BOOKLET SERIES

A

MADE EASY

Simulate the Real **ESE Prelims Exam** by

ANUBHAV
OPEN MOCK TEST

ESE 2026
Preliminary Exam

ELECTRONICS & TELECOMMUNICATION ENGINEERING

FULL SYLLABUS TEST • PAPER-II

Answer Key

1.	(d)	26.	(c)	51.	(d)	76.	(d)	101.	(a)	126.	(d)
2.	(d)	27.	(d)	52.	(d)	77.	(b)	102.	(a)	127.	(d)
3.	(a)	28.	(c)	53.	(b)	78.	(c)	103.	(b)	128.	(b)
4.	(b)	29.	(d)	54.	(c)	79.	(c)	104.	(c)	129.	(b)
5.	(a)	30.	(a)	55.	(c)	80.	(d)	105.	(c)	130.	(c)
6.	(a)	31.	(b)	56.	(a)	81.	(d)	106.	(d)	131.	(b)
7.	(b)	32.	(c)	57.	(b)	82.	(c)	107.	(c)	132.	(d)
8.	(c)	33.	(c)	58.	(b)	83.	(a)	108.	(b)	133.	(a)
9.	(c)	34.	(c)	59.	(a)	84.	(c)	109.	(d)	134.	(a)
10.	(c)	35.	(a)	60.	(d)	85.	(c)	110.	(a)	135.	(c)
11.	(a)	36.	(b)	61.	(d)	86.	(b)	111.	(a)	136.	(d)
12.	(d)	37.	(d)	62.	(b)	87.	(c)	112.	(b)	137.	(a)
13.	(d)	38.	(a)	63.	(a)	88.	(d)	113.	(d)	138.	(d)
14.	(b)	39.	(a)	64.	(d)	89.	(d)	114.	(d)	139.	(b)
15.	(c)	40.	(a)	65.	(c)	90.	(b)	115.	(a, b)	140.	(c)
16.	(b)	41.	(d)	66.	(c)	91.	(a)	116.	(c)	141.	(b)
17.	(d)	42.	(d)	67.	(b)	92.	(c)	117.	(d)	142.	(b)
18.	(a)	43.	(a)	68.	(a)	93.	(c)	118.	(d)	143.	(d)
19.	(d)	44.	(c)	69.	(b)	94.	(c)	119.	(c)	144.	(b)
20.	(d)	45.	(b)	70.	(b)	95.	(d)	120.	(b)	145.	(c)
21.	(a)	46.	(a)	71.	(a)	96.	(a)	121.	(b)	146.	(b)
22.	(a)	47.	(c)	72.	(d)	97.	(a)	122.	(c)	147.	(d)
23.	(b)	48.	(a)	73.	(c)	98.	(c)	123.	(d)	148.	(c)
24.	(d)	49.	(c)	74.	(a)	99.	(b)	124.	(a)	149.	(a)
25.	(b)	50.	(a)	75.	(b)	100.	(a)	125.	(b)	150.	(a)

Note: Answer key has been updated for Question no. 103 and 115.

DETAILED EXPLANATIONS

1. (d)

The wave is incident from air to the material. Hence, we have

$$\eta_1 = \eta_0$$

$$\eta_2 = \frac{\eta_0}{\sqrt{9}}$$

The transmission coefficient

$$\tau = \frac{2\eta_2}{\eta_2 + \eta_1} = \frac{\frac{2}{\sqrt{9}}}{\frac{1}{\sqrt{9}} + 1} = \frac{2}{1+\sqrt{9}}$$

$$= \frac{2}{1+3} = \frac{2}{4} = \frac{1}{2}$$

The electric field inside the slab $E_t = \tau E_i = \frac{1}{2} \times 25 = 12.5 \text{ V/m}$

The transmitted magnetic field,

$$H_t = \frac{E_t}{\eta_2} = \frac{125 \times 3}{120\pi \times 10} = \frac{5 \times 7}{16 \times 22} = \frac{35}{352}$$

The power transferred to the slab is

$$P = E_t H_t = \frac{25}{2} \times \frac{35}{352} \cong 1.243 \text{ W/m}^2$$

2. (d)

$$2\gamma = 120°$$

$\because$ At each reflection, skew ray change its path by 2γ.

$$\gamma = 60°$$

We know that acceptance angle for skew rays,

$$\theta_A = \sin^{-1}\left[\frac{\sqrt{n_1^2 - n_2^2}}{n_0 \cos\gamma}\right]$$

$$45° = \sin^{-1}\left[\frac{\sqrt{n_1^2 - n_2^2}}{(1.2)\cos 60°}\right]$$

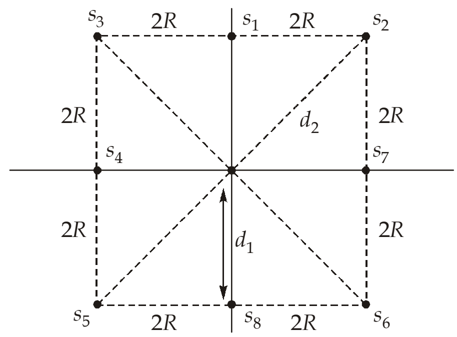
$$\sin 45° = \frac{\sqrt{n_1^2 - n_2^2}}{1.2 \times 0.5}$$

$$\sqrt{n_1^2 - n_2^2} = \frac{1}{\sqrt{2}} \times 1.2 \times 0.5$$

$$\sqrt{n_1^2 - n_2^2} = 0.42 = \text{N.A}$$

Hence, numerical aperture of the fiber is 0.42.

3. (a)



The point S_1, S_4, S_7, S_8 are equidistant from origin with $d_1 = 2R$.
The constellation points S_3, S_2, S_5 and S_6 are equidistant from the origin with distance

$$d_2 = \sqrt{(2R)^2 + (2R)^2} = 2\sqrt{2}R$$

Since, the square of the distance of the signalling point from origin gives the energy of the transmitted state.
For equally probable signals, the average energy transmitted for given constellation is

$$E_{avg} = \frac{4 \times (2R)^2 + 4 \times (2\sqrt{2}R)^2}{8}$$

$$E_{avg} = \frac{4 \times 4R^2 + 4 \times 8R^2}{8} = \frac{48R^2}{8} = 6R^2$$

4. (b)

$$\phi = (5 - 1) \times (7 - 1) = 24$$

If private key = e; public key = p then, $(e \times p) \bmod \phi = 1$

Here, Public key, $p = 5$ then,

$$(e \times p) \bmod \phi = 1$$
$$(e \times 5) \bmod 24 = 1$$

By options, we get $e_{min} = 5$ but it is discarded as RSA is a Asymmetric type of algorithm.
Asymmetric algorithm means it works on two different keys i.e., public key and private key.
Hence, for $e = 29$, $(e \times 5) \bmod 24 = 1$ is also satisfied.
Hence, $e_{min} = 29$

5. (a)

- Bandwidth required ⇒ AM = DSB > VSB > SSB
- VSB modulation is used for transmission of the video signal in commercial television broadcasting because of significant low-frequency content.
- For a DSB-SC signal, $s(t) = m(t)c(t)$, hence product modulator is used for generation of DSB-SC signal.
- Envelope detector is used for detection of AM signal ($\mu \le 1$).

6. **(a)**

We know that,

PMMC instrument measure DC current only. Therefore, current measured by PMMC instrument is

$$Y = 5 \text{ A} \quad \text{...(i)}$$

We have,

$$i = 5 + 10\sqrt{2}\sin(314t + 30°)\text{A}$$

The moving iron instrument and hot wire instrument measures RMS current i.e.,

$$\sqrt{5^2 + \left(\frac{10\sqrt{2}}{\sqrt{2}}\right)^2} = \sqrt{125}$$

Note: Hot wire instrument is an electrical measuring device that operates based on the thermal expansion of a fine wire when current passes through it, causing Joule heating. The expansion of the wire moves a pointer over a calibrated scale, allowing measurement of both AC and DC currents, including high-frequency signals. **A hot wire instrument measure rms value of the current.**

7. **(b)**

A Microprocessor consists only of a Central Processing Unit (CPU) and relies on external components like RAM, ROM, and peripherals to function. In contrast, a microcontroller integrates the CPU, memory (RAM and ROM), and input/output (I/O) peripherals into a single chip. It makes microcontrollers ideal for specific control tasks and embedded applications, as they require fewer external components and connections.

Comparison between microprocessor and microcontroller.

Microprocessor	Microcontroller
• It is used in personal computers.	• It is used in an embedded system.
• Microprocessor consists of only a CPU (Central processing unit)	• Microcontroller contains a CPU, memory, I/O all integrated into one chip.
• Microprocessor uses an external bus to interface RAM, ROM and other peripherals.	• Microcontroller uses an internal controlling bus.
• Microprocessor is complicated and expensive with large number of instructions to process	• Microcontroller is inexpensive and straight forward with fewer instructions to process.
• It is based on Von Neumann model.	• It is based on Harvard architecture.

8. **(c)**

Due to high starting torque, DC series motors are used in electric locomotives, cranes etc.

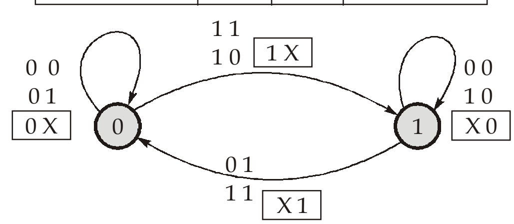
Hence, statement (I) is correct but statement (II) is incorrect.

9. **(c)**

FIR filters are always stable as the FIR filters has only zeros and no poles, except multiple poles in the origin of the z-plane. Thus, Statement (II) is not correct.

10. (c)

Present State	Inputs		Next State
Q_n	J	K	Q_{n+1}
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0



11. (a)

A	B	C	
0	0	0	(Q_1: OFF, Q_2: OFF, Q_3:ON)
0	1	1	(Q_1: OFF, Q_2: ON, Q_3:OFF)
1	0	1	(Q_1: ON, Q_2: OFF, Q_3:OFF)
1	1	1	(Q_1: ON, Q_2: ON, Q_3:OFF)

12. (d)

For 10 bit ring counter, $f_{out} = \frac{f_{clk}}{10} = \frac{100 \text{ kHz}}{10}$

Clock output at '*P*' $f_{out} = 10$ kHz

⇒ For MOD-20 ripple counter

$$f_{out} = \frac{10 \text{ kHz}}{20}$$

Clock output at '*Q*' ⇒ $f_{out} = 0.5$ kHz

⇒ For 4 bit parallel counter,

$$f_{out} = \frac{0.5 \text{ kHz}}{16}$$

Clock output at '*R*' $f_{out} = 31.25$ Hz

⇒ For 4 bit Johnson counter

$$f_{out} = \frac{31.25}{2 \times 4} = 3.9 \text{ Hz}$$

Clock output at '*S*' $f_{out} = 3.9$ Hz

13. (d)

$$S = A \odot B$$
$$R = B$$
$$Q_{n+1} = S + \bar{R}Q = A \odot B + \bar{B}Q$$
$$Q^{+} = \bar{A}\bar{B} + AB + \bar{B}Q$$

14. (b)

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

15. (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.

16. (b)

The energy of the discrete time signal is,

$$E = \sum_{n=-\infty}^{\infty} |x[n]|^2$$

$$\Rightarrow \quad E = \sum_{n=0}^{\infty} \left|\left(\frac{-1}{5}\right)^n\right|^2 = \sum_{n=0}^{\infty} \left(\frac{1}{25}\right)^n = \frac{1}{1-\frac{1}{25}} = \frac{25}{24}$$

17. (d)

Length of output sequence, $p = 6$

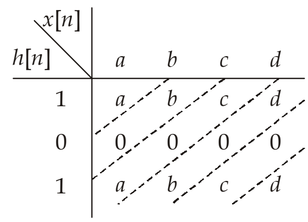
Length of impulse response, $n = 3$

$\therefore$ Length of input sequence is, $p = m + n - 1$

$$6 = m + 3 - 1$$
$$m = 4$$

Let the input sequence be $x[n] = \{a, b, c, d\}$

Using tabular method of convolution,



$$y[n] = \{a, 0 + b, a + 0 + c, b + 0 + d, c + 0, d\}$$

$\Rightarrow$ $$y[n] = \{a, b, a + c, b + d, c, d\}$$

On comparing with given $y[n]$, we get

$$a = 1, b = 0, c = 1, d = 0$$

$\Rightarrow$ $$x[n] = \{1, 0, 1, 0\}$$

18. (a)

	Continuous time		Discrete time	
	Time Domain	Frequency Domain	Time Domain	Frequency Domain
Fourier Series	Continuous periodic	Discrete Aperiodic	Discrete Periodic	Discrete Periodic
Fourier Transform	Continuous Aperiodic	Continuous Aperiodic	Discrete Aperiodic	Continuous Periodic

19. (d)

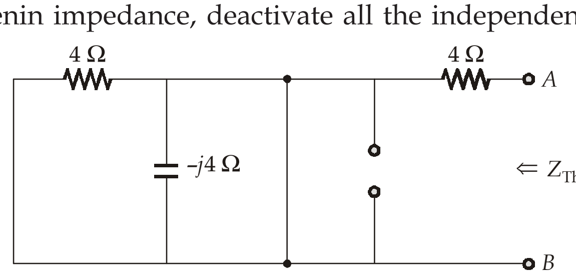
Tellegen theorem can be applied to any network- linear or non-linear, active or passive, time-variant, or time-invariant. According to Tellegen's theorem, the summation of instantaneous powers for all the branches in an electrical network is zero. The Superposition, Thevenin and Norton Theorem are applicable only to linear circuits.

