) is correct.

69. (c)

- Let the base of the system be P, then product of roots,

$$(9 \times 5 \times 8)_{10} = (190)_P$$

$$P^2 + 9P - 360 = 0$$

$$(P - 15)(P + 24) = 0$$

$$P = 15, -24$$

  $\because$ $P > 0 \Rightarrow P = 15$

  Therefore, statement (1) is correct.

- We know that, sum of roots

$$a = 5 + 8 + 9 = (22)_{10}$$

  Therefore, statement (2) is incorrect.

- Sum of the product of roots,

$$b = (5 \times 8) + (5 \times 9) + (8 \times 9)$$

$$b = (157)_{10} = (A7)_{15} \text{ .... in the given number system}$$

  Therefore statement (3) is also incorrect.

- In Hexadecimal system, $a = (22)_{10} = (16)_H$; $b = (157)_{10} = (9D)_H$ and $(190)_{15} = (360)_{10} = (168)_H$.

  Thus, the the equation is

$$x^3 - 16x^2 + 9Dx - 168 = 0$$

70. (a)

The 16-bit flag register in 8086 microprocessor contains 9 active flags as given below,

D_{15}	D_{14}	D_{13}	D_{12}	D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
X	X	X	X	O	D	I	T	S	Z	X	AC	X	P	X	CY
				Overflow flag	Direction flag	Interrupt flag	Trap flag	Sign flag	Zero flag		Auxiliary Carry flag		Parity flag		Carry flag

71. (c)

Let area of one hexagon cell be 'a'.
Total area to be covered be 'A'.
The number of cells (N) required will be,

$$N = \frac{A}{a}$$

where a = Area of hexagon = $\frac{3\sqrt{3}}{2}r^2 = 2.6r^2$

Given that, A = 1100 square km
r = 2 km

Number of cells required, $N = \frac{A}{a} = \frac{A}{2.64r^2}$

$$N = \frac{1100}{2.6\times(2)^2} = \frac{1100}{10.4} = 105 \text{ cells}$$

72. (a)

Acceptor atoms accept an electron and thus, are negatively charged whereas Donor atoms donate an electron and thus, are positively charged. Thus, using the charge neutrality equation, we get

$$p_0 + N_d^+ = n_0 + N_a^-$$

73. (d)

Given, conduction current density,

$$J_c = \sigma E = 0.1\cos(2\pi \times 10^3 t)$$

$$E = \frac{0.1}{\sigma}\cos(2\pi\times10^3 t)$$

Displacement current density, $J_d = \in \frac{\partial E}{\partial t}$

$$J_d = -\frac{0.1}{\sigma}\in(2\pi\times10^3)\sin(2\pi\times10^3 t)$$

$$= -\frac{0.1}{10^{-4}}\times4.5\times\frac{10^{-9}}{36\pi}(2\pi\times10^3)\sin(2\pi\times10^3 t)$$

$$J_d = -0.025 \times 10^{-2}\sin(2\pi \times 10^3 t)$$

$$J_d = -2.5 \times 10^{-4}\sin(2\pi \times 10^3 t) \text{ A/m}^2$$

74. (d)

Figure of Merit:

It is the ratio of maximum power dissipation in transistors and maximum AC power which can be supplied to load.

$$\text{Figure of merit, } F = \frac{P_{D\,max}}{P_{AC\,max}}$$

Now,

Figure of merit, (F) for Class A amplifier = 2

Class B amplifier = 0.4

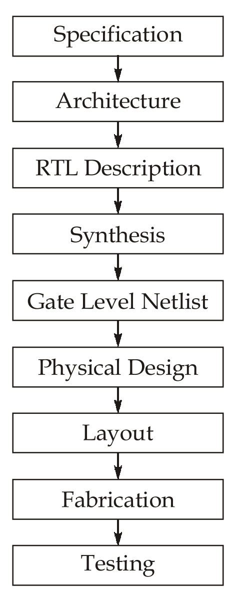
Class AB amplifier = 0.4 – 2

Class C amplifier = 0.25

As the transistor remains on for significantly less time compared to all other power amplifier classes, there is less power dissipation. Therefore, Class C amplifier has best figure of merit among these.

75. (b)

As the circuit complexity and number of transistor/gates is large in case of VLSI chips compared to SSI/MSI/LSI chips, a new sequence of steps is required for designing a VLSI chip. This sequence of steps is called VLSI design flow.



76. (b)

Given, $R = 0.1431$ nm

For FCC crystal structure, the lattice parameter is,

$$a = 2\sqrt{2}R$$

$$\Rightarrow \quad a = 2\sqrt{2} \times 0.1431 \text{ nm}$$

The interplanar spacing for the (221) set of planes is,

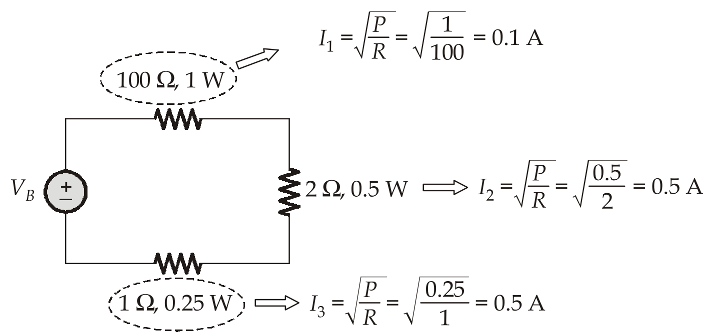
$$d_{221} = \frac{a}{\sqrt{(2)^2+(2)^2+(1)^2}} = \frac{a}{\sqrt{9}} = \frac{a}{3}$$

$$\Rightarrow \quad d_{221} = \frac{2\sqrt{2}\times 0.1431}{3}\text{nm} = \frac{2\times 1.414\times 0.1431}{3}\text{nm}$$

$$\Rightarrow \quad d_{221} = 0.1349 \text{ nm}$$

77. (d)

The maximum current rating for each of the resistors is obtained as below,



Thus, for safe operation current I = min {0.1 A, 0.5 A, 0.5 A} = 0.1 A

Now, on applying KVL,

$$-V_B + (0.1)100 + (0.1)2 + (0.1) = 0$$

$$V_B = 10 + 0.2 + 0.1$$

$$V_B = 10.3 \text{ Volt}$$

Now, power delivered by source,

$$P_{\text{delivered}} = V_B I_1$$

$$P_{\text{delivered}} = 10.3 \times 0.1$$

$$= 1.03 \text{ Watt}$$

78. (d)

- American Standard Code for Information Interchange (ASCII), is a character encoding standard for text data used in computers. It represents a particular set of 95 printable and 33 control characters – a total of 128 = 2^7 code points using a 7-bit code.
- The ASCII codes for the uppercase letters A-Z are 65-90, and the lowercase letters a-z are 97-122. Thus, the ASCII code for 'K' = 65 + 10 = 75 = $(4B)_H$.

