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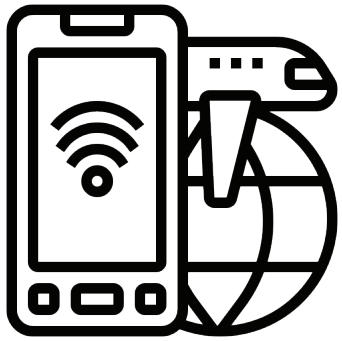
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ANALOG AND DIGITAL COMMUNICATION SYSTEMS

SECTION 1

SYLLABUS

Random signals, noise, probability theory, information theory; Analog versus digital communication & applications: Systems- AM, FM, transmitters/receivers, theory/practice/standards, SNR comparison; Digital communication basics: Sampling, quantizing, coding, PCM, DPCM, multiplexing-audio/video; Digital modulation: ASK, FSK, PSK; Multiple access: TDMA, FDMA, CDMA; Optical communication: fibre optics, theory, practice/standards.



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NUMBER OF QUESTIONS ASKED IN ESE ELECTRONICS ENGINEERING VOLUME-II (2001 TO 2025)

Analog and Digital Communication Systems		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1.1	Analog Communication Systems	8	4	8	4	3	6	5	2	3	4	3	4	5	9	10	6	4	3	4	4	2	4	10	5	5
1.2	Random Variables, Random Process and Noise	1	5	4	1	2	2	2	6	-	2	-	3	1	5	3	3	5	1	2	3	2	2	-	3	-
1.3	Digital Communication Systems	3	3	3	6	8	6	4	4	5	8	6	1	5	5	5	8	5	4	3	7	7	3	4	3	3
1.4	Information Theory	2	-	1	1	3	3	2	5	-	1	2	2	5	-	1	-	1	-	2	-	1	2	-	2	2

CHAPTER-1 ANALOG & DIGITAL COMMUNICATION SYSTEMS

Unit 1.1: Analog Communication Systems

Previous Year Exam Questions

[ESE-2001]

1. For an AM wave, the maximum voltage was found to be 10 V and the minimum voltage was found to be 5 V. The modulation index of the wave would be

(a) 0.33 (b) 0.52
(c) 0.40 (d) 0.1

[ESE-2001]

2. A signal $x(t) = 6\cos 10\pi t$ is sampled at the rate of 14 Hz. To recover the original signal, the cut-off frequency f_c of the ideal low-pass filter should be

(a) $5\text{ Hz} < f_c < 9\text{ Hz}$ (b) 9 Hz
(c) 10 Hz (d) 14 Hz

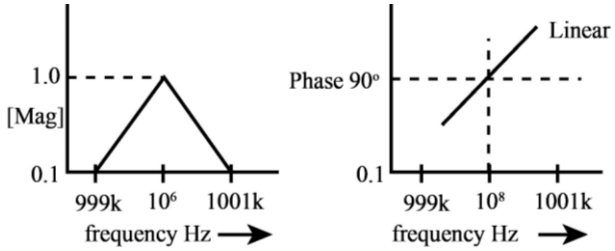
[ESE-2001]

3. The ratio $\frac{(S/N)_{WBFM}}{(S/N)_{AM}}$ for 100% amplitude modulation with identical total transmitted power (m_f is modulation index of FM) is

(a) $9/2m_f^2$ (b) $3/2m_f^2$
(c) $3/2m_f^3$ (d) $9/2m_f^3$

[ESE-2001]

4. A carrier of frequency 1 MHz is amplitude modulated by a signal of frequency of 1 kHz to a depth of 60%. This is passed through a filter of characteristics shown in the given Figure-I and Figure-II. If the filter output is fed to an envelope detector, the detector output will be



(a) zero (b) dc
(c) dc +1 kHz signal (d) 1 kHz signal

[ESE-2001]

5. If the radiated power of AM transmitter is 10 kW, the power in the carrier for modulation index of 0.6 is nearly

(a) 8.24 kW (b) 8.47 kW
(c) 9.26 kW (d) 9.6 kW

[ESE-2001]