20. (d)

Time domain analysis becomes complex when the system has special input functions and more inductors and capacitors.

21. (a)

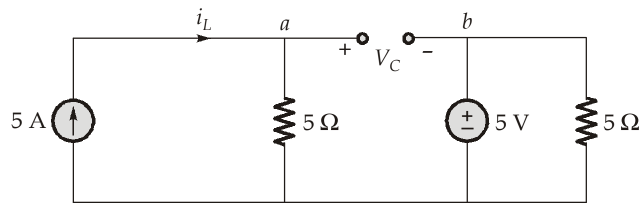
In order to find the thevenin impedance, deactivate all the independent sources in the network.



$\Rightarrow$ $$Z_{Th} = 4\ \Omega$$

22. (a)

Circuit is under steady state and hence, capacitor acts as open circuit and inductor acts as short circuit.



$$V_a = 5 \times 5 = 25$$
$$V_b = 5 \text{ Volt}$$

Hence, $V_{ab} = 25 - 5 = 20$ V

23. (b)

The Routh array for the characteristic equation is

s^3	1	c
s^2	b	1
s^1	$c - \frac{1}{b}$	0
s^0	1	

For stability, $c > \frac{1}{b}$

$$bc > 1$$

24. (d)

The corner frequency associated with a pole causes a slope change by –20 dB/decade and the corner frequency associated with a zero causes a slope change by 20 dB/decade. Therefore, from the given bode magnitude plot, we can write

$$T(s) = \frac{K\left(\frac{s}{40}+1\right)}{\left(\frac{s}{10}+1\right)\left(\frac{s}{20}+1\right)}$$

Alsol we have $20\log_{10}K = 40$

$$K = 10^2 = 100$$
$$K = 100$$

$\therefore$ $$T(s) = \frac{100(s+40)}{40\left(\frac{s+10}{10}\right)\left(\frac{s+20}{20}\right)} = \frac{500(s+40)}{(s+10)(s+20)}$$

25. (b)

Let C_s be the self capacitance and C_d be the distributed capacitance of the coil

Given: $Q_1 = \frac{1}{wRC_s} = 360$ (True value) and $$Q_2 = \frac{1}{wR(C_s + C_d)} = 359.8 \text{ (measured value)}$$

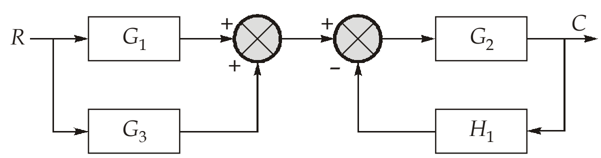
∴ $$\frac{Q_1}{Q_2} = \frac{360}{359.8} = \left(\frac{C_s + C_d}{C_s}\right)$$

or, $$\frac{C_d}{C_s} + 1 = 1.00055$$

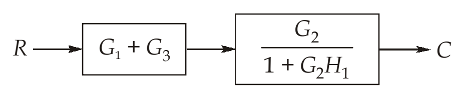
$$\frac{C_d}{C_s} = 0.000555 = 5.55 \times 10^{-4}$$

26. (c)

The given block diagram can be redrawn as shown in figure.



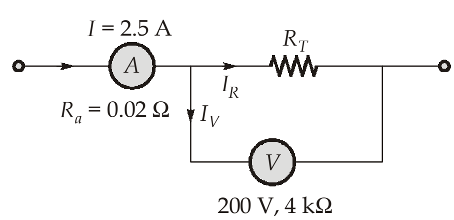
The block diagram can further be simplified as below:



$$\frac{C}{R} = \frac{(G_1 + G_3)G_2}{1 + G_2H_1} = \frac{G_1G_2 + G_2G_3}{1 + G_2H_1}$$

27. (d)

Given:



$$I_V = \frac{200}{4 \times 10^3} = 5 \times 10^{-2} = 0.05\text{A}$$

$$I_R = 2.5 - 0.05 = 2.45 \text{ A}$$

$$R_T = \frac{V}{I_R} = \frac{200}{2.45} = \frac{20000}{245} = 81.632\ \Omega = \text{true value of resistance}$$

$$R_m = \frac{V}{I} = \frac{200}{2.5} = 80\ \Omega = \text{measured value of resistance}$$

∴ Error, $$\in_r = \frac{R_m - R_T}{R_T} = \frac{80 - 81.632}{81.632} = \frac{-1.632}{81.632}$$

$$\%\in_r = \frac{-1.632 \times 100}{81.632} = \frac{-163.2}{81.632} \cong -2\%$$

28. (c)

$$v_L(t) = L\frac{di_L}{dt}$$

If $i_L(t) = u(t) \Rightarrow v_L(t) = L\delta(t)$ i.e. a sudden change in current would require an infinite voltage across the inductor. Thus, the inductor does not allow sudden change in current.

$$i_c(t) = \frac{Cdv_c}{dt}$$

If $v_c(t) = u(t) \Rightarrow i_c(t) = C\delta(t)$ i.e. a sudden change in voltage would require an infinite current to flow through the capacitor. Thus, the capacitor does not allow sudden change in voltage.
Therefore, statement 3 and 4 are incorrect.

29. (d)

On comparing the transfer function $\frac{169}{s^2+13s+169}$ with $\frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$, we get

$$\omega_n^2 = 169 \Rightarrow \omega_n = 13 \text{ rad/s}$$

$$2\xi\omega_n = 13 \Rightarrow \xi = \frac{13}{2\omega_n} = \frac{13}{2\times 13} = 0.5$$

For second peak undershoot, $n = 4$

$$\Rightarrow \quad t_p = \frac{n\pi}{\omega_n\sqrt{1-\xi^2}} = \frac{4\pi}{13\sqrt{1-(0.5)^2}} = \frac{4\pi}{13\sqrt{\frac{3}{4}}} = \frac{8\pi}{13\sqrt{3}}$$

$$\Rightarrow \quad t_p = \frac{8\pi}{13\sqrt{3}} s$$

30. (a)

Integral controller improves steady state performance while derivative controller improves transient state response.

31. (b)

Given,

Open loop transfer function, $G(s) = \frac{K}{s(\tau s+1)} = \frac{K/\tau}{s(s+1/\tau)}$

On comparing with standard open loop second order transfer function,

$$G(s) = \frac{\omega_n^2}{s(s+2\xi\omega_n)}$$

We get,

$$\omega_n^2 = \frac{K}{\tau} \Rightarrow \omega_n = \sqrt{\frac{K}{\tau}}$$

$$2\xi\omega_n = \frac{1}{\tau} \Rightarrow \xi = \frac{1}{2\omega_n\tau} = \frac{1}{2\left(\sqrt{\frac{K}{\tau}}\right)\tau} = \frac{1}{2\sqrt{\tau K}}$$

$$\Rightarrow \qquad \xi \propto \frac{1}{\sqrt{K}}$$

$$\therefore \qquad \frac{\xi_1}{\xi_2} = \sqrt{\frac{K_2}{K_1}} \Rightarrow \left(\frac{0.4}{0.8}\right)^2 = \frac{K_2}{K_1} \Rightarrow 0.25K_1 = K_2$$

Hence, the amplifier gain must be multiplied by 0.25 to increase damping ratio from 0.4 to 0.8.

32. (c)

We have,
$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$$

The characteristic equation of the system is given by

$$|sI - A| = 0 \Rightarrow \left| \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \right| = 0$$

$$\begin{vmatrix} s & -1 \\ +2 & s+3 \end{vmatrix} = 0 \Rightarrow s(s+3) + 2 = 0$$

$$\Rightarrow s^2 + 3s + 2 = 0$$

On comparing with standard second order equation,

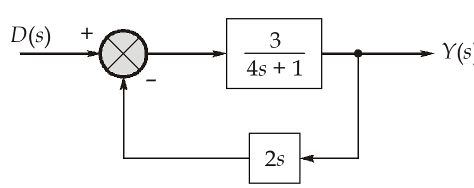
$$s^2 + 2\xi\omega_n s + \omega_n^2 = 0 \Rightarrow \omega_n^2 = 2 \Rightarrow \omega_n = \sqrt{2} \text{ rad/sec}$$

$$2\xi\omega_n = 3 \Rightarrow \xi = \frac{3}{2\omega_n} = \frac{3}{2\sqrt{2}} = 1.061$$

As $\xi > 1$, the given system is over-damped.

33. (c)

To calculate $\frac{Y(s)}{D(s)}$, set $R(s) = 0$ and redraw the given circuit.



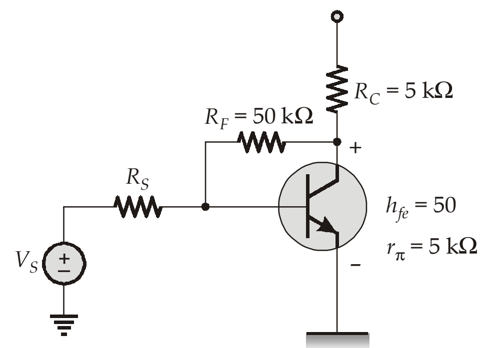
$$\frac{Y(s)}{D(s)} = \frac{3}{4s+1+3(2s)} = \frac{3}{4s+1+6s} = \frac{3}{1+10s}$$

$$\Rightarrow \qquad \frac{Y(s)}{D(s)} = \frac{3}{1+10s}$$

34. (c)

Given, R_F = 50 kΩ, R_C = 5 kΩ, h_{fe} = 50, r_π = 5 kΩ

The circuit can be drawn as below,



We know, the gain of CE amplifier is,

$$A_V = -g_m R_C$$

$$\Rightarrow \quad A_V = \frac{-h_{fe}}{r_\pi} R_C = \frac{-50}{5\text{ k}\Omega} \times 5\text{ k}\Omega = -50$$

35. (a)

We know, the transconductance of n-channel MOSFET is,

$$g_m = 2K_n(V_{GS} - V_{TN})$$

$$\Rightarrow \quad g_m = 2 \times 0.5 \times 4 = 4 \text{ m℧}$$

The unity gain-bandwidth is,

$$f_T = \frac{g_m}{2\pi(C_{gs} + C_{gd})}$$

$$\Rightarrow \quad f_T = \frac{4 \times 10^{-3}}{2\pi(0.1 + 0.01) \times 10^{-12}}$$

$$\Rightarrow \quad f_T = \frac{4 \times 10^{-3}}{2\pi \times 0.11 \times 10^{-12}}$$

$$\Rightarrow \quad f_T \simeq \frac{18}{\pi} \times 10^9 = \frac{18}{\pi} \text{GHz}$$

36. (b)

- The numerical difference between no load (V_{nl}) and full load voltage (V_{fl}) is called inherent voltage regulation. The percentage regulation is defined as

$$\%R = \frac{V_{nl} - V_{fl}}{V_{fl}} \times 100\%$$

- The maximum temperature rise in a large transformer is determined by the full load test. This test is called, back-to-back test, regenerative test or Sumpner's test.
- Skin effect, is defined as the tendency of alternating high-frequency currents to crowd toward the surface of a conducting material. This phenomenon restricts the current to a small part of the total cross-sectional area and so has the effect of increasing the resistance of the conductor.

By using multi-stranded wire, the individual strands provide more surface area collectively, effectively reducing the skin effect and minimizing power losses. Hence, skin effect can be minimized by using multistrand wire. Therefore, statement 4 is incorrect.

37. (d)

Since β is very large. Hence, we assume,

$$I_{B1} = I_{B2} = 0$$

$$I_{C1} = \frac{0 - V_{BE} + 15}{R} = \frac{15 - 0.7}{10} = \frac{14.3}{10} = 1.43 \text{ mA}$$

$$\therefore \quad I_{C1} = I_{S1} e^{\frac{V_{BE}}{\eta V_T}} = 1.43 \text{ mA}$$

$$I_{C2} = I_0 = I_{S2} e^{\frac{V_{BE}}{\eta V_T}}$$

Since, emitter area of transistor Q_1 is one fourth of transistor Q_2, hence,

$$I_{S2} = 4I_{S1}$$

$$I_0 = 4I_{S1} \exp\left(\frac{V_{BE}}{\eta V_T}\right)$$

$$= 4I_{C1} = (4 \times 1.43) \text{ mA} = 5.72 \text{ mA}$$

38. (a)

39. (a)

The 8086 μP does not have 20 bit register to store 20-bit address. Hence, the memory is divided into logical segments of size 64 kB. Each segment will have Base address and offset address for the given memory location. The 8086 μP has dedicated hardware to produce 20-bit address by using two 16-bit registers which holds the base and offset address respectively.