79. (b)

We know, Slip, $s = \dfrac{N_s - N_r}{N_s}$

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

$$\Rightarrow \quad \frac{N_r}{N_s} = -1$$

$\therefore$ When rotor rotates at synchronous speed in the reverse direction ($N_r = -N_s$), the slip of the induction motor is '2'.

80. (d)

Given, $\mu = 0.5, f = ?$

$N = 3.25 \times 10^4$ electrons/m^3

We have, $$\mu = \sqrt{1 - \frac{81N}{f^2}}$$

$$(0.5)^2 = 1 - \frac{81N}{f^2}$$

$$0.75 = \frac{81N}{f^2}$$

$$f = \sqrt{\frac{81N}{0.75}} = \sqrt{\frac{81 \times 3.25 \times 10^4}{0.75}}$$

$$= 9 \times 10^2 \times 2.08 = 1.87 \text{ kHz}$$

81. (c)

When two materials are in intimate contact at equilibrium, the fermilevel equilibrium is constant i.e., no gradient exists in the fermilevel at equilibrium.

i.e., $$\frac{dE_F}{dx} = 0$$

82. (c)

Given, no. of isotropic radiators, $N = 50$

Spacing between radiators, $d = \frac{\lambda}{2}$

Array length, $L = (N - 1) \cdot d = \frac{49}{2}\lambda$

∴ Directivity of broadside array $= 2\left(\frac{L}{\lambda}\right) = 2\left(\frac{49/2}{\lambda}\lambda\right) = 49$

83. (d)

The maxwell equations for time-varying fields are given as below:

1. $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$

2. $\vec{\nabla} \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t} \Rightarrow \oint \vec{H}.\vec{dl} = \int\left(\sigma\vec{E} + \in\frac{\partial \vec{E}}{\partial t}\right)\cdot\vec{ds}$

3. $\vec{\nabla} \cdot \vec{D} = \rho_v$

4. $\vec{\nabla} \cdot \vec{B} = 0$

Hence, expressions 1 and 4 are not correct.

84. (d)

n++ → Post-increment i.e. substitute the value of n and then increase the value of n.

++n → Pre-increment i.e. increase the value first and then substitute the value in variable n.

This question can be solved in two different ways by different compilers:

1. First perform n++ then calculate ++n for index value.
2. Calculate ++n for index value initially and then find n++.

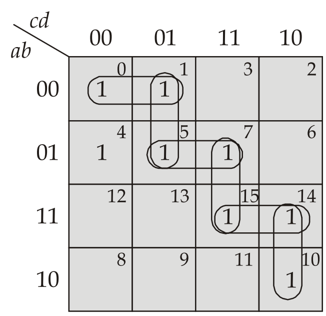
Therefore different compilers can solve this code in one of the above ways.

85. (a)

In order to get hazard-free expression, group all the possible minterms.

Given, $f(a, b, c, d) = \Sigma m(0, 1, 5, 7, 10, 14, 15)$

Using K-map,



∴ $$f = \bar{a}\bar{b}\bar{c} + \bar{a}\bar{c}d + \bar{a}bd + bcd + abc + ac\bar{d}$$

86. (c)

- Surface energy is generally greater than grain boundary energy in materials. This is due to surface atoms having fewer neighboring atoms to bond with, resulting in a higher energy state. On the other hand, grain boundaries have partial misalignment of atoms, which leads to a lower energy state compared to the surface.
- The grain boundary energy of a small-angle grain boundary is less than that for a high-angle grain boundary. A small-angle grain boundary typically results from a slight misalignment of adjacent grains, hence the atomic structure across the boundary experiences less disruption. In contrast, a high-angle grain boundary involves a significant misorientation, leading to a larger number of dislocations and greater atomic misalignment, which results in higher energy due to increased bond disruption.

87. (b)

In a circuit with 'B' branches and 'N' nodes,

Number of independent KVL equations,

$$L = B - N + 1 = 3 \quad \text{...(i)}$$

Number of independent KCL equations,

$$C = N - 1 = 4 \quad \text{...(ii)}$$

Now, from equation (i) and (ii), we get,

$$N = 5 \text{ and } B = 7$$

Thus, Number of branches, $X = B = 7$ and Number of nodes, $Y = N = 5$

As the circuit have 7 branches, then total number of elements (R, L, C, V...) must be greater than or equal to 7. Therefore, statements 1, 3 and 5 are correct.
Thus, option (b) is our answer.

88. (b)

We have,

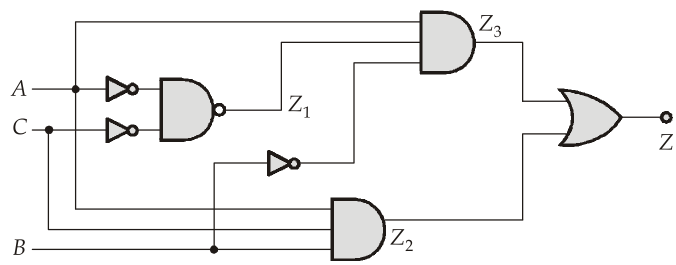


Figure-1

$$Z = Z_2 + Z_3 \quad \text{...(i)}$$

where, $$Z_2 = ABC \quad \text{...(ii)}$$

$$Z_3 = A \cdot Z_1 \cdot \overline{B} \quad \text{...(iii)}$$

and $$Z_1 = \overline{\overline{A}\,\overline{C}} = (A + C) \quad \text{...(iv)}$$

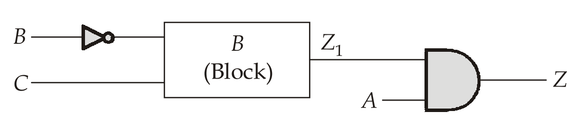
Using (iii) and (iv), we get

$$Z_3 = A(A+C)\overline{B}$$
$$Z_3 = A\overline{B} + A\overline{B}C$$
$$Z_3 = A\overline{B}(1+C)$$
$$Z_3 = A\overline{B} \quad \text{...(v)}$$

Substituting (ii) and (v) in (i), we get

$$Z = ABC + A\overline{B}$$
$$Z = A(BC + \overline{B})$$
$$Z = A(\overline{B} + C) = A\overline{B} + AC$$

Now, on analysing figure 1, we get



$$Z = A \cdot Z_1$$

For getting, $$Z = A\overline{B} + AC$$

Z_1 must be, $$Z_1 = (\overline{B} + C)$$

On comparing, we get block '*B*' as OR Gate.