6. In a low-level AM system, the amplifier which follows the modulated stage must be the

(a) linear device (b) harmonic device
(c) class-C amplifier (d) non-linear device

[ESE-2001]

7. An angle-modulated signal is expressed by $f_a(t) = \cos(2 \times 10^8 \pi t + 75\sin 2 \times 10^3 \pi t)$.
The peak frequency deviation of the carrier is then

(a) 1 kHz (b) 7.5 kHz
(c) 75 kHz (d) 100 MHz

[ESE-2001]

8. MCVF telegraphy uses

(a) SSB techniques (b) Pulse modulation
(c) out-of-band signalling (d) FM

[ESE-2002]

9. Which of the following are the advantages of FM over AM?

1. Better noise immunity is provided
2. Lower bandwidth is required
3. The transmitted power is more useful
4. Less modulating power is required

Select the correct answer using the codes given below:

(a) 1, 2 and 3 (b) 2, 3 and 4
(c) 2 and 4 (d) 1, 3 and 4

[ESE-2002]

10. Assertion (A): The demodulated output power spectral density is parabolic over the range $|f| < w$ for FM where w is the signal bandwidth.
Reason (R): FM demodulation is essentially a differentiation process.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2002]

11. Assertion (A): If the index of modulation (m_f) of an FM signal gradually increases beyond 0.25, it will contribute to the generation of a progressively larger number of side bands separated by the modulation frequency (f_m).

Reason (R): A large modulation index will generate a finite number of side bands.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2002]

12. Assertion (A): SSB transmission is not appropriate for rectangular pulse transmission.
Reason (R): Whenever SSB modulating signal has abrupt transitions, the resulting envelope $A(t)$ gives rise to envelope horns.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2003]

13. Consider the following statements:
1. Intermediate-frequency (IF) amplifier is designed for a bandwidth of a few kHz at a centre frequency of a few hundred kHz for voice-modulated signals.
2. IF amplifier is designed for a frequency of 6 MHz at a centre frequency of 40 MHz for TV receivers.
3. Tuned amplifiers are used for IF amplifier.

Which of these statements is/are correct?

(a) 1 only (b) 3 only
(c) 2 and 3 (d) 1, 2 and 3

[ESE-2003]

14. Consider the following:
1. Filter system
2. Phase-shift method
3. Third method
4. Balanced modulator

Which of these can be used to remove unwanted side-bands in SSB?

(a) 1, 2 and 4 (b) 1, 2 and 3
(c) 2, 3 and 4 (d) 1, 3 and 4

[ESE-2003]

15. In a modulator it is found that the amplitude spectrum consists of a component at $f_{c'}$ the carrier frequency and one component each at $f_c - f_s$ and $f_c + f_s$, where f_s is the modulating signal frequency. Then the modulator used is

(a) AM
(b) AM and/or Narrow band FM with depth ≤ 0.5
(c) FM
(d) PAM

[ESE-2003]

16. The modulation index of an AM wave is changed from 0 to 1. The transmitted power is

(a) Unchanged (b) Halved
(c) Increased by 50% (d) Quadrupled

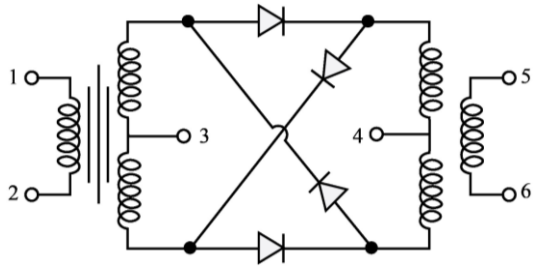
[ESE-2003]

17. In an SSB transmitter one is most likely to find

(a) Class-C audio amplifier
(b) Tuned modulator
(c) Class-B RF amplifier
(d) Class-AB power amplifier

[ESE-2003]