40. (a)

A monostable multivibrator, also known as a one-shot multivibrator, has one stable state and one quasistable (or unstable) state. On the application of trigger, the circuit enters into the quasi-stable state, but it returns to the stable state on its own after a certain time. The duration of the quasi-stable state is determined by the time constant (RC) of the circuit. Hence, both the statements are true and Statement (II) is the correct explanation of Statement (I).

41. (d)

In a superconductor,

(i) Entropy decreases on going from normal state to superconducting state.

(ii) In an ideal superconductor, there is a marked drop in the thermal conductivity when superconductivity sets in.

Thus, Statement (I) is not correct.

42. (d)

Amplifier exhibit some non-linear behaviour that causes voltage gain to vary as the input voltage changes resulting in distortion. The use of negative feedback decreases the distortion and will cause the amplifier to behave more linearly.

43. (a)

$$\left.\begin{aligned}\text{Output of Gate 1} &= \overline{X \oplus X} = 1\\ \text{Output of Gate 2} &= \overline{1 \oplus X} = X\\ \text{Output of Gate 3} &= \overline{X \oplus X} = 1\\ \text{Output of Gate 4} &= \overline{1 \oplus X} = X\end{aligned}\right\} \text{ Repetition of output pattern after 2 gates}$$

$$\text{Output of Gate 5} = \overline{X \oplus X} = 1$$

$$\vdots$$

$$\text{Output of Gate 57} = \overline{X \oplus X} = 1$$

$$\text{Output of Gate 58} = 1 \oplus X = X$$

44. (c)

The INHIBIT function is available in integrated circuit form for an AND gate, with one of its inputs negated by an inverter. Whenever this input is logic ‘1’, the output is 0 i.e. inhibiting the input. The output expression for INHIBIT logic for a 2-input AND Gate is, $Y = A\overline{B}$

45. (b)

The output of D-flip flop is,

$$Q(t+1) = D$$

From the given circuit, $D = x \oplus Q(t)$

$\Rightarrow$ $Q(t+1) = x \oplus Q(t)$

which is the characteristic equation of T flip-flop.

46. (a)

Given, $t_{pd} = 25$ psec, $f_{clk} = 20$ GHz

For the ripple counter to work properly,

$$T_{CLK} \geq n t_{pd}$$

$$\Rightarrow \quad f_{CLK} \leq \frac{1}{n t_{pd}}$$

$$\Rightarrow \quad (20 \times 10^9) \leq \frac{1}{n \times 25 \times 10^{-12}}$$

$$\Rightarrow \quad n \leq \frac{1}{20 \times 10^9 \times 25 \times 10^{-12}}$$

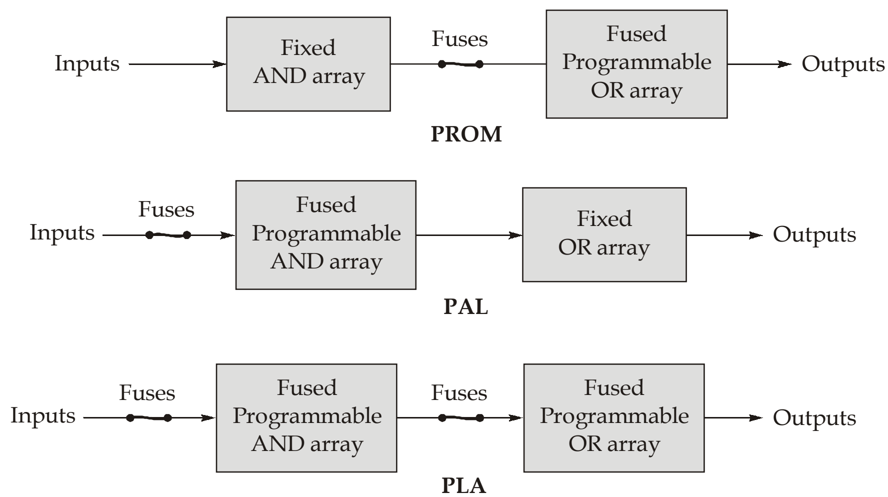
$$\Rightarrow \quad n \leq \frac{1000}{500}$$

$$\Rightarrow \quad n \leq 2$$

$\therefore$ The maximum number of J-K flip-flops that can be used is 2.

$\Rightarrow$ Maximum possible MOD of counter with 2 flip-flops is $2^2 = 4$.

47. (c)



48. (a)

Input combinations $(0110)_2$ to a 4 × 1 MUX makes it act like a XOR gate. Thus,

$$\left.\begin{aligned} Y &= \bar{A}B + A\bar{B} \\ &= A \oplus B \end{aligned}\right\} \Rightarrow X = \bar{Y}C + Y\bar{C} = \overline{(A \oplus B)}C + (A \oplus B)\bar{C}$$

49. (c)

According to reciprocity theorem,

$$\frac{V_x}{I_y} = \frac{V_y}{I_x}$$

50. (a)

For negative feedback.

$$(\text{B.W})_f > (\text{B.W})$$

Also, the gain of the amplifier decreases due to negative feedback.

51. (d)

The common mode gain of BJT differential amplifier is given as

$$A_{cm} = \frac{-R_C}{2R_E}$$

Since, the resistance of ideal current source is very high, hence A_{cm} decreases and the CMRR of the amplifier is increased.

52. (d)

Dry oxidation Vs Wet oxidation

Parameter	Dry Oxidation	Wet Oxidation
Oxidizing agent	Dry oxygen (O_2)	Water vapour (H_2O/Steam)
Reaction	$Si + O_2 \rightarrow SiO_2$	$Si + 2H_2O \rightarrow SiO_2 + 2H_2$
Oxidation rate	Slow	Fast
Oxide thickness	Thin Oxide (<100 nm)	Thick Oxide (>100 nm)
Oxide quality	Very high	Lower than dry oxide
Electrical properties	Low interface state	More interface state
Surface roughness	Smooth	Rough
Dielectric strength	High	Lower
Temperature	900-1200°C	800-1100°C
Growth control	Excellent	Poor
Time required	Long	Short

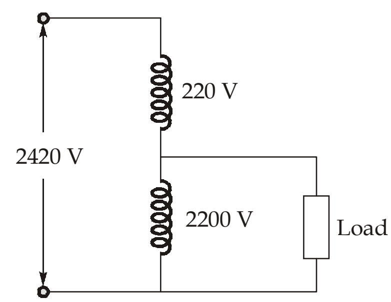
53. (b)

$$\text{Saving in conductor material} = \frac{1}{a_A}\text{Pu}$$

$$\text{where voltage ratio, } a_A = \frac{V_H}{V_L} = \frac{2420}{2200} = \frac{11}{10}$$

$$\text{Saving in conductor material} = \frac{1}{a_A} \times 100\%$$

$$= \frac{10}{11} \times 100\% = 90.9\%$$



Hence, option (b) is correct.

54. (c)

Hamming code is used to detect and correct single-bit errors. When the data word and parity bits in check word is even, then there is no error. In the 7-bit hamming code, we have 4 data bits and 3 parity bits given by

P_1	P_2	D_3	P_4	D_5	D_6	D_7
1	0	1	1	1	1	1

We have,

$C_1 = (1, 3, 5, 7) = 1111 \rightarrow$ Even number of 1's, so no error.

$\Rightarrow \quad C_1 = 0$

$C_2 = (2, 3, 6, 7) = 0111 \rightarrow$ Odd number of 1's, so error present.

$\Rightarrow \quad C_2 = 1$

$C_4 = (4, 5, 6, 7) = 1111 \rightarrow$ Even number of 1's, so no error.

$\Rightarrow \quad C_4 = 0$

$\therefore$ Check word, $C = C_4\, C_2\, C_1 = 010$ = decimal 2

So, error is present at position 2 of the Hamming code, hence reverse the corresponding bit detected in code.

So, correct code = 1111111.

55. (c)

In an n-type semiconductor,

$$n \approx N_D = N_C e^{\frac{-(E_C - E_F)}{kT}}$$

For degenerated semiconductor, the Fermi level lies inside the conduction band. Hence,

$$\frac{N_C}{N_D} << 1 \qquad \left\{\text{For option } (c): \frac{N_C}{N_D} = \frac{3\times10^{19}}{3\times10^{22}} = 10^{-3} << 1\right\}$$

56. (a)

We know,
$$\alpha = \frac{\beta}{1+\beta}$$

$$\frac{\partial\alpha}{\partial\beta} = \frac{\beta}{(1+\beta)^2}$$

$$\Rightarrow \quad \frac{\partial\alpha}{\alpha} = \frac{1}{1+\beta}\cdot\frac{\partial\beta}{\beta}$$

$$\Rightarrow \quad \left(\frac{\partial\alpha}{\alpha}\right)\% = \frac{1}{1+80}\times(0.8\%) = \frac{0.8}{81}\% = 0.00987\%$$

57. (b)

We know,
$$\text{Fill factor} = \frac{P_m}{V_{OC}\cdot I_{SC}}$$

$$\Rightarrow \quad 0.5 = \frac{P_m}{0.8\times100\times10^{-3}}$$

$\Rightarrow$ Maximum output power, P_m = 40 mW

$$\text{Efficiency, } \eta = \frac{P_m}{P_{in}} = \frac{P_m}{G\times A} = \frac{40\times10^{-3}}{(100\times10^{-3}\times2)} = 0.2 = 20\%$$

$G \rightarrow$ Input light in W/cm^2

58. (b)

We have,

$$n_1 = 1.5;\ n_2 = 1.2$$

$$B_{T(\max)} = 0.1 \text{ Mbps}$$

$$B_{T(\max)} = \frac{0.2}{\sigma_s}$$

where, σ_s = RMS pulse broadening due to intermodal dispersion on the link.

$$0.1\times10^6 = \frac{0.2}{\sigma_s}$$

$$\sigma_s = \frac{0.2}{0.1\times10^6} = 2\times10^{-6} \text{ sec}$$

$$\sigma_s = \frac{Ln_1\Delta}{2\sqrt{3}\,c}$$

$$2 \times 10^{-6} = \frac{L \times 1.5\Delta}{2\sqrt{3} \times 3 \times 10^8} \qquad \because \Delta = \frac{n_1 - n_2}{n_1} = \frac{1.5 - 1.2}{1.5}$$

$$L = \frac{2 \times 10^{-6} \times 2\sqrt{3} \times 3 \times 10^8}{1.5 \times \frac{(1.5-1.2)}{1.5}}$$

$$L = \frac{2 \times 10^{-6} \times 2\sqrt{3} \times 3 \times 10^8}{0.3} = 40\sqrt{3} \times 100$$

$$L \approx 7000 \text{ m} = 7 \text{ km}$$

59. (a)

We have,

$$n_1 = 1.5, n_2 = 1.2$$

$$\text{Critical angle } \theta_c = \sin^{-1}\left(\frac{1.2}{1.5}\right)$$

$$\theta_c = \sin^{-1}(0.8)$$

$$\theta_c = 53.13°$$

For TIR to occur, angle of incidence (θ) must be greater than critical angle (θ_c = 53.13°). Hence, statement (1) is correct. However, it also must be less than acceptance angle.

Mathematically,

$$\theta > 53.13° \quad \text{...(i)}$$

$$\theta < \theta_A \quad \text{...(ii)}$$

Combining (i) and (ii), we get

$$53.13° < \theta < \theta_A$$

Hence, statement (4) is correct.

60. (d)

DHCP (Dynamic host configuration protocol) is not a multiple access protocol. It is a network protocol used in Internet Protocol (IP) networks to automatically assign IP addresses and other configuration information to devices on a network.

61. (d)

At $t = 0^-$, the source is disconnected

$$i_L(0^-) = i_L(0^+) = 0$$

for $t > 0$, the source is connected to circuit.