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89. (d)

Squirrel cage rotor is also called as cage rotor. It consists of a cylinder of steel laminations with aluminium or copper conductor embedded in its surface. Solid bars are short circuited by end rings of same material. They are simple, rugged and self-starting and maintain a reasonably constant speed from light load to full load. No external resistance and slip rings can be added because rotor bars are permanently short circuited. Thus, number of slip rings used in squirrel cage induction motor is 'zero'. Squirrel cage winding has no orientation and sense (due to rotor bars) but create poles depending on stator poles.

90. (a)

The given circuit is a low pass filter with cut-off frequency,

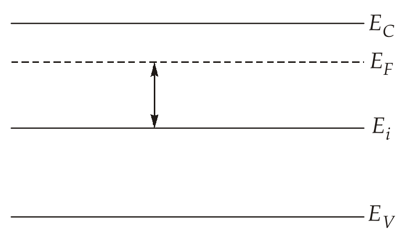
$$f_c = \frac{1}{2\pi R_2 C}$$

$$= \frac{1}{2\pi \times 10 \times 10^3 \times 10^{-9}} = 15.9\ \text{kHz}$$

91. (a)

Given,
$$n = 10^{18}\ \text{cm}^{-3}$$
$$n_i = 1.5 \times 10^{10}\ \text{cm}^{-3}$$
$$V_T = 0.0259\ \text{V}$$

For an n-type semiconductor, the fermi level is close to the conduction band. Thus, energy band diagram for the given silicon sample is :



We have,
$$E_F - E_i = kT \ln\left(\frac{n_0}{n_i}\right)$$

$$= 0.0259 \ln\left(\frac{10^{18}}{1.5 \times 10^{10}}\right)$$

∴ $$E_F - E_i = 0.467\ \text{eV}$$

92. (c)

We know that, phase velocity, $$v_p = \frac{c}{\cos\theta}$$

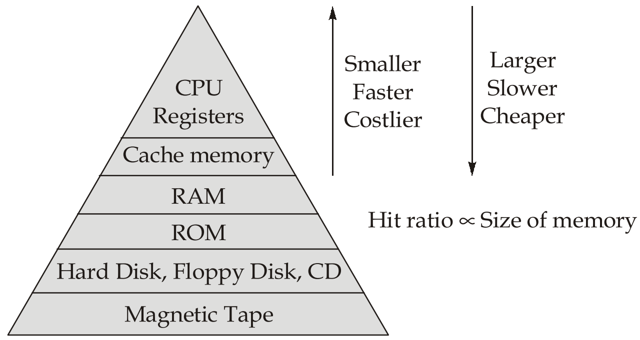
given, $\theta = 60°$

$c = 3 \times 10^8$ m/sec

∴ $$v_p = \frac{3 \times 10^8}{\cos 60°} = 6 \times 10^8\ \text{m/sec}$$

93. (d)

Memory Hierarchy



94. (c)

Let $x(t) = e^{-3t}\cos(2t)$

$\Rightarrow$ $x(-t) = e^{-3(-t)}\cos(2(-t)) = e^{3t}\cos(2t)$

Even part,
$$x_e(t) = \frac{1}{2}[x(t)+x(-t)] = \frac{1}{2}\left[e^{-3t}\cos 2t + e^{3t}\cos 2t\right]$$
$$= \cos 2t\left[\frac{e^{-3t}+e^{3t}}{2}\right]$$
$$= \cos 2t\ \cosh(3t)$$

Odd part,
$$x_0(t) = \frac{1}{2}[x(t)-x(-t)]$$
$$= \frac{1}{2}\left[e^{-3t}\cos 2t - e^{3t}\cos 2t\right]$$
$$= \cos 2t\left[\frac{e^{-3t}-e^{3t}}{2}\right] = -\cos 2t\ \sinh(3t)$$

95. (d)

The cubic system, for which $a = b = c$ and $\alpha = \beta = \gamma = 90°$, has the greatest degree of symmetry. Least symmetry is displayed by the triclinic system, since $a \neq b \neq c$ and $\alpha \neq \beta \neq \gamma$.

96. (b)

We know that,
$$V_R^2 + (V_L - V_C)^2 = V^2$$
$$(100)^2 = (50)^2 + (100\sqrt{3} - V_C)^2$$
$$(2 \times 50)^2 - (50)^2 = (100\sqrt{3} - V_C)^2$$
$$3 \times (50)^2 = (100\sqrt{3} - V_C)^2$$
$$\sqrt{3}\times 50 = 100\sqrt{3} - V_C$$
$$V_C = (100-50)\sqrt{3} = 50\sqrt{3}\text{ V}$$

97. (a)

In combinational circuits, the outputs depends only on the inputs and is independent of present or past outputs. Eg: Multiplexers, Read Only Memories (fixed OR array and programmable AND array)

98. (d)

Given,
$$V_1 = 240 \text{ V}, f_1 = 50 \text{ Hz}, W_{h1} = 75 \text{ W}$$
$$V_2 = 160 \text{ V}, f_2 = 25 \text{ Hz}, W_{h2} = ?$$

$$\left.\begin{aligned} B_{m1} &= \frac{V_1}{f_1} = \frac{240}{50} = 4.8 \\ B_{m2} &= \frac{V_2}{f_2} = \frac{160}{25} = 6.4 \end{aligned}\right\}$$

$B_{m1} \neq B_{m2}$

As 'B_m' is not constant

$$W_h \propto B_m f \Rightarrow W_h \propto \left[\left(\frac{V}{f}\right)^{1.6} \times f\right] \Rightarrow W_h \propto V^{1.6} f^{-0.6}$$