18. In the circuit shown below, the transformers are centre tapped and the diodes are connected as shown in a bridge. Between the terminals 1 and 2 an A.C voltage source of frequency 400 Hz is connected. Another A.C voltage of 1.0 MHz is connected between 3 and 4. The output between 5 and 6 contains components at



(a) 400 Hz, 1.0 MHz, 1000.4 kHz, 999.6 kHz
(b) 400 Hz, 1000.0 kHz, 999.6 kHz
(c) 1 MHz, 1000.4 kHz, 999.6 kHz
(d) 1000.4 kHz, 999.6 kHz

[ESE-2003]

19. A public broadcast system using amplitude modulation with double sideband should invariably have which one of the following features at the transmitter?

(a) Band limit the signal to 5 kHz
(b) Use a high frequency carrier oscillator
(c) use a stable crystal oscillator
(d) Use an all-round radiating transmitting antenna

[ESE-2003]

20. Assertion (A): Narrow band FM signal can be detected using an envelope detector.
Reason (R): Narrow band FM signal contains a carrier component and two sideband components.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2004]

21. Which one of the following is represented by $V(t) = 5[\cos(10^6\pi t) - \sin(10^3\pi t) \times \sin(10^6\pi t)]$?

(a) SSB under sideband signal

(b) DSB suppressed carrier signal

(c) AM signal

(d) Narrow band FM signal

[ESE-2004]

22. Which one of the following statements is correct? In a ratio detector,

(a) linearity is worse than that of a phase discriminator

(b) stabilization is provided against signal strength variations

(c) the output is twice of that obtainable from a similar phase discriminator

(d) the circuit is same as that in a discriminator, except that the diode connections are reversed

[ESE-2004]

23. In a broadcast transmitter, the RF output is represented as $e(t) = 50[1 + 0.89\cos 5000t + 0.30\sin 9000t]\cos(6 \times 10^{10}t)$ volt.

What are the sidebands of the signals in radians?

(a) 5×10^3 and 9×10^3

(b) 5.991×10^6, 5.995×10^6, 6.005×10^6 and 6.009×10^6

(c) $4 \times 10^3, 1.4 \times 10^4$

(d) 1×10^6, 1.1×10^7, 3×10^6 and 1.5×10^7

[ESE-2004]

24. Assertion (A): AM stereo broadcasting uses quadrature carrier multiplexing (QAM).

Reason (R): QAM involves more stringent synchronization than an FDM system.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE-2005]

25. A composite signal $x_c(t)$ is expressed as:

$$x_c(t) = A_c\cos\omega_c t - A_m\cos(\omega_c - \omega_m)t + A_m\cos(\omega_c + \omega_m)t$$

Which of the following methods can be employed to retrieve the sinusoidal component at ω_m from $x_c(t)$?

(a) An envelope detector, square law detector

(b) Only a discriminator

(c) Only a square law detector

(d) Only an envelope detector

[ESE-2005]

26. A circuit produces an output $y(t) = a + bx(t)^2$ where $x(t)$ is its input. This circuit can produce which one of the following?

(a) Rectified output

(b) Pulse modulation

(c) Amplitude modulation

(d) Frequency modulation

[ESE-2005]

27. Assertion (A): The microprocessor based products used by the general consumer must comply FCC rules.

Reason (R): FCC regulates the use of radio leansmission.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE-2006]

28. Match List-I (Communication Service) with List-II (Bandwidth) and select the correct answer using the code given below the lists:

List-I	List-II
A. AM Broadcast	1. 10 kHz
B. Telephone	2. 4 kHz
C. Wideband FM	3. 200 kHz
D. TV	4. 7 MHz

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	3	4	1	2
(c)	1	4	3	2
(d)	3	2	1	4

[ESE-2006]

29. Assertion (A): The capture range of a PLL is always less than or equal to the lock range and is related to the cut-off frequency of the low-pass filter in the loop.