In steady state, inductor acts as short circuit. Applying nodal analysis,

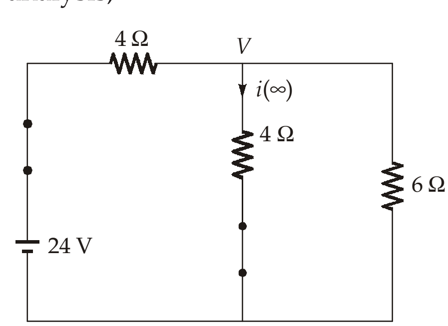
$$\frac{V-24}{4} + \frac{V}{4} + \frac{V}{6} = 0$$

$$\frac{3V - 72 + 3V + 2V}{12} = 0$$

$$8 \text{ V} = 72$$

$$V = 9 \text{ V}$$

$$i_L(\infty) = \frac{V}{4} = \frac{9}{4} \text{ A}$$



$$i(t) = \left[i(0^+) - i(\infty)\right]e^{-\frac{t}{\tau}} + i(\infty)$$

$$i(t) = \frac{9}{4} + \left(0 - \frac{9}{4}\right)e^{-\frac{t}{\tau}} \quad \text{...(1)}$$

$$\tau = \frac{L}{R_{eq}} = \frac{0.8}{6.4} = \frac{1}{8}$$

Where, $$R_{eq} = \frac{6 \times 4}{10} + 4 = 6.4\ \Omega$$

$\therefore$ $$i(t) = \frac{9}{4}(1 - e^{-8t})\text{A};\ t > 0$$

62. (b)

Given,
$$G_L = 10^{16}\ \text{cm}^{-3}\text{s}^{-1}$$
$$\tau_n = \tau_p = 10\ \mu\text{s}$$
$$N_D = 10^{15}\ \text{cm}^{-3}$$

excess carrier concentration under illumination,

$$\Delta n = \Delta p = \tau_p G_L = \tau_n G_L = 10 \times 10^{-6} \times 10^{16}$$

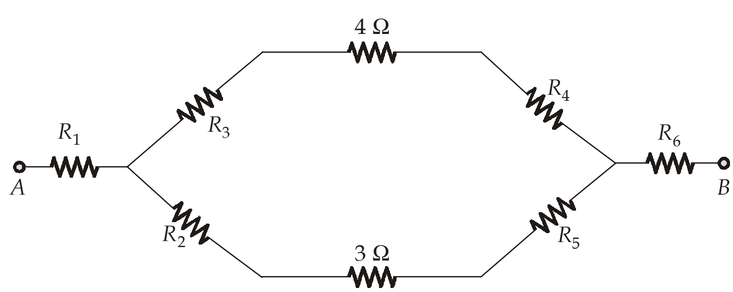
$\therefore$ $$\Delta n = \Delta p = 10^{11}\ \text{cm}^{-3}$$

electron concentration, $n = n_{n0} + \Delta n$
$$= N_D + \Delta n$$
$$= 10^{15} + 10^{11} \simeq 10^{15}\ \text{cm}^{-3}$$

hole concentration, $$p = \frac{n_i^2}{N_D} + \Delta p = \frac{(10 \times 10^{10})^2}{10^{15}} + 10^{11} = 10^{11}\ \text{cm}^{-3}$$

63. (a)

Converting the two delta network formed by resistors 4.5 Ω, 3 Ω and 7.5 Ω into equivalent star network, we have,

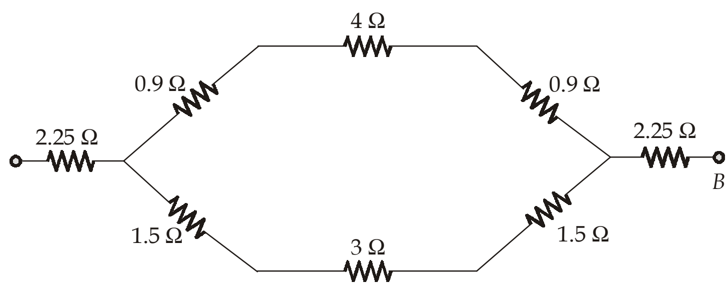


$$R_1 = R_6 = \frac{4.5 \times 7.5}{4.5 + 7.5 + 3} = 2.25\ \Omega$$

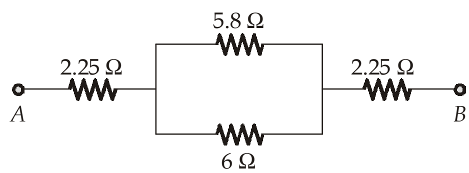
$$R_2 = R_5 = \frac{7.5 \times 3}{4.5 + 7.5 + 3} = 1.5\ \Omega$$

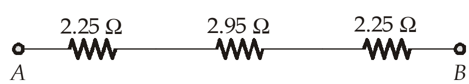
$$R_3 = R_4 = \frac{4.5 \times 3}{4.5 + 7.5 + 3} = 0.9\ \Omega$$

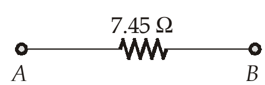
The simplified network is



The network can be simplified as follows:







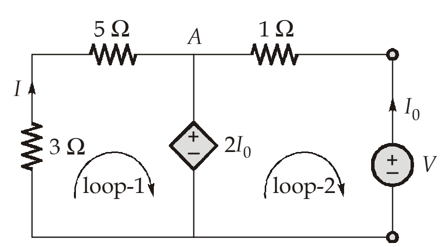
$$R_{AB} = 7.45\ \Omega$$

64. (d)

For the given tree, the possible fundamental cut-sets are {1, 6, 8}, {2, 6, 8, 3}, {8, 7, 5, 3} and {4, 7, 8}.

65. (c)

To calculate R_{th}, the equivalent circuit is



KVL in loop-1

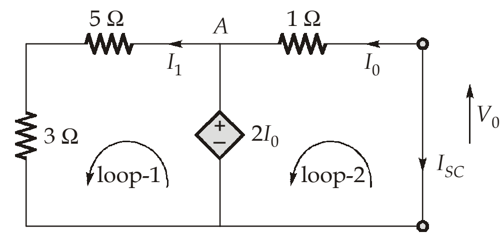
$$8I + 2I_0 = 0 \quad \text{...(i)}$$

KVL in loop-2

$$V = I_0 + 2I_0$$

$$\frac{V}{I_0} = 3\ \Omega = R_{th}$$

Calculate V_{th}



$$I_{sc} = -I_0$$

KVL in loop-1

$$2I_0 = 8I_1$$

$$I_1 = \frac{1}{4}I_0 \quad \text{...(ii)}$$

KVL in loop-2

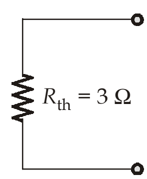
$$3I_0 = 0$$

$$I_0 = 0$$

Hence, $\quad I_{sc} = 0$

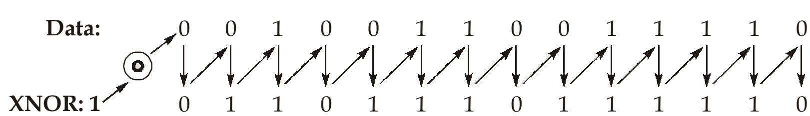
∴ $\quad V_{th} = R_{th}\, I_{sc} = 0 \text{ V}$

Thevenin equivalent circuit is



66. (c)

DPSK bit stream is obtained by XNORing current bit to previous bit. Assume bit '1' as initial reference bit.



So, DPSK bit stream is 01101110111110.

67. (b)

$$Q = 90; \text{ IF} = 475 \text{ kHz}, f_s = 950 \text{ kHz}$$

∴ $\quad$ image frequency $f_{si} = f_s + 2IF$

$$= 950 + 2(475) = 1900 \text{ kHz}$$

image frequency rejection ratio $\alpha = \sqrt{1+Q^2\rho^2}$

where $\rho = \dfrac{f_{si}}{f_s} - \dfrac{f_s}{f_{si}} = \dfrac{1900}{950} - \dfrac{950}{1900} = \dfrac{3}{2}$

∴ $\quad \alpha = \sqrt{1+(90)^2\left(\dfrac{3}{2}\right)^2} = 135.00$

68. (a)

Under channel length modulation,

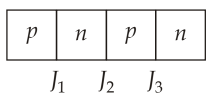
$$I_D = I_{Dsat}(1 + \lambda V_{DS})$$

$$\frac{dI_D}{dV_{DS}} = \frac{1}{r_0} = \lambda I_{Dsat}$$

$$\Rightarrow \quad r_0 = \frac{1}{\lambda I_{Dsat}} = \frac{1}{0.01 \times 5 \times 10^{-3}} = 20\ \text{k}\Omega$$

69. (b)

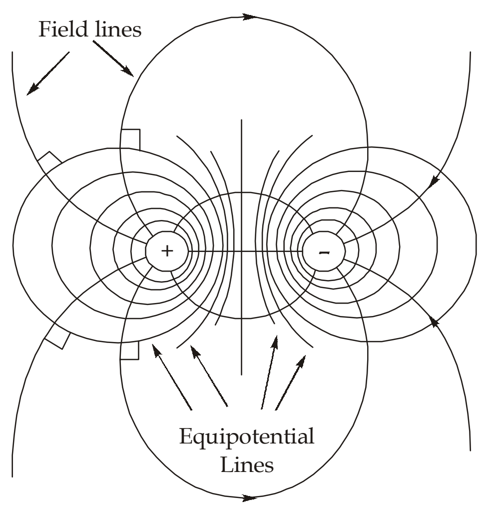
1. SCR is a p-n-p-n device having 3 junctions



2. Gunn diode is a junctionless device as it is formed by only N-type material.
3. BJT is a double junction device having two p-n junctions, creating three regions; emitter, base and collector.
4. Solar cell is basically a p-n junction diode. Hence, it is a single junction device.

70. (b)

For equal and opposite line charge, the equipotential surface is non concentric cylinders as shown in the figure below:



71. (a)

72. (d)

Even though there is negative feedback and open loop control system is stable, we can have closed loop system as unstable depending on the open loop gain K. Thus, statement (I) is not correct.

73. (c)

Just as analog filters are designed using the Laplace transform, recursive digital filters are designed using z-transform. The relationship between the recursion coefficients and the filter's response is given by z-transform. Thus, Statement (II) is not correct.

74. (a)

Self complementing code is a binary code in which the complement of a number is equal to the code for the 9's complement of that number. 2421 is a self-complementing code. For example, consider the 2421 code of $4_{10} = (0100)_2$.

The complement of $(0100)_2$ is $(1011)_2$ which is 2421 code for $(5)_{10}$

$\therefore \quad 4 + 5 = 9$

75. (b)

Dry oxidation uses pure oxygen, resulting in a denser, higher quality oxide layer that grows more slowly than wet oxidation.

Wet oxidation uses oxygen and water vapour, resulting in a faster growing oxide layer with a lower density than dry oxidation.

76. (d)

The amplitude of sidebands in angle modulated signal is proportional to $J_n(\beta)$. However, $J_n(\beta)$ decreases with increase in "β". Hence, statement (I) is correct but statement (II) is incorrect.

77. (b)

For dominant mode,

$$f_{c10} = \frac{c}{2a} = \frac{3\times10^8}{2\times0.5\times10^{-2}} = 30\times10^9 = 30\text{ GHz}$$

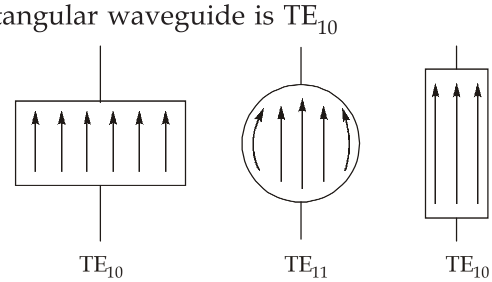
Given, operating frequency, f = 1 GHz

Since $f < f_c$, $\gamma = \alpha + j0$ i.e. the wave is attenuated,

where,
$$\alpha = \omega\sqrt{\mu_0\varepsilon_0}\sqrt{\left(\frac{f_{c10}}{f}\right)^2 - 1}$$
$$= \frac{2\pi\times2\times10^9}{3\times10^8}\sqrt{\left(\frac{30}{1}\right)^2 - 1}$$
$$\simeq \frac{2\pi\times2\times10}{3}(30)$$
$$\simeq 400\pi$$
$$\simeq 1257\text{ m}^{-1}$$

78. (c)

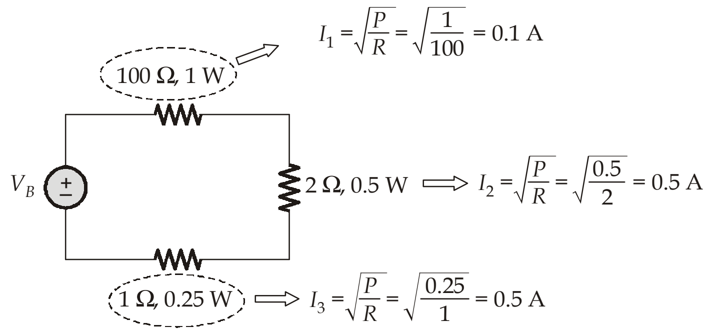
The dominant mode in a rectangular waveguide is TE_{10}



Due to change in orientation of the guide, the field orientation does not change, but 'a' becomes smaller dimension than 'b'. As the field orientation doesn't change, TE_{10} mode is excited in the waveguide.

79. (c)

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, $V_{2\,\Omega} = \dfrac{10.3 \times 2}{100 + 2 + 1} = 0.2$ Volt ....(on applying voltage division rule)

80. (d)

- AM is more susceptible to noise because noise affects amplitude, which is where information is stored in an AM signal. FM is less susceptible to noise because information in an FM signal is transmitted through varying the frequency, and not the amplitude.
- FM requires more complex and expensive transmitters and receivers, as they need to generate and detect frequency variations accurately and precisely.

81. (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

82. (c)

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

83. (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.
   - Noise power $P_n = kTB$
   - Mean square noise voltage, $V_n^2 = 4\,kTBR$
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.
   - Mean square noise current, $i_n^2 = 2qIB$ where I = Avg. DC current
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.
   - $V_n^2 \propto \frac{1}{f}$
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.
   - PDF = $\frac{1}{\sqrt{2\pi\sigma^2}} e^{\left(\frac{-(x-\mu)^2}{2\sigma^2}\right)}$, where μ = mean; σ^2 = variance

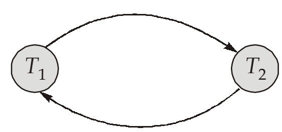
84. (c)

For a schedule to be conflict serializable, there should be no cycle present in its precedence graph.