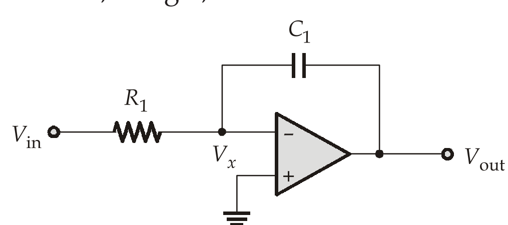
As $\frac{V_1}{f_1} \neq \frac{V_2}{f_2}$,
$$\frac{W_{h1}}{W_{h2}} = \frac{V_1^{1.6} f_1^{-0.6}}{V_2^{1.6} f_2^{-0.6}} = \left(\frac{V_1}{V_2}\right)^{1.6} \times \left(\frac{f_1}{f_2}\right)^{-0.6}$$

$$\Rightarrow \quad \frac{75}{W_{h2}} = \left(\frac{240}{160}\right)^{1.6} \times \left(\frac{50}{25}\right)^{-0.6}$$

$$\Rightarrow \quad W_{h2} = \left(\frac{75}{(1.5)^{1.6} \times (2)^{-0.6}}\right)$$

99. (b)

Applying KCL at inverting terminal, we get,



$$\frac{V_{in} - V_x}{R_1} = \frac{V_x - V_{out}}{\frac{1}{C_1 s}}$$

Since the op-amp has open loop gain A_v, thus
$$V_x = -\frac{V_{out}}{A_0}$$
$$\frac{V_{in}}{R_1} = \frac{V_x}{R_1} + V_x C_1 s - V_{out} C_1 s$$
$$\Rightarrow \quad \frac{V_{in}}{R_1} = -\frac{V_{out}}{A_0}\left[\frac{1}{R_1} + C_1 s\right] - V_{out} C_1 s = -V_{out}\left[\frac{1}{A_0 R_1} + \frac{C_1 s}{A_0} + C_1 s\right]$$

$$\Rightarrow \quad \frac{V_{out}}{V_{in}} = \frac{-1}{R_1\left[\frac{1}{A_0 R_1}+\frac{C_1 s}{A_0}+C_1 s\right]} = \frac{-1}{\left[s\left(1+\frac{1}{A_0}\right)R_1C_1+\frac{1}{A_0}\right]}$$

$$\therefore \quad s = \frac{-1}{(1+A_0)R_1C_1}$$

which corresponds to a pole frequency of $\frac{1}{(1+A_0)R_1C_1}$

100. (c)

Given,

$$t = 0.33 \text{ mm}$$
$$I = 50 \text{ A}$$
$$B = 1.3 \text{ Wb/m}^2$$
$$V_H = 9.6 \text{ }\mu\text{V}$$

We know that,

$$n = \frac{1}{R_H q} = \frac{BI}{V_H t q} \qquad \left[\because V_H = R_H \frac{BI}{t}\right]$$

$$\therefore \quad n = \frac{1.3\times 50}{9.6\times 10^{-6}\times 0.33\times 10^{-3}\times 1.6\times 10^{-19}}$$
$$= 1.28 \times 10^{29} \text{ m}^{-3}$$

101. (b)

We know that, in a circular waveguide, the dominant mode is TE_{11}. The cut-off frequency for the dominant mode is given as

$$f_c = \frac{1.8412c}{2\pi a},$$

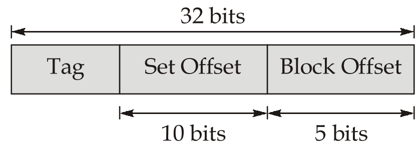
where a is the radius of the inner circular cross-section of waveguide.

We have, $\lambda_c = c/f_c$. Therefore, the cutoff wavelength for circular waveguide for dominant mode propagation is,

$$\lambda_c \simeq 3.41 \times (\text{radius})$$
$$\lambda_c \simeq 3.41 \times 3$$
$$\lambda_c \simeq 10.23 \text{ cm}$$

102. (d)

$$\text{Block size} = 32 \text{ B} = 2^5 \text{ B}$$
$$\therefore \quad \text{Block Offset} = 5 \text{ bits}$$
$$\text{Number of blocks in cache memory} = \frac{128 \text{ kB}}{32 \text{ B}}$$
$$= 2^2 \times 2^{10} = 2^{12}$$
$$\text{Number of sets in cache memory} = \frac{2^{12}}{4} = 2^{10}$$
$$\therefore \quad \text{Set offset} = 10 \text{ bits}$$



Since the address is of 32 bits,

$\therefore$ Number of Tag bits = 32 – (10 + 5) = 32 – 15 = 17

103. (c)

We know,
$$s(n) = \sum_{k=-\infty}^{n} h(k)$$

$$\Rightarrow \quad s(n) = \sum_{k=-\infty}^{n} (-1)^k [u(k+1) - u(k-1)]$$

$$= \sum_{k=-\infty}^{n} (-1)^k u(k+1) - \sum_{k=-\infty}^{n} (-1)^k u(k-1)$$

$$= \sum_{k=-1}^{n} (-1)^k - \sum_{k=1}^{n} (-1)^k$$

$$= \left[(-1)^{-1} + (-1)^0 + (-1)^1 + \ldots + (-1)^n\right] - \left[(-1)^1 + (-1)^2 + \ldots + (-1)^n\right]$$

$$= 0$$

104. (c)

Given,
$$\rho = 1.2215 \times 10^{-6}\ \Omega\text{-cm}$$
$$= 1.2215 \times 10^{-8}\ \Omega\text{-m}$$
$$T = 27°\text{C} = (273 + 27)°\text{K} = 300°\text{K}$$
$$L = 2.443 \times 10^{-8}\ \text{W-}\Omega/\text{K}^2$$

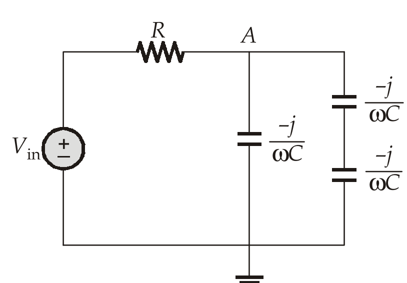
Using Wiedemann Franz Law, Thermal conductivity,

$$K = \sigma LT = \frac{LT}{\rho}$$

$$\Rightarrow \quad K = \frac{2.443 \times 10^{-8} \times 300}{1.2215 \times 10^{-8}} = 2 \times 300 = 600\ (\text{W/m-K})$$

105. (b)

We have,



On applying KCL at node A, we get

$$\frac{V_A - V_{in}}{R} + \frac{V_A}{\left(\frac{-j}{\omega C}\right)} + \frac{V_A}{\left(\frac{-2j}{\omega C}\right)} = 0$$

$$V_A\left[\frac{1}{R} + \frac{1}{\left(\frac{-j}{\omega C}\right)} + \frac{1}{\left(\frac{-2j}{\omega C}\right)}\right] = \frac{V_{in}}{R}$$

$$\frac{V_A(\omega)}{V_{in}(\omega)} = \frac{1}{R\left[\frac{1}{R} + j\omega C + \frac{j\omega C}{2}\right]} = H(\omega)$$

$$H(\omega) = \frac{2}{2 + 3j\omega CR}$$

Now,

$$|H(\omega)| = \frac{2}{\sqrt{4 + 9\omega^2 C^2 R^2}}$$

And, we know that

$$|A(\omega)| = |H(\omega)| \times 2$$

$$0.5 = \frac{4}{\sqrt{4 + 9(\omega CR)^2}} \times 2$$

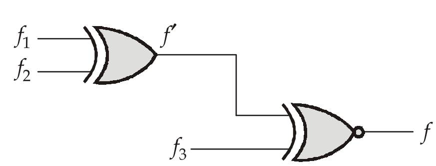
$$\frac{1}{2} = \frac{4}{\sqrt{2 + 9(\omega CR)^2}}$$

$$4 + 9(\omega CR)^2 = 16$$

$$9(\omega CR)^2 = 12$$

$$(\omega CR)^2 = \frac{4}{3} \Rightarrow \omega = \frac{2}{\sqrt{3}CR} \text{ rad/sec}$$

106. (d)



In the given circuit,

The output of XOR Gate, f' will be zero when both f_1 and f_2 are same. Thus,

$f' = \Sigma m(0, 2, 4, 5, 6, 14, 15)$

Now, the output of XNOR Gate, f will be zero when the inputs are different. Thus,

$$f = \Sigma m(2, 4, 14, 15)$$
$$= \Pi M(0, 1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13)$$

Note:

- For XOR - Common minterms between f_1 and f_2 will be eliminated in f'.
- For XNOR - Only common minterms between f' and f_3 will be present at output f.

107. (c)

Given, Number of poles, $P = 6$

$$f = 50 \text{ Hz}$$

$$\text{Rotor frequency, } f_r = 120 \text{ oscillations/min} = \frac{120 \text{ oscillations}}{60 \text{ seconds}} = 2 \text{ Hz}$$

$$\Rightarrow \quad N_s = \frac{120f}{P} = \frac{120 \times 50}{6} = 1000 \text{ rpm}$$

$$\text{Slip, } s = \frac{f_r}{f} = \frac{2}{50} = \frac{1}{25}$$

$$\therefore \quad \text{Motor speed, } N_r = N_s[1 - s]$$

$$= 1000\left[1 - \frac{1}{25}\right] = 960 \text{ rpm}$$

108. (d)

The input current $i(t)$ is equal to

$$i(t) = \frac{V_{\text{in}}(t)}{200 \text{ k}\Omega}$$

$$V_o = -\frac{1}{C_1}\int i(t)dt = \frac{-1}{200 \times 10^3 \times 0.1 \times 10^{-6}}\int V_{\text{in}}(t)dt$$

$$= (-50)\ (1.5)t = -75t$$

109. (d)

Given, $I_B = 100$ μA; $\beta = 100$; $W_B = 2.5$ μm; $D_P = 6$ cm²/s

$$\therefore \quad I_C = \beta I_B = 10 \text{ mA}$$

$\therefore$ The charge in the base region,

$$Q_B = I_C \times \tau_B$$

Where,

$$\text{Transit time of minority carries, } \tau_B = \frac{W_B^2}{2D_P} = \frac{\left(2.5 \times 10^{-4}\right)^2}{2 \times 6} = 5.2 \times 10^{-9} \text{ sec.}$$

$$\therefore \quad Q_B = 10 \times 10^{-3} \times 5.2 \times 10^{-9} = 52 \times 10^{-12} \text{ C}$$

(or) $Q_B = 52$ pC

110. (c)

Let, Time taken to prepare the data = t_x

To prepare 1 MB, device takes 1 second.

$\therefore$ To prepare 1 Byte, device takes 1μ second.

$$\Rightarrow \quad t_x = 1 \ \mu\text{sec}$$

Given, Time taken to transfer the data = t_y = 0.5μ seconds

% time CPU is blocked in cycle stealing mode

$$= \left(\frac{t_y}{t_x}\right) \times 100 = \left(\frac{0.5}{1}\right) \times 100 = 50\%$$

111. (c)

The group delay is,

$$\tau_g(\omega) = -\frac{d}{d\omega}(\angle + H(\omega))$$
$$= \frac{-d}{d\omega}(-\tan^{-1}\omega - \tan^{-1}\omega)$$
$$= -\frac{d}{d\omega}(-2\tan^{-1}(\omega)) = 2\left(\frac{1}{1+\omega^2}\right) = \frac{2}{1+\omega^2}$$

112. (b)

- At point 'P'', almost all of the magnetic domains are aligned and an additional increase in H will produce very little increase in B. The material has reached the point of magnetic saturation.
- When the external magnetic field (H-field) is zero, there exists a residual B-field that is called the remanence (point 'O').
- To reduce the B-field within the specimen to zero, an H-field of magnitude $-H_C$ must be applied in a direction opposite to that of the original field; H_C is called the coercivity (point 'N').
- As the magnetizing force is increased in the negative direction, the material will again become magnetically saturated but in the opposite direction (point 'M').

113. (c)

Ruggedness refers to the ability of an instrument to maintain its performance and reliability despite variations in environmental conditions such as temperature, humidity, and mechanical vibrations.

114. (c)

In an 8085 microprocessor, for an RSTn interrupt, the vector address is given by $(n * 8)_{10}$.