Schedule S_1

T_1	T_2
$R[X]$	
	$R[X]$
	$R[Y]$
$W[X]$	
$W[Y]$	
	$W[Y]$

Precedence Graph:



Since the precedence graph is having cycle, hence S_1 is not conflict serializable.

Schedule S_2

T_1	T_2
$R[X]$	
	$R[X]$
	$R[Y]$
$W[X]$	
	$W[Y]$
$W[Y]$	

Precedence Graph:

Since there are no cycles in the precedence graph, hence S_2 is conflict serializable.

Schedule S_3

T_1	T_2
$R[X]$	
$W[X]$	
	$R[X]$
$W[Y]$	
	$R[Y]$
	$W[Y]$

Precedence Graph:

Since there are no cycles in the precedence graph, hence S_3 is conflict serializable.

So, S_2 and S_3 conflict serializable.

85. (c)

We know that,

$$\text{Time period of satellite, } T = \frac{2\pi r}{V} = \frac{2\pi r^{3/2}}{\sqrt{GM}} \text{ seconds}$$

Substituting, $G = 6.67 \times 10^{-11}\ \text{Nm}^2/\text{kg}^2$

M = Mass of earth = 5.98×10^{24} kg

We get, $T = (0.314 \times r^{3/2})\ \mu\text{sec}$

86. (b)

Given system, $y(t) = u\{x(t)\}$

Let $x_1(t) = V(t)$, then $y_1(t) = u[V(t)]$

$x_2(t) = kV(t)$, then $y_2(t) = u[kV(t)] = ku[V(t)] = ky_1(t)$

For $x(t) = x_1(t) + x_2(t)$,

$$y(t) = u\{x_1(t) + x_2(t)\} \neq u\{x_1(t)\} + u\{x_2(t)\}$$

The system satisfies the homogeneity principle but not the superposition principle.

Hence, the system is non-linear.

$$y_1(t) = u\{V(t)\}$$

$$y_2(t) = u\{V(t - t_0)\} = y_1(t - t_0)$$

Hence, the given system is time-invariant.

Since the response at any time depends only on the excitation at time $t = t_0$ and not on any future values, hence the given system is causal.

87. (c)

For $\rho_X(x)$ to be a probability density function,

$$\int_{-\infty}^{+\infty} \rho_X(x)dx = 1$$

$$\int_{-\infty}^{+\infty} ae^{-10|x|}dx = 1 \Rightarrow 2\int_0^{\infty} ae^{-10x}dx = 1$$

$$\Rightarrow \quad 2a\left[\frac{e^{-10x}}{-10}\right]_0^{\infty} = 1 \Rightarrow \frac{2a}{10} = 1 \Rightarrow a = 5$$

88. (d)

Given, $B_2 = \frac{B_1}{2}$, $(\text{SNR})_1 = 60$ dB

Since the signal power remains constant and Noise power = N_0B is directly proportional to B, we have

$$\therefore \quad B_1(\text{SNR})_1 = B_2(\text{SNR})_2$$

$$\Rightarrow \quad (\text{SNR})_2 = \frac{B_1}{B_2}(\text{SNR})_1 = \frac{B_1}{\left(\frac{B_1}{2}\right)}(\text{SNR})_1 = 2(\text{SNR})_1$$

$$\Rightarrow \quad 10 \log(\text{SNR})_2 = 10 \log 2 + 10 \log (\text{SNR})_1$$

$$\Rightarrow \quad (SNR)_2(dB) = 3 + (SNR)_1(dB)$$

$$\Rightarrow \quad (SNR)_2(dB) = 3 + 60$$

$$\Rightarrow \quad (SNR)_2 = 63 \text{ dB}$$

89. (d)

For coherent binary signalling schemes,

$$P_e = Q\left(\sqrt{\frac{d_{\min}^2}{2N_0}}\right)$$

For coherent ASK, $d_{\min} = \sqrt{E_b}$, where $E_b = \frac{A_c^2}{2}T_b$

$$P_{e(\text{ASK})} = Q\left(\sqrt{\frac{A_c^2 T_b}{4N_0}}\right)$$

For coherent FSK, $d_{\min} = \sqrt{2E_b}$

$$P_{e(\text{FSK})} = Q\left(\sqrt{\frac{A_c^2 T_b}{2N_0}}\right)$$

For coherent PSK, $d_{\min} = \sqrt{2E_b}$

$$P_{e(\text{PSK})} = Q\left(\sqrt{\frac{A_c^2 T_b}{N_0}}\right)$$

Hence, option (d) is correct.

90. (b)

The amplitude of the input signal is symmetrically distributed about zero. Hence,

$P(\Delta_1) = P(\Delta_2) = 0.5$, where Δ_1 and Δ_2 are the step-sizes

So, the quantization noise power will be,

$$N_Q = \frac{\Delta_1^2}{12}[P(\Delta_1)] + \frac{\Delta_2^2}{12}[P(\Delta_2)]$$

$$N_Q = \frac{0.5}{12}\left[(0.3)^2 + (0.1)^2\right] = \frac{1}{24}[0.09 + 0.01] = \frac{0.1}{24}$$

$$\Rightarrow \quad N_Q = \frac{1}{240}$$

91. (a)

- At high frequency, skip distance is high and for the frequency less than critical frequency, skip distance is zero.
- Microwave bending correction factor $K = \dfrac{\text{Value of parameter for the optical horizon}}{\text{Value of parameter for the radio horizon}}$

  Hence, $K > 1 \Rightarrow$ Value of the parameter for the radio horizon is smaller than optical horizon.

Hence, statement 3 is incorrect.

92. (c)

$$\text{Intensity of magnetization} = \frac{\text{Total magnetic moment}}{\text{Volume}}$$

Given, Magnetic moment = 3 A-m^2

Mass of the bar = 7.9×10^{-3} kg

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}} = \frac{7.9\times10^{-3}}{7.9\times10^{3}} = 1\times10^{-6}\,\text{m}^3$$

$$\therefore \quad \text{Intensity of magnetization} = \frac{3}{1\times10^{-6}} = 3\times10^{6}\ \text{A/m}$$

93. (c)

- Diamagnetic substances are slightly repelled by a magnet, hence they have a small and negative susceptibility.
- Paramagnetic substances are feebly attracted by magnets, hence they have a small and positive susceptibility.
- Ferromagnetic substances exhibit a strong attraction to magnetic fields, hence they have a large and positive susceptibility.
- Superconductors exhibit perfect diamagnetism, i.e. they completely expel magnetic fields. Hence, their susceptibility is -1.

94. (c)

Bucky ball (or) Buckminster fullerene has total 60 carbon atoms with sp^2 bonding arranged in a football shape having 20 Hexagons and 12 pentagons with a carbon at vertex of each hexagon, polygon and a bond along each hexagon and polygon edge.

95. (d)

Hysteresis loss of transformer is directly proportional to frequency.

$$\because \quad P_{Hy} \propto f \;\Rightarrow\; \frac{P_{Hy_2}}{P_{Hy_1}} = \frac{f_2}{f_1}$$

$$P_{Hy_2} = \frac{f_2}{f_1}\times P_{H_{y1}} = \frac{75}{100}\times 50 = 37.5\ \text{W}$$

96. (a)

$$\text{Spectral efficiency} = \frac{R_b}{B} = 10\ \text{bps/Hz}$$

We have,

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

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

$$10 = \log_2\left(1+\frac{S}{N}\right)$$

$$1+\frac{S}{N} = 2^{10}$$

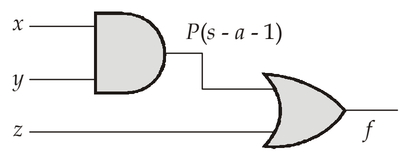
$$\frac{S}{N} = 2^{10} - 1$$

$$\frac{E_b R_b}{N_0 B} = 2^{10} - 1$$

$$10 \times \frac{E_b}{N_0} = 2^{10} - 1$$

$$\frac{E_b}{N_0} = \frac{1}{10}\left[2^{10} - 1\right] = \frac{1023}{10} = 102.3$$

97. (a)



Step 1: To propagate the fault at output, i.e., $f = P$,
Put $z = 0$, then $f = P$

Step 2: To detect the s-a-1 fault, we need to force the value at P to 0 in the fault-free circuit.
For $P = 0$, x and y can be 00 or 01 or 10

So, test vectors are:

x	y	z
0	0	0
0	1	0
1	0	0

98. (c)

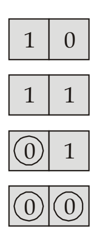
For sequence generator using counters, if 'n' is the required number of flip-flops,

$$\text{max.}(0\text{'s}, 1\text{'s}) \le 2^{n-1}$$

$\Rightarrow$ $2 \le 2^{n-1}$

$\Rightarrow$ $n = 2$

To generate 0 1 1 0



All 4 states are different, so total 4 states are required i.e. 2FFs are required.

99. (b)

Given: t = 15 min = 15 × 60 = sec ; $N_s = 3 \times 10^{20}$ atoms/cm^3 ; $D = 3.14 \times 10^{-14}$ cm^2/s

Dose,
$$Q = \frac{2}{\sqrt{\pi}} N_s \sqrt{Dt} = \frac{2}{\sqrt{\pi}} \times 3 \times 10^{20} \sqrt{3.14 \times 10^{-14} \times 15 \times 60}$$

$$= 2 \times 3 \times 30 \times 10^{-7} \times 10^{20} = 1.8 \times 10^{15} \text{ atoms/cm}^2$$

100. (a)

We have,

$$\text{Path difference} = 0.1 \text{ inch}$$
$$= 0.254 \text{ cm} \qquad \because 1 \text{ inch} = 2.54 \text{ cm}$$
$$= \frac{0.254}{100} \text{ m}$$
$$\text{Phase difference} = 1.06 \text{ radian}$$
$$\text{Phase difference} = \frac{2\pi}{\lambda}(\text{Path difference})$$
$$1.06 = \frac{2\pi}{\lambda} \times \frac{0.254}{100}$$
$$\lambda = \frac{2\pi \times 0.254}{1.06 \times 100} = 0.015 \text{ m}$$
$$f = \frac{3 \times 10^8}{1.5 \times 10^{-2}} = 20 \text{ GHz}$$

K band is ranging from 18-27 GHz.

Hence, option (a) is correct.

Note:

- To avoid complex calculation, we can proceed with approximation, answer will not be changed.
-

Band	**Frequency range**
L	1-2 GHz
S	2-4 GHz
C	4-8 GHz
X	8-12 GHz
Ku	12-18 GHz
K	18-27 GHz
Ka	27-40 GHz

101. (a)

- Symmetric encryption is a encryption technique where data is encrypted and decrypted using a single, secrete crytographic key.

  Eg:-
  - Data Encryption Standard (DES)
  - Triple Data Encryption Standard (Triple DES)
  - Advance Encryption Standard (AES), etc....
- Asymmetric encryption is a encryption technique where data is encrypted and decrypted using different keys.

  Eg:-
  - Rivest Shamir Adleman (RSA)
  - Elliptical curve cryptography (ECC)
  - The Diffie-Hellman key exchange method, etc.

Hence, option (a) is not asymmetric encryption technique.

102. (a)

The attenuation constant for the compartment material (assuming the compartment material as non magnetic),

$$\alpha = \sqrt{\pi f \mu_0 \sigma} = \sqrt{\pi \times 500 \times 10^3 \times 4\pi \times 10^{-7} \times 4 \times 10^6}$$

$$= 4\pi \times 100\sqrt{5}$$

$$= 400 \times 3.14 \times 2.23$$

$$\cong 2800 \text{ Np/m}$$

The wave amplitude after passing through the compartment wall will be

$$E = E_0 e^{-\alpha z}$$

$$= 0.8 e^{-2800 \times 5 \times 10^{-3}}$$

$$= 0.8 e^{-14}$$

$$= 0.8 \times 8.315 \times 10^{-7}$$

$$= 6.652 \times 10^{-7} \text{ V/m}$$

103. (b)

We have,

EMF per turn, E_t = 18 Volts

Thus,

$$\text{Number of secondary turns} = \frac{\text{Secondary voltage}}{E_t}$$

$$N_2 = \frac{230}{18} = 12.77$$

Since, the number of turns can't be a fraction, therefore, N_2 = 13 (nearest whole number)

For N_2 = 13,

Number of primary turns,

$$N_1 = N_2\left(\frac{V_1}{V_2}\right) = 13\left(\frac{2340}{230}\right)$$

$$N_1 = 132.26 \simeq 133 \text{ turns}$$

104. (c)

The emf per turn of a transformer is given as

$$\frac{E}{N} = \sqrt{2}\pi f_1 \phi_{max} = 4.44 f_1 \phi_{max}$$

105. (c)

We know that,

Energy stored in the magnetic field,

$$E = \frac{1}{2}Li^2$$

$$0.5 = \frac{1}{2}L(1)^2$$

$$L = 1 \text{ Henry}$$

We also have,
$$N\phi = Li$$
$$N = \frac{Li}{\phi}$$
$$N = \frac{1\times1}{1\times10^{-3}} = 1000 \text{ turns}$$

106. (d)

- Silica gel is used to absorb moisture and prevent entering the oil tank while breathing. It is used in an oil transformer breather.
- Porcelain is widely used for making transformer bushings.
- Buchholz relay is a safety device to protect a transformer from internal faults, like impulse breakdown of the transformer insulating oil or transformer coil turns insulation failure, etc. It consists of two floated hinges accomplished with a mercury switch, one at the top and other at the bottom, both are in an oil-filled chamber. The upper float mercury switch is connected to an alarm circuit and the lower float mercury switch is connected to an external trip breaker.
- The presence of the cooling fins increases the outer surface area of the tank, thereby enhancing the tank cooling capacity.

107. (c)

Feedback topology	Input impedance	Output impedance
Voltage series	increases	decreases
Voltage shunt	decreases	decreases
Current series	increases	increases
Current shunt	decreases	increases

108. (b)

- Portable Batteries are used for starting, lighting and ignition in internal-combustion engine vehicles.

Note:

1.

Power Generating Unit	Efficiency
Hydraulic turbine	85-90%
Solar cell	10-12%
Diesel Engine	25%
Fuel cell	60-70%

2.

Electric Power Plant	Operation speed
Hydro	80-1275 rpm
Steam	1500-3000 rpm
Diesel	500-1000 rpm

2. The secondary batteries are classified as below:

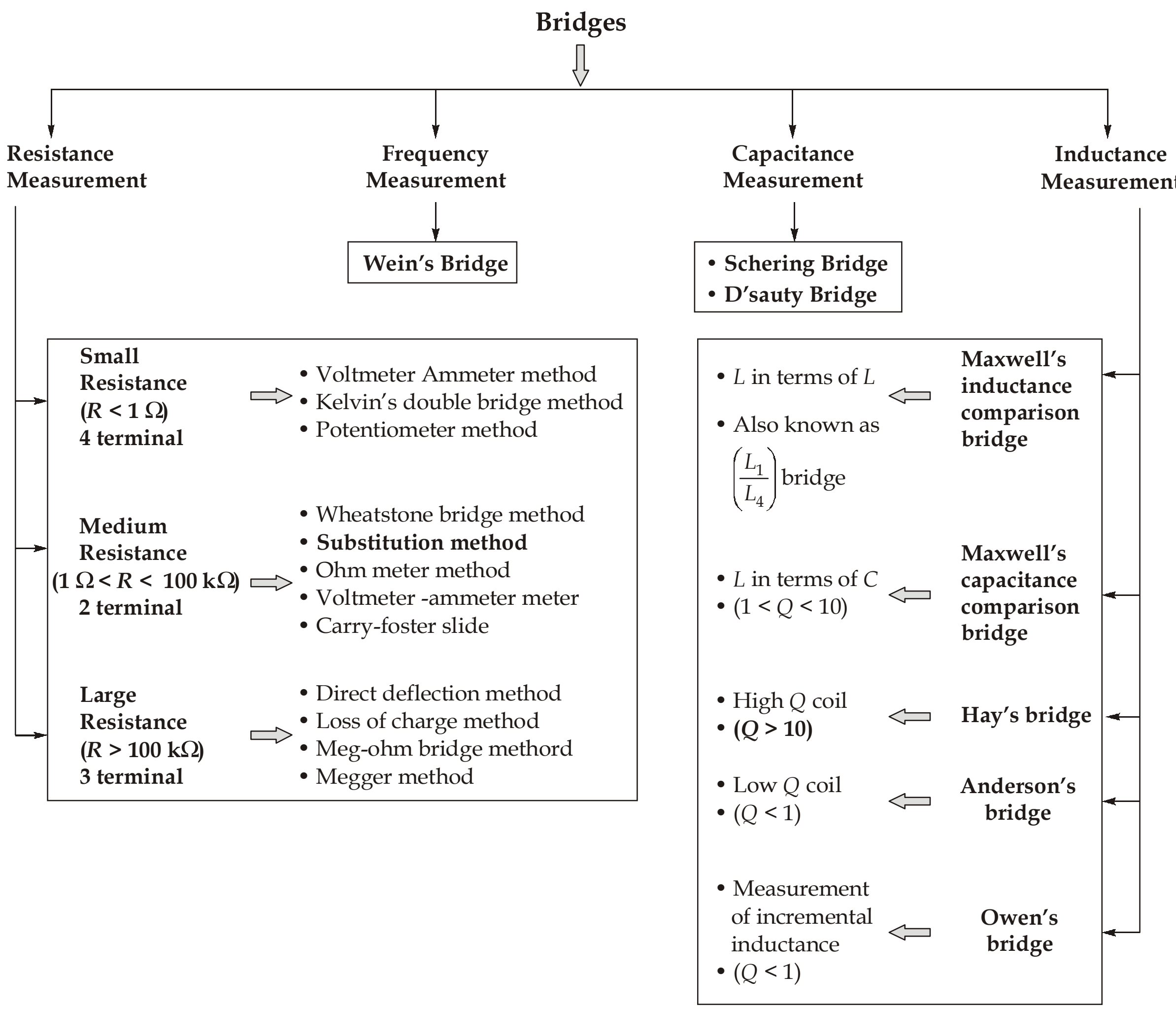
(i) Automotive batteries: These are used for starting, lighting and ignition (SLI) in internal-combustion engined vehicles.

(ii) Vehicle Traction Batteries or Motive Power Batteries or Industrial Batteries: These are used as a motive power source for a wide variety of vehicles.

(iii) Stationary Batteries: These fall into two groups (a) standby power system which is used intermittently and (b) load-levelling system which stores energy when demand is low and, later on, uses it to meet peak demand.

3. The electromechanical energy converters are of two types:
   - Gross-motion devices: such as electrical motors or generators.
   - Incremental motion devices: such as microphones, loudspeakers, electromagnetic relays and electrical measuring instruments, etc.

109. (d)



110. (a)

We have, Gauge factor, $G_f = \dfrac{\Delta R / R}{\Delta L / L}$

$$\frac{\Delta L}{L} = \frac{\Delta R / R}{G_f}$$

$$\frac{\Delta L}{L} = \frac{\left(\frac{0.010}{200}\right)}{2.1}$$

$$\frac{\Delta L}{L} = \frac{0.010}{200\times 2.1} = \frac{10\times 10}{200\times 1000\times 21}$$

$$\frac{\Delta L}{L} = 2.38 \times 10^{-5}$$

$$\text{Stress} = \text{Strain} \times \text{Young's modulus}$$

$$\text{Stress} = 2.38 \times 10^{-5} \times 200 \times 10^{9}$$

$$\text{Stress} = 4.76 \times 10^{6}\ \text{N/m}^2$$

Note:

- Gauge factor, G.F = $\frac{(\Delta R/R)}{(\Delta l/l)}$
- Longitudinal strain = $\frac{\Delta l}{l}$
- Poisson's ratio, $\gamma = \frac{(\Delta D/D)}{(\Delta l/l)}$
- Lateral strain = $\frac{\Delta D}{D}$
- Young's Modulus = $\frac{\text{Stress}}{\text{Strain}}$
- Stress = $\frac{\text{Force}}{\text{Area}}$

(where, D = Diameter; L = Length)

111. (a)

Types of Instruments

Absolute Instruments

- Output in terms of the instruments constant.
- High accuracy; Low operational power

Eg: Tangent Galvanometer, Rayleight Current Balance

Absolute Electrometer-used as standard instrument for calibration of secondary instrument

Secondary Instruments

- Output directly in terms of parameters
- High accuracy
- Used as general purpose meter

Analog Instruments

- Output varies continuously w.r.t input.

Digital Instruments

- Output varies discretely with respect to input.

Null Deflection Instruments

- Indicate end of measurement with zero/Null deflection.
- **Operational power ≈ 0**
- High Accuracy

Eg.: AC, DC Bridge

Deflecting Instruments

- Indicate end of measurement by the deflection of pointer away from zero.
- Having some operational power loss.
- Low Accurracy
- Instruments are more suitable under dynamic conditions than null type of instruments as the intrinsic response of null type are slower than deflection type instrument.

Indicating Instruments

- Give instantaneous values
- Eg. Ammeter, Voltmeter, Wattmeter
- Indicating type instruments are generally second order having $\xi < 1$ $(0.7 < \xi < 0.8)$

Integrating Instruments

- Give the sum total
- Eg. Energy meter

Recording Instruments

- Maintain a continuous record
- Ex: Recording voltmeter

Induction Effect

- $\theta \propto (\phi_1, \phi_2)$
- Eg. Shaded Pole instrument, Split ring instrument

Thermal Effect

- $\theta \propto I^2$
- **Eg. Hot wire instrument (gives rms value)**
- Thermocouple instrument
- Bolometer

Electrostatic Effect

- $\theta \propto V^2 \dfrac{dC}{d\theta}$
- Quadrant Electrometer
- Kelvin multicellular voltmeter
- Absolute Electrometer

Magnetic Effect

- Based on the principle that a current-carrying conductor produces a magnetic field arount it.

Moving Coil Instrument

PMMC

$\theta \propto I$

- Measures only DC
- Linear scale
- Spring controlling torque
- Eddy current damping

Electrodynamometer

$\theta \propto I_1 I_2 \dfrac{dM}{d\theta}$

- Measures both AC and DC
- Non-linear scale

- **Accuracy :** ED > PMMC > MI
- **Sensitivity:** PMMC > MI > ED

Moving Iron

- $\theta \propto I^2 \dfrac{dL}{d\theta}$
- Measures both AC and DC
- Non-linear scale
- Spring controlling torque
- Air friction damping

Attractive type **Repulsive type**

112. (b)

In squirrel-cage induction motors, the rotor slots are slightly skewed in order to eliminate magnetic locking between the stator and rotor and to reduce magnetic helm.

113. (d)

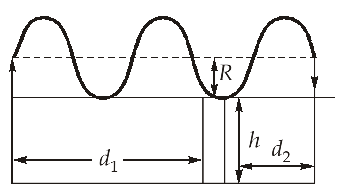
$$\text{SNR} = \frac{3}{8\pi^2}\frac{f_s^3}{f_m^2 \cdot f_c}$$

$$\text{SNR} = \frac{3}{8\pi^2} \times \frac{(40\times10^3)^3}{(10\times10^3)^2 \times (10\times10^3)}$$

$$\text{SNR} = \frac{3}{8\pi^2} \times \frac{(40)^3}{10^3}$$

$$\text{SNR} = 2.43$$

114. (d)



Height of antenna = 36 m = $h + R$

$$R = (36 - 1.4)\text{m}$$

$$R = 34.6 \text{ m}$$

R = radius of first Fresnel's zone

$$R = 17.3\left(\frac{d_1 d_2}{(d_1+d_2)f}\right)^{1/2} \quad \text{...}f \text{ in GHz}$$

$$\lambda = 30 \text{ cm} = 0.3 \text{ m}$$

$$f = \frac{3\times10^8}{0.3} = 1 \text{ GHz}$$

$$34.6 = 17.3\left(\frac{d_1 d_2}{(d_1+d_2)1}\right)^{1/2}$$

$$4 = \frac{d_1 d_2}{d_1+d_2} \quad \text{...(i)}$$

Distance between the antenna is $D = d_1 + d_2$

Accroding to given question we have,

$$d_1 = \frac{2}{3}(d_1+d_2) \quad \text{...(ii)}$$

from equation (i) and (ii)

$$d_1 = 12 \text{ m and } d_2 = 6 \text{ m}$$

$$D = d_1 + d_2 = 18 \text{ m}$$

Hence, option (d) is correct.

115. (a, b)

$$(BW)_{PM} = (BW)_{FM}$$

$$\left(\frac{\Delta f}{f_m}+1\right)2f_m = \left(\frac{\Delta f}{f_m}+1\right)2f_m$$

Hence,

$$\Delta f_{PM} = \Delta f_{FM}$$
$$K_p A_m f_m = K_f A_m$$
$$K_f = 3000\ K_p$$

116. (c)

117. (d)

Class A:

$$\underbrace{0......}_{(1^{st}\text{ Octet})}\ \underbrace{.\quad .\quad .}_{(\text{Remaining octets})}$$

Class B:

$$\underbrace{10......}_{(1^{st}\text{ Octet})}\ \underbrace{.\quad .\quad .}_{(\text{Remaining octets})}$$

Class C:

$$\underbrace{110......}_{(1^{st}\text{ Octet})}\ \underbrace{.\quad .\quad .}_{(\text{Remaining octets})}$$

Class D:

$$\underbrace{1110......}_{(1^{st}\text{ Octet})}\ \underbrace{.\quad .\quad .}_{(\text{Remaining octets})}$$

Class E:

$$\underbrace{1111......}_{(1^{st}\text{ Octet})}\ \underbrace{.\quad .\quad .}_{(\text{Remaining octets})}$$

In Class E IP address, the higher-order bits of the first octet are always set to 1111. Thus, option (d) is correct.