Given, $(003C)_H = (60)_{10}$ $[\because (3 \times 16^1) + (12) = 60]$

$\Rightarrow$ $n \times 8 = 60$

$\Rightarrow$ $n = \frac{60}{8} = 7.5$

115. (b)

116. (b)

Using the Miller effect, the capacitance at the input,

$$C_{in} = C_1(1 - A_v) = 1 \times 10^{-9}(1 + 10^3)$$
$$C_{in} \approx 1 \times 10^{-6}\text{ F}$$

$\therefore$ $\tau = RC_{in} = 10 \times 10^3 \times 1 \times 10^{-6} = 10^{-2}$

$\therefore$ $\omega_{in} = \frac{1}{\tau} = 100\text{ rad/sec}$

Input pole frequency, $f_{in} = \frac{100}{2\pi} = 15.91\text{ Hz}$

117. (c)

Given, $R = 0.65 \text{ A/W}$

Incident power, $P_{in} = 10 \text{ W/m}^2 \times 2 \times 10^{-6} \text{ m}^2 = 20 \times 10^{-6} \text{ W}$

∴ Photocurrent generated, $I_P = R \times P_{in}$

$= 0.65 \times 20 \times 10^{-6}$

$I_P = 13 \text{ μA}$

118. (b)

- Circular waveguide occupy more space compared to rectangular waveguide.
- The circular waveguides are easier to manufacture and easier to join, in the regular plumbing fashion than rectangular waveguides.
- The angle of polarization of wave changes because of discontinuities and even small irregularities, as a result of which coupling energy out of waveguide at receiving end becomes difficult and hence, is a disadvantage.

Hence, statements 2 and 3 are correct.

119. (d)

The floating-point number corresponding to the given representation is given as,

$$N = (-1)^S * (1.M) * 2^{E\text{-Bias}}$$

where S is the sign bit, M is the Mantissa and E is exponent.

Thus, in a floating-point number representation, the number of bits allocated to the mantissa determines the precision of the number (how accurately it can represent a value), while the number of bits in the exponent field controls the range of values the number can represent; essentially, a larger mantissa means higher precision, and a larger exponent field allows for larger numbers to be stored.

120. (b)

We know, $$b_n = \frac{2}{T}\int_0^T x(t)\cdot\sin(n\omega_0 t)dt, \text{ where } \omega_0 = \frac{2\pi}{T} = \frac{2\pi}{2\pi} = 1$$

For $n = 1$:

$$b_1 = \frac{2}{T}\int_0^T x(t)\cdot\sin(\omega_0 t)dt$$

$$= \frac{2}{2\pi}\left(\int_0^{\pi}\sin^2 t\,dt + \int_{\pi}^{2\pi} 0\cdot\sin t\,dt\right)$$

$$= \frac{1}{\pi}\int_0^{\pi}\sin^2 t\,dt = \frac{1}{\pi}\int_0^{\pi}\frac{1-\cos 2t}{2}dt = \frac{1}{2\pi}\left[t - \frac{\sin 2t}{2}\right]_0^{\pi} = \frac{\pi}{2\pi} = 0.5$$

121. (c)

Given, Number of dipoles per unit volume,

$$N = 4 \times 10^{19} \text{ m}^{-3}$$

Distance between charges in a dipole,

$$d = 0.5 \text{ mm} = 0.5 \times 10^{-3} \text{ m}$$

Thus, Dipole moment of each dipole, $p = qd$, where q is the electronic charge.

$\therefore$ Polarization, $P = Np = Nqd = 4 \times 10^{19} \times 1.6 \times 10^{-19} \times 0.5 \times 10^{-3}$

$\Rightarrow$ $P = 3.2 \times 10^{-3}\ \text{C/m}^2$

122. (d)

We have,

$$x(t) = (A + 2\sin 3t \cdot \cos t) = A + \sin 4t + \sin 2t$$

We know that,

RMS value of a constant 'A' is 'A' and RMS value of sin x is $\frac{1}{\sqrt{2}}$.

$$\therefore \quad \text{RMS of } x(t) = \sqrt{A^2 + \left(\frac{1}{\sqrt{2}}\right)^2 + \left(\frac{1}{\sqrt{2}}\right)^2} = \sqrt{10}$$

$$A^2 + \frac{1}{2} + \frac{1}{2} = 10$$

$$A^2 = 9$$

$$A = \pm 3$$

$\therefore$ Correct option is (d).

123. (d)

- A tautology is a logical statement or expression that always evaluates to TRUE or 1.

$$C = A + \overline{A} = 1$$

$$C = 1 + \overline{B} = 1$$

$$C = A + \overline{A} + \overline{B} = 1 + \overline{B} = 1$$

- A Fallacy is the opposite of tautology; it's a logical statement that always evaluates to FALSE or 0.

$$C = B \cdot \overline{B} = 0$$

Thus, 1, 2 and 4 represents tautology expressions, and 3 represents Fallacy expression.

124. (d)

- The outer frame of the machine is known as yoke.It has the following functions: (i) it provides low reluctance path for the magnetic flux and carries half of it. i.e. $\phi/2$ and (ii) it acts as a protecting cover for the whole machine and provides mechanical support to the whole machine and the poles.
- Cast iron is used for the construction of yoke in small DC machines and fabricated steel, cast steel or rolled steel is used for the construction of yoke in large DC machines.
- The yoke is stationary and no flux variations take place and hence, there is no iron losses. Hence, it is not laminated.
- Power electronic converters often supply pulsating DC current to the field windings of the DC motor. This pulsating current creates a varying magnetic flux in the field poles and consequently in the yoke. Thus, Yoke is laminated to reduce the eddy current loss if the machine is operated through a power electronics converter.

Thus, all the statements are correct.

125. (b)

We have, $g_m = \sqrt{2\mu_n C_{ox} \frac{W}{L} I_{DS}} = \sqrt{2\times1\times10^{-3}\times0.4\times10^{-3}}$ = 0.894 mA/V

Thus, $A_v = -g_m R_D = -0.894 \times 10 = -8.94$ V/V

126. (d)

127. (c)

Given, $Z_0 = 50\ \Omega$

$l = 0.1\ \lambda$

Input impedance of short circuit transmission line,

$$Z_{in} = jZ_0 \tan \beta l$$

$$= j50 \tan\left[\frac{2\pi}{\lambda} 0.1\lambda\right]$$

$$Z_{in} = j36.32\ \Omega$$

128. (c)

Key reasons why an interface is needed in I/O organization:

(i) Data Translation: Different devices have different data formats and transfer rates, so the interface translates data between the CPU's standardized format and the specific format required by the peripheral device.

(ii) Synchronization: The interface manages the timing and flow of data between the CPU and peripheral devices, ensuring that data is transferred at a pace that both can handle.

(iii) Control Signal Interpretation: The interface decodes control signals sent by the CPU and translates them into appropriate commands for the peripheral device.

(iv) Error Detection and Handling: Interfaces can include mechanisms to detect errors during data transfer and initiate error recovery procedures.

(v) Addressing: The interface helps the CPU identify and access the correct peripheral device by interpreting device addresses.