118. (d)

Given;

$$n_1 = 1.5,\ L = 10\text{ km}$$
$$\Delta = 2\% = 0.02$$

The delay difference is,

$$\delta T_s \approx \frac{Ln_1\Delta}{c}$$

$$\Rightarrow \quad \delta T_s \approx \frac{10\times10^3\times1.5\times0.02}{3\times10^8} = 1\times10^{-6} = 1\ \mu\text{s}$$

119. (c)

Given;
$$\beta_x - \beta_y = 70$$
$$\lambda = 0.143\ \mu\text{m}$$

We have,
$$\beta_x - \beta_y = \frac{2\pi B_F}{\lambda}$$

$\Rightarrow$ Modal birefringence,
$$B_F = \frac{(\beta_x - \beta_y)\lambda}{2\pi} = \frac{70 \times 0.143 \times 10^{-6}}{2\pi} = \frac{10^{-5}}{2\pi}$$

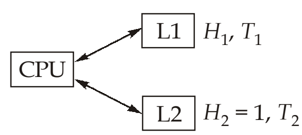
120. (b)

Frequency range: VLF = 3 kHz - 30 kHz
LF = 30 kHz - 300 kHz
MF = 0.3 MHz - 3 MHz
HF = 3 MHz - 30 MHz
VHF = 30 MHz - 300 MHz
UHF = 300 MHz - 3 GHz
SHF = 3 GHz - 30 GHz
EHF = 30 GHz - 300 GHz

121. (b)

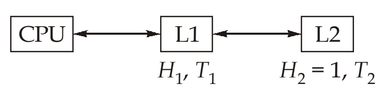
Two-level memory organization

Independent:



Average Memory access time (AMAT),
$$\text{AMAT} = H_1 T_1 + (1 - H_1) T_2$$

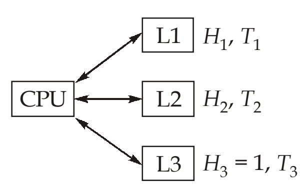
Hierarchical



$$\text{AMAT} = H_1 T_1 + (1 - H_1)(T_1 + T_2)$$

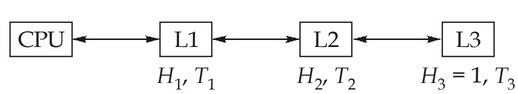
Three-level memory organization

Independent:



$$\text{AMAT} = H_1 T_1 + (1 - H_1) H_2 T_2 + (1 - H_1)(1 - H_2) T_3$$

Hierarchical



$$\text{AMAT} = H_1 T_1 + (1 - H_1) H_2 (T_1 + T_2) + (1 - H_1)(1 - H_2)(T_1 + T_2 + T_3)$$

122. (c)

There are 256 software interrupts in the 8086 microprocessor.

Some important software interrupts are:

- TYPE 0: It corresponds to division by zero(0).
- TYPE 1: It is used for single-step execution for debugging the program.
- TYPE 2: It represents NMI and is used in power failure conditions.
- TYPE 3: It represents a break-point interrupt.
- TYPE 4: It is the overflow interrupt.

123. (d)

Procedure to find type of feedback:

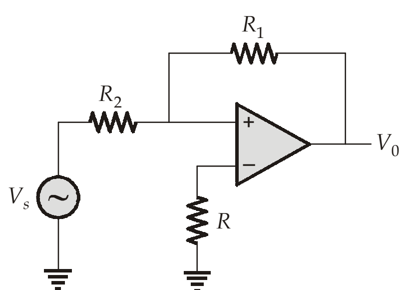
Step-I: Identify feedback element or feedback network in the given circuit.

Step-II: If feedback element is directly connected to output node, then it indicates voltage sampling otherwise current sampling.

Step-III: If feedback element is directly connected to input node, then it indicates shunt mixing otherwise series mixing.

Now,

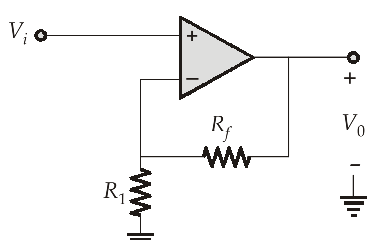
P.



- Feedback element-R_1.
- R_1 is directly connected to output, hence voltage sampling.
- R_1 is directly connected to input, hence shunt mixing.

Therefore, P-voltage shunt feedback.

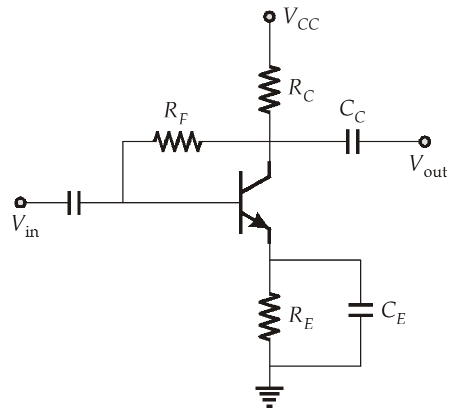
Q.



- Feedback element-R.
- R is directly connected to output, hence voltage sampling.
- R is not directly connected to input, hence series mixing.

Therefore, Q-voltage series feedback.

R.



- Feedback element-R_F.
- R_F is directly connected to output ⇒ Voltage sampling.
- R_F is directly connected to input ⇒ Shunt mixing.

Therefore, R-voltage shunt feedback.

124. (a)

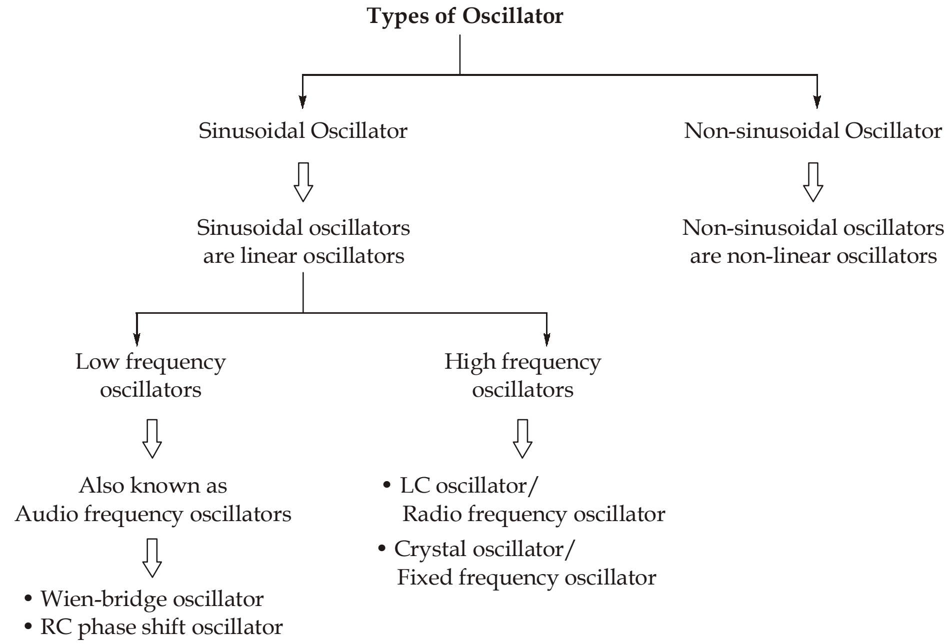
	Mealy Machine	**Moore Machine**
Output Dependency	Output depends on both the current state and the input.	Output depends only on the current state.
State Transitions	Output can change during state transitions based on the input.	Output changes only when the state changes.
Output Change frequency	Output can change more frequently (because it depends on input and state).	Output changes only when the state transitions
Number of states	Typically requires fewer states to represent the same functionality.	Typically requires more states for the same functionality.
Design Complexity	Slightly more complex due to output dependency on both state and input.	Simpler to design, as the output depends only on the state.
Timing Diagram	Output changes in response to both input and state transitions.	Output changes only on state transitions.
Examples	Used in systems where outputs need to react immediately to inputs (e.g., control systems, data encoding).	Used in simpler systems where output is less dependent on the input (e.g., counters, sequence detectors).
Output Stability	Output can change asynchronously with the input.	Output is more stable, as it only changes when entering a new state.

125. (b)

- In a superheterodyne receiver, RF amplifiers uses single tuned amplifiers to achieve more selectivity.
- When 'N' identical single tunned amplifier are cascaded then overall $BW = BW_1\sqrt{2^{1/N} - 1}$.
- When 'N' identical double tunned amplifier are cascaded then overall BW is given as $BW = BW_1\sqrt[4]{(2^{1/N} - 1)}$.

126. (d)

Oscillator is an electronic circuit which generates AC waveform without using AC input.



127. (d)

There are four possible combinations for Voltage and Current with which we can sample at the output and mix the feedback to the input.

We know that,

Input	Output
⇓	⇓
Mixing	Sampling
⇓	⇓
• Voltage mixing (Series mixing)	• Voltage sampling (Shunt sampling)
• Current mixing (Shunt mixing)	• Current sampling (Series sampling)

Now, let see each column one by one,

P.	Shunt	Series feedback	
	⇓	⇓	
	Input	Output	.....(1)
	⇓	⇓	
	Current mixing	Current sampling	
Q.	Voltage	Series feedback	
	⇓	⇓	
	Output	Input	.....(3)
	⇓	⇓	
	Voltage sampling	Voltage mixing	

R. Current ⇓ Output ⇓ Current sampling; Series feedback ⇓ Input ⇓ Voltage mixing .....(4)

S. Shunt ⇓ Output ⇓ Voltage sampling; Sampling and shunt mixing ⇓ Input ⇓ Current mixing .....(2)

128. (b)

Initialization:

(8000 H) = 04 H

MOV B, M: (B) = 04 H

MOV C, M: (C) = 04 H

MVI A, 00H: (A) = 00 H

LOOP: (A) = (A) + (B) + (B) + (B) + (B)

= 00 H + 04 H + 04 H + 04 H + 04 H = 10 H

∵ ADD B instruction will be executed for 4 times.

129. (b)

RS1 (PSW.4)	RS0 (PSW.3)	Register Bank
0	0	0 (00H – 07H)
0	1	1 (08H – 0FH)
1	0	2 (10H – 17H)
1	1	3 (18H – 1FH)

130. (c)

Given that,

$$D = 5\text{ cm} = 5 \times 10^{-2}\text{ m}$$
$$l = 4\text{ cm} = 4 \times 10^{-2}\text{ m}$$
$$d = 2\text{ cm} = 2 \times 10^{-2}\text{ m}$$
$$V_a = 5000\text{ V}$$
$$L = 50\text{ cm} = 50 \times 10^{-2}\text{ m}$$

The deflection on the screen is given by

$$D = \frac{V_d \times L \times l}{2V_a \times d}$$

$$\Rightarrow \quad V_d = \frac{D \times 2V_a \times d}{L \cdot l}$$

$$= \frac{5\times10^{-2}\times2\times5000\times2\times10^{-2}}{50\times10^{-2}\times4\times10^{-2}} = 500\text{ V}$$

131. (b)

$$\text{Sensitivity of LVDT, } S_{LVDT} = \frac{\text{Output voltage}}{\text{Displacement}} = \frac{5\times10^{-3}}{0.1} = 50\times10^{-3} \text{ V/mm}$$

$$\text{Sensitivity of instrument, } S_{instrument} = \text{Amplification factor} \times S_{LVDT}$$
$$= 100 \times 50 \times 10^{-3} = 5 \text{ V/mm}$$

$$\text{1 scale division} = \frac{10 \text{ V}}{100} = 0.1 \text{ V}$$

Minimum voltage that can be read on the voltmeter

$$= \frac{1}{10}\times 0.1 \text{ V} = 0.01 \text{ V}$$

$$\therefore \quad \text{Resolution} = \frac{0.01 \text{ V}}{5 \text{ V/mm}} = 0.002 \text{ mm}$$

132. (d)

Given

$$\vec{E}(z,t) = 3\sin(\omega t - kz + 30°)\hat{a}_y - 4\cos(\omega t - kz + 45°)\hat{a}_x \text{ V/m}$$

We have,

$$E_x = 4 \sin(\omega t - kz - 45°)$$
$$E_y = 3 \sin(\omega t - kz + 30°)$$
$$\therefore \quad \Delta\phi = \phi_y - \phi_x = 75°$$

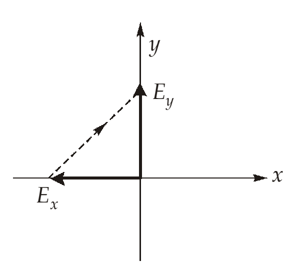
Therefore, $\Delta\phi \neq 180°$, and the amplitudes are unequal, hence the wave is elliptically polarized.

At a fixed point say $z = 0$,

$$\omega t = 0$$

$$\therefore \quad E_x = -2\sqrt{2}; \; E_y = \frac{3}{2}$$

So, initially the field vector moves from $(-x, +y)$ towards $(+x, +y)$

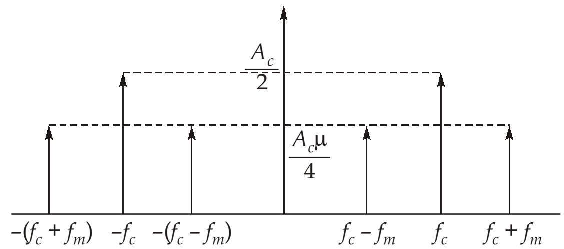


∴ Counter-clockwise rotation (viewed in direction of propagation)

∴ It is left-hand elliptical polarization.