129. (a)

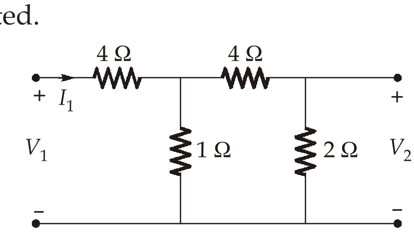
A, B, C, D parameter matrix is given by,

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix}\begin{bmatrix} V_2 \\ I_2 \end{bmatrix}$$ {as port current I_2 is outgoing}

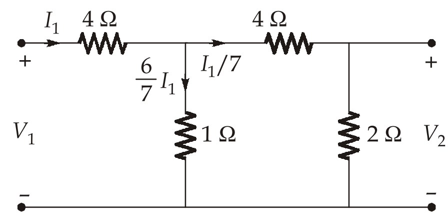
$$V_1 = AV_2 + BI_2$$

$$I_1 = CV_2 + DI_2$$

For $I_2 = 0$, port 2 is open circuited.



Using current division,



$$V_2 = \frac{2I_1}{7}$$

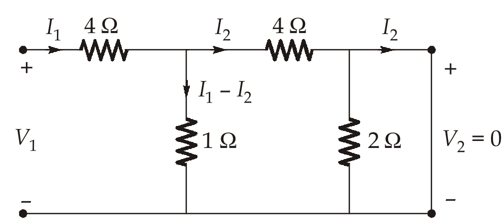
$$C = \left.\frac{I_1}{V_2}\right|_{I_2=0} = \frac{7}{2}\mho$$

$$V_1 = 4I_1 + \frac{6}{7}I_1$$

$$V_1 = \frac{34I_1}{7}$$

$$A = \left.\frac{V_1}{V_2}\right|_{I_2=0} = \frac{34I_1}{7\times\frac{2}{7}I_1} = 17$$

For $V_2 = 0$, output is short-circuited



$$I_1 - I_2 = 4I_2$$

$$I_1 = 5I_2$$

$$\frac{I_1}{I_2} = 5 \rightarrow D$$

$$V_1 = 4I_1 + 4I_2$$

$$V_1 = 4(5I_2) + 4I_2$$

$$V_1 = 24I_2$$

$$\frac{V_1}{I_2} = 24\ \Omega \rightarrow B$$

130. (d)

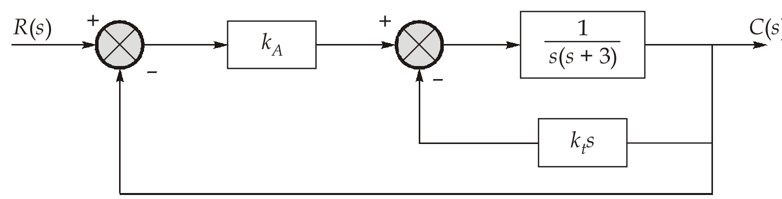
For the substitutional type, solute or impurity atoms replace or substitute for the host atoms. Several features of the solute and solvent atoms determine the degree to which the former dissolves in the latter. These are expressed as four Hume-Rothery rules, as follows:

1. **Atomic size factor:** Appreciable quantities of a solute may be accommodated in this type of solid solution only when the difference in atomic radii between the two atom types is less than about ±15%. Otherwise the solute atoms create substantial lattice distortions and a new phase forms.

2. **Crystal structure:** For appreciable solid solubility, the crystal structures for metals of both atom types must be the same.
3. **Electronegativity:** The more electropositive one element and the more electronegative the other, the greater is the likelihood that they will form an intermetallic compound instead of a substitutional solid solution.
4. **Valences:** Other factors being equal, a metal will have more of a tendency to dissolve another metal of higher valency than one of the lower valency.

131. (a)

Given circuit is



With derivative feedback, open loop transfer function,

$$G(s) = 15\times\frac{\frac{1}{s(s+3)}}{1+\frac{1}{s(s+3)}\times k_t s} = \frac{15}{s^2+(3+k_t)s}$$

Therefore, the overall transfer function is

$$\frac{C(s)}{R(s)} = \frac{\frac{15}{s^2+s(3+k_t)}}{1+\frac{15}{s^2+s(3+k_t)}} = \frac{15}{s^2+s(3+k_t)+15}$$

Comparing the characteristic equation

$$s^2 + (3 + k_t)s + 15 = 0 \text{ with } s^2+2\xi\omega_n s+\omega_n^2 = 0$$

We get, $\omega_n^2 = 15$

$\therefore$ $\omega_n = \sqrt{15} = 3.873 \text{ rad/s}$

and $2\xi\omega_n = 3 + k_t$ [Given, $\xi = 0.7$]

i.e., $2 \times 0.7 \times 3.873 = 3 + k_t$

$\Rightarrow$ $k_t = 2 \times 0.7 \times 3.873 - 3 = 2.422$

$\therefore$ $$G(s) = \frac{15}{s^2+(3+2.442)s} = \frac{15}{s^2+5.422s}$$

For a unit-ramp input, $k_v = \lim_{s\to 0} sG(s)$

$$= \lim_{s\to 0} s\frac{15}{s(s+5.422)} = \frac{15}{5.422} = 2.766$$

$$e_{ss} = \frac{1}{k_v} = \frac{1}{2.766} = 0.3615$$

132. (a)

Coincidence ROM refers to a specific type of ROM that utilizes two decoders to select a memory location. This approach, also known as coincident decoding, helps to reduce the complexity of large ROMs by dividing the address decoding into two stages. Hence, statement 2 is not correct. In one-dimensional ROM, we require more number of AND, NAND gates. In order to reduce the number of gates required, we are using two-dimensional ROMs.

133. (d)

A certain harmonic can be completely eliminated from the induced emf by choosing an appropriate pitch for the coils that makes the pitch factor zero for that harmonic. The pitch factor for the n^{th} harmonic is given by,

$$K_p = \cos\left(\frac{n\alpha}{2}\right)$$

where 'α' is coil pitch.