133. (a)

Spectrum of standard AM signal is shown below:



Now on comparison we get

$$\frac{A_c}{2} = 10$$

$$A_c = 20 \text{ volt}$$

$$\frac{A_c\mu}{4} = 4$$

$$20\,\mu = 16$$

$$\mu = 0.8$$

And for $\mu < 1$, we prefer envelope detector. Hence, option (a) is correct.

134. (a)

Length of IP address is 4 bytes in IPv4 and 16 bytes (256 bits) in IPv6.

	Class A	Class B	Class C	Class D	Class E
1. Range of first order	0-127	128-191	192-223	224-239	240-255
2. First octet start with bit	0	10	110	1110	1111
3. Number of possible networks	2^7-2	2^{14}-2	2^{21}-2	–	–
4. Number of possible hosts per network	$2^{24}-2$ = 16777214 hosts	$2^{16}-2$ = 65534 hosts	2^8-2 = 254 hosts	–	–
5. Network mask	8 bits	16 bits	24 bits	–	–

- Class D addresses are multicast address.
- Class E address are reserved for experimental purposes.

∴ Statement 2 and 4 are incorrect. Hence, option (a) is correct.

135. (c)

$$\vec{E}(x,t) = 100\cos(\omega t - 5x)\hat{a}_y \text{ V/m}$$

Comparing with,

$$\vec{E} = E_0\cos(\omega t - \beta x)$$

⇒

$$E_0 = 100$$

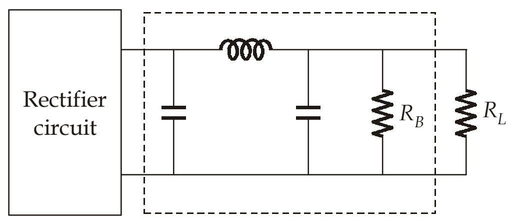
Average power, $P = \frac{1}{2}\frac{E_0^2}{\eta}\times \text{Area}$

$$= \frac{1}{2}\frac{(100)^2}{120\pi}\times\pi\times(10)^2 = \frac{12500}{3} = 4.17 \text{ kW}$$

136. (d)

Purpose of bleeder resistance:

The operation of a filter using an inductor is based on the fact that a minimum current flows through it at all times. The bleeder resistance is used to maintain a certain minimum current through the choke (inductor) even if no load.



$R_B \geq 10R_L$

- The value of bleeder resistance (R_B) should be such that to draw only 10% of total load current.
- Bleeder resistance can be used as voltage divider for tapping out any desired output.
- Single power supply can be used to provide more voltage.
- It provides better voltage regulation.
- It provides safety to operator by providing discharge path to the capacitor.

137. (a)

We know, $P = WQH\eta \times 9.81$ Watt

where P = specific weight of water in kg/m^3; Q = rate of flow of water (m^3/sec); H = height of water fall in meter (head); η = overall efficiency of operation

$P = 1000 \times 50 \times 300 \times 0.70 \times 9.81$

$P = 103.005$ MW

$P \approx 103$ MW

Hence, option (a) is correct.

138. (d)

Bourdon gauges are mechanical devices utilising the mechanical deformation of a flattened but bent tube that winds or unwinds depending on the pressure difference between the inside and the outside.

139. (b)

We know, the output of differential amplifier is,

$$V_0 = A_d V_d + A_{cm} V_{cm}$$

where, $V_d = V_1 - V_2 = (25 - 20)\text{ mV} = 5\text{ mV}$

$$V_{cm} = \frac{V_1 + V_2}{2} = \left(\frac{25+20}{2}\right)\text{mV} = 22.5\text{ mV}$$

$$\text{CMRR} = \frac{A_d}{A_{cm}} \Rightarrow 1000 = \frac{A_d}{2} \Rightarrow A_d = 2000$$

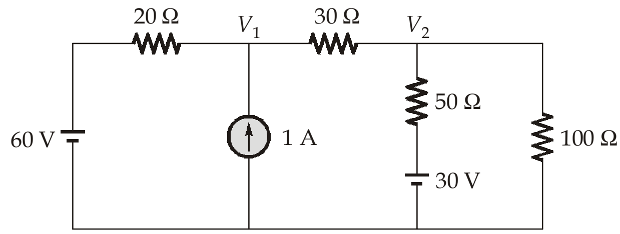
$\therefore$ $V_0 = (2000 \times 5 \times 10^{-3}) + (2 \times 22.5 \times 10^{-3})$

$$V_0 = 10 + (45 \times 10^{-3})$$

$$V_0 = 10.045\text{ V}$$

140. (c)

Given circuit is



Applying KCL at node 1,

$$\frac{V_1-60}{20}+\frac{V_1-V_2}{30} = 1$$

$$\Rightarrow \quad \frac{3V_1-180+2V_1-2V_2}{60} = 1$$

$$\Rightarrow \quad 5V_1 - 2V_2 = 60 + 180$$

$$\Rightarrow \quad 5V_1 - 2V_2 = 240 \qquad \text{...(i)}$$

$$\frac{V_2-V_1}{30}+\frac{V_2-30}{50}+\frac{V_2}{100} = 0$$

$$\Rightarrow \quad \frac{10V_2-10V_1+6V_2-180+3V_2}{300} = 0$$

$$\Rightarrow \quad -10V_1 + 19V_2 = 180 \qquad \text{...(ii)}$$

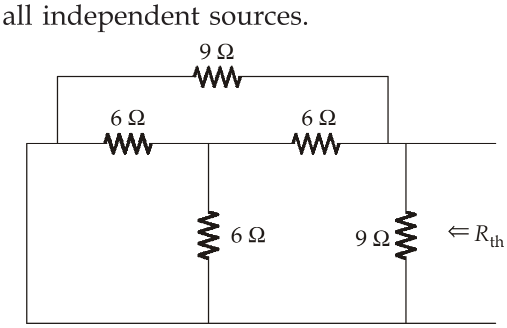
Solving equation (i) and (ii), $V_1 = 54.6$ V

$V_2 = 44$ V

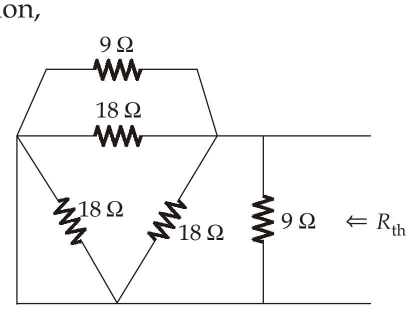
$$I_{100\,\Omega} = \frac{V_2}{100}=\frac{44}{100}=\frac{1.84}{5}=0.44 \text{ A}$$

141. (b)

To calculate R_{th}, deactivate all independent sources.



Using star to delta transformation,



$$R_{th} = 9 \parallel [(9 \parallel 18) \parallel 18] = 9 \parallel \frac{9}{2} = \frac{9 \times \frac{9}{2}}{9 + \frac{9}{2}} = \frac{9 \times 9}{27} = 3\ \Omega$$

For maximum power transfer, $R_L = R_{th} = 3\ \Omega$

142. (b)

$$V(t) = 10 \sin \omega t \text{ V}$$
$$\text{B.W} = 400 \text{ rad/s}$$
$$V_{rms} = \frac{10}{\sqrt{2}} = 7.07 \text{ V}$$
$$\text{B.W} = \frac{R}{L}$$
$$400 = \frac{100}{L}$$
$$L = 0.25 \text{ H}$$
$$Q_0 = \frac{V_c}{V} = \frac{500}{7.07} = 70.72$$

We have,
$$Q_0 = \frac{1}{R}\sqrt{\frac{L}{C}}$$
$$70.72 = \frac{1}{100}\sqrt{\frac{0.25}{C}}$$
$$(70.72 \times 100)^2 = \frac{0.25}{C}$$
$$C = \frac{0.25}{(7072)^2} = 4.99 \times 10^{-9} \text{ F}$$

143. (d)

Given data,
$$\text{Power factor} = 0.6 \text{ (lag)}$$
$$\cos\theta = 0.6$$
$$\theta = \cos^{-1}(0.6) = 53.13°$$

According to given circuit,
$$Z_{eq} = \frac{R_2(1+2j)}{R_2 + 1 + j2}$$
$$\angle\theta = \tan^{-1} 2 - \tan^{-1}\frac{2}{R_2+1}$$
$$\angle 53.13° = \tan^{-1}\frac{2 - \frac{2}{R_2+1}}{1 + \frac{4}{R_2+1}}$$
$$\tan(53.13°) = \frac{2R_2 + 2 - 2}{R_2 + 5}$$

$$\frac{4}{3}(R_2+5) = 2R_2$$
$$4R_2 + 20 = 6R_2$$
$$2R_2 = 20$$
$$R_2 = 10\ \Omega$$

144. (b)

We have, $i = 3, j = 2, D = 4$ km

We know that,

$$\text{cluster size, } N = i^2 + j^2 + ij$$
$$N = 3^2 + 2^2 + (2 \times 3)$$
$$N = 19$$

We have relation $\frac{D}{R} = \sqrt{3N}$ or $\frac{D}{d} = \sqrt{N}$

where, R = radius of cell

and d = Distance between centres of adjacent cells ($d = \sqrt{3}R$)

We can use any of the one relation,

We take

Method (I): $\frac{D}{d} = \sqrt{N}$

$$\frac{4}{\sqrt{19}} = d$$
$$d = 0.92 \text{ km}$$

Method (II): $\frac{D}{R} = \sqrt{3N}$

$$\frac{D}{\sqrt{57}} = R$$
$$R = 0.53 \text{ km}$$
$$d = \sqrt{3}R$$
$$d = 0.92 \text{ km}$$

Hence, option (b) is correct.

145. (c)

$$\text{Loss tangent, } \frac{\sigma}{\omega\varepsilon} = \left(\frac{10}{2\pi\times 10\times 10^3\times 80\times 8.854\times 10^{-12}}\right) >> 1$$

Since $\frac{\sigma}{\omega\varepsilon} \gg 1$, hence sea water is acting as a good conductor.

The amplitude of the radio signal attenuates as

$$E_t = E_0 e^{-\alpha x}$$

Since attenuation is 80%, the amplitude at say distance 'x' is 20% i.e. $0.2E_0$.

i.e., $e^{-\alpha x} = 0.8$

where, α = attenuation constant = $\sqrt{\dfrac{\omega\mu\sigma}{2}}$

$\Rightarrow$ $$\alpha = \sqrt{\frac{2\pi\times(10\times10^3)\times4\pi\times10^{-7}\times10}{2}} = \sqrt{\frac{8\pi^2\times10^{-2}}{2}}$$

$\Rightarrow$ $\alpha = 2\pi \times 0.1 = 0.2\pi\ \text{m}^{-1}$

We have, $e^{-\alpha x} = 0.2$

$\Rightarrow$ $-\alpha x = \ln(0.2)$

$$x = \frac{-\ln(0.2)}{\alpha} = \frac{-\ln(0.2)}{0.2\pi}\text{m}$$

146. (b)

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

1. $\vec{\nabla}\times\vec{E} = -\dfrac{\partial\vec{B}}{\partial t}$
2. $\vec{\nabla}\times\vec{H} = \vec{J} + \dfrac{\partial\vec{D}}{\partial t} \Rightarrow \oint\vec{H}.\vec{dl} = \int\left(\sigma\vec{E}+\in\dfrac{\partial\vec{E}}{\partial t}\right)\cdot\vec{ds}$
3. $\vec{\nabla}\cdot\vec{D} = \rho_v$
4. $\vec{\nabla}\cdot\vec{B} = 0$

Hence, expressions 2 and 3 are correct.

147. (d)

A	B	C	(P) Sum/Difference	(Q) Carry	(R) Borrow
0	0	0	0	0	0
0	0	1	1	0	1
0	1	0	1	0	1
0	1	1	0	1	1
1	0	0	1	0	0
1	0	1	0	1	0
1	1	0	0	1	0
1	1	1	1	1	1

Sum = $\Sigma m(1, 2, 4, 7)$

Carry = $\Sigma m(3, 5, 6, 7)$

Borrow = $\Sigma m(1, 2, 3, 7)$

Hence, the ROM can be used as a Full Adder with P as the Sum and Q as the Carry. Also, the ROM can be used as a subtractor with P as the Difference and R as the Borrow.

148. (c)

Measurement of pressure can be done by using wire, foil or semiconductor type strain gauges. The semiconductor strain gauge has high temperature sensitivity because the resistivity of the semiconductor depend on the intrinsic carrier concentration (η_i) which is highly sensitivity to temperature.

149. (a)

Fast Fourier transform (FFT) algorithm reduces the computational complexity of discrete Fourier transform (DFT) from $O(N^2)$ to $O(N\log_2 N)$. Thus, both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).

150. (a)

The input impedance of a short circuited lossless line is given by

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

Since, $\lambda = \frac{c}{f}$, at a particular frequency, have $l = \lambda/4$. For $l = \lambda/4$

$Z_{in} = \infty$ i.e. the line behaves as a parallel resonant circuit.

❍❍❍❍