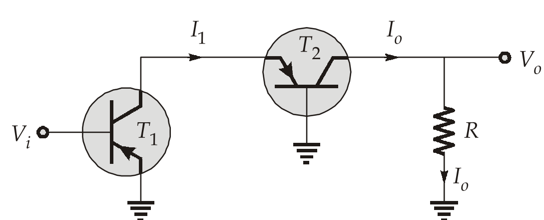
To eliminate 7^{th} harmonic in the induced emf of synchronous generator,

$$\cos\left(\frac{7\alpha}{2}\right) = 0$$

$$\Rightarrow \quad \frac{7\alpha}{2} = 90°$$

$$\Rightarrow \quad \alpha = \frac{90° \times 2}{7} = 25.71°$$

134. (a)



$$g_{m_1} = \frac{I_1}{V_i}$$

Now, $$I_o = \frac{I_1}{\alpha} \approx I_1$$

$$\therefore \quad g_m = \frac{I_o}{V_i} \approx \frac{I_1}{V_i} = g_{m_1}$$

135. (b)

With contacts only at the edge of a thin n-region, the path length for the current to travel to the contact is long, and the cross-sectional area for current flow is small, both contributing to a large series resistance.

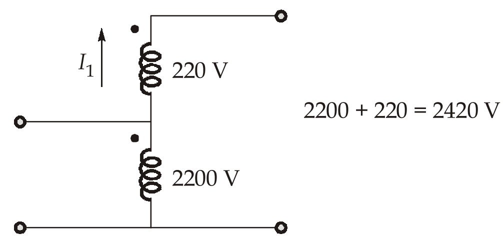
136. (a)

Bluetooth operates using a TDD scheme where communication occurs in a paired, alternating fashion: one device transmits while the other listens within a single frequency. This reduces the need for multiple frequencies as both transmitting and receiving happen at different times on the same frequency. It also employs frequency hopping spread spectrum (FHSS) for avoiding interference, where the devices rapidly change their operating frequency within a range. This feature enhances reliability in environments with potential interference.

137. (c)

138. (b)

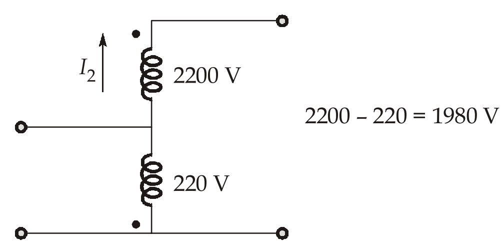
Connection for maximum kVA will be



$$I_1 = \frac{22\times10^3}{220} = 100 \text{ A}$$

$$(\text{kVA})_{max} = 2420 \times 100 = 242 \text{ kVA}$$

Connection for minimum kVA will be



$$I_2 = \frac{22\times10^3}{2200} = 10 \text{ A}$$

$$(\text{kVA})_{min} = 1980 \times 10 = 19.8 \text{ kVA}$$

$$\text{Sum} = (\text{kVA})_{max} + (\text{kVA})_{min} = 242 + 19.8 = 261.8 \text{ kVA}$$

139. (a)

The continuity equation describes that a change in carrier density over time is due to the difference between the incoming and outgoing flux of carriers plus the generation and minus the recombination i.e.

$$\frac{\partial \delta n}{\partial t} = \frac{1}{q}\frac{\partial J_n}{\partial x} - \frac{\delta n}{\tau_n} + G$$

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

140. (a)

According to Barkhausen criteria, for an amplifier to sustain oscillations, the loop gain must be unity ($A\beta = 1$) and the phase shift around the loop must be an integral multiple of 360°.

141. (a)

The emission of photons in an LED occurs through spontaneous emission i.e. an electron in excited state, may spontaneously decay into a lower energy level releasing energy in the form of a photon which is emitted in a random direction.

142. (a)

- AES (advanced Encryption standard) is considered more secure than DES (Data Encryption standard) due to its larger key sizes and stronger encryption structure.
- AES supports 128 bit, 192-bit and 256 bit key lengths. It uses a substitution-permutation network, making it highly secure.
- **DES:** Uses a fixed 56-bit key, making it vulnerable to brute-force attacks. Modern hardware can break DES encryption in a short time.
- AES allows larger key sizes, whereas DES is limited to 56-bit keys, which are susceptible to brute-force attacks, making AES significantly more secure.

143. (a)

While OC and SC tests on a transformer yield its equivalent circuit parameters, these cannot be used for the 'heat run' test wherein the purpose is to determine the steady temperature rise if the transformer was fully loaded continuously; this is so because under each of these tests the power loss to which the transformer is subjected is either the core-loss or copper-loss but not both. The way out of this impasse without conducting an actual loading test is the Sumpner's (Back-to-Back) test which can only be conducted simultaneously on two identical transformers.

144. (c)

- In memory-mapped I/O, the CPU accesses I/O devices using the same instructions it uses to access memory locations. This simplifies the CPU's design and instruction set because there's no need for dedicated I/O instructions.
- I/O-mapped I/O uses a separate address space specifically for I/O devices. This requires the CPU to have dedicated I/O instructions to communicate with the I/O devices.

Thus, Statement (I) is true but Statement (II) is false.

145. (a)

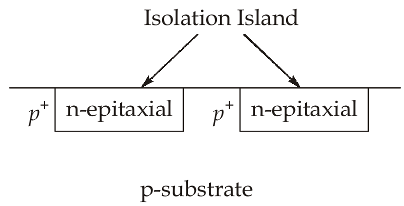
- Companding (Compression + Expanding) is used to improve the dynamic range of signals.
- It applies non-linear quantization, which gives more quantization levels to weak signals and fewer to strong signals, thus improving SQNR for weak signals.
- Common companding techniques include μ-law and A-law companding in telecommunication systems.

146. (b)

147. (a)

Aliasing occurs when higher frequency components of a sampled signal overlap with lower frequency components due to undersampling. The use of a sampling rate higher than the Nyquist rate has a beneficial effect of easing the design of the reconstruction filter used to recover the original signal from its sampled version.

148. (a)



The concentration of the acceptor atoms in the region between isolation islands is usually kept much higher (p^+) than the p-type substrate. This prevents the depletion region of the reverse biased isolation to substrate junction from penetrating more into p^+ region and possibly connecting the isolation islands.

149. (a)

Wet oxidation is commonly used to produce thicker oxide layers due to its faster oxidation rate, facilitated by the use of water vapor (H_2O) as the oxidizing agent, which diffuses more rapidly through the formed silicon dioxide (SiO_2) compared to dry oxygen. However, Dry oxidation produces a higher-quality and denser oxide than wet oxidation.

150. (b)

For TE wave propagating in z-direction,

$$E_z = 0$$

i.e. the electric field is entirely transverse to the direction of propagation.

In a rectangular waveguide, the lowest TM mode is TM_{11}.

$$\therefore \quad xy = 1$$

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