Reason (R): The capture range is range of frequencies, the VCO can produce.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE-2006]

30. Match List-I (Modulation) with List-II (Power Input to Antenna in Watts) and select the correct answer using the code given below the lists:

List-I	List-II
A. 100% AM	1. 1.5
B. 50% AM	2. 1.125
C. 10% AM	3. 1.005
D. FM	4. 1.00

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	3	4	1	2
(c)	1	4	3	2
(d)	3	2	1	4

[ESE-2006]

31. Which one of the following blocks is not common in both AM and FM receivers?

(a) RF amplifier (b) Mixer
(c) IF amplifier (d) Slope detector

[ESE-2006]

32. A signal contains components at 400 Hz and 2400 Hz. This signal modulates a carrier of frequency 100 MHz. However, after demodulation it is found that the 400 Hz signal component is present. The channel BW is 15 kHz. What is the reason for the higher frequency signal not to be detected properly?

(a) Modulation used is FM and BW is insufficient
(b) Modulation used is AM and BW is insufficient
(c) Modulation used is FM but pre-emphasis is not used
(d) Modulation used is AM but detector is for FM

[ESE-2006]

33. In FDM systems used for telephone, which modulation scheme is adopted?

(a) AM (b) DSB-SC
(c) SSB-SC (d) FM

[ESE-2007]

34. FM broadcast standards specify a maximum deviation of frequency to be equal to 75 kHz and a maximum modulating frequency of 15 kHz. What is the modulation index for FM wave?

(a) $1/5$ (b) 5
(c) 60 (d) 1125

[ESE-2007]

35. Why does an FM radio station perform better than an AM station radiating the same total power?

(a) FM is immune to noise
(b) AM has only two sidebands while FM has more
(c) FM uses larger bandwidth for large modulation depth
(d) Capture effect appears in FM

[ESE-2007]

36. On modulating a carrier of frequency f_c by an audio signal f_s, the following components have resulted:

$$f_c, f_c + f_s \text{ and } f_c - f_s$$

What is this type of modulation likely to be?

(a) Amplitude modulation DSB
(b) Single sideband modulation
(c) Frequency modulation only
(d) Amplitude modulation or frequency modulation

[ESE-2007]

37. A carrier signal at frequency 100 MHz is frequency modulated with modulation index 2 by a signal at 2 kHz. At what frequencies are the sidebands produced?

(a) 102 MHz and 98 MHz
(b) $100\ \text{MHz} + 2\ \text{kHz}$, and $100\ \text{MHz} - 2\ \text{kHz}$
(c) $100\ \text{MHz} \pm \Delta f_d$, where f_d is frequency deviation
(d) $100\ \text{MHz} \pm n2\ \text{kHz}$, where n is $1, 2, \ldots, 5$ integer

[ESE-2007]

38. The modulation index of an AM is changed from 0 to 1. How does the transmitted power change?

(a) Gets halved
(b) Gets doubled
(c) Gets increased by 50 percent
(d) Remains unchanged

[ESE-2008]

39. Which one of the following is an indirect way of generating FM?

(a) Reactance FET modulator
(b) Varactor diode modulator
(c) Armstrong modulator
(d) Reactance tube modulator

[ESE-2008]

40. Match List-I (Section) with List-II and select the correct answer using the code given below the lists:

List-I	List-II
A. IF amplifier	1. Demodulator
B. Mixer	2. Narrow band tuned amplifier
C. Detector	3. Variable gain amplifier
D. Automatic gain control	4. Frequency conversion

	A	B	C	D
(a)	1	4	2	3
(b)	2	3	1	4
(c)	1	3	2	4
(d)	2	4	1	3

[ESE-2009]

41. A balanced modulator, is used in the generation of which of the following?

(a) DSB-SC signal (b) FM signal
(c) PM signal (d) PAM signal

[ESE-2009]

42. An amplitude modulated signal occupies a frequency range from 395 kHz to 405 kHz. It can be demodulated by which of the following?

(a) Using an envelope detector and filter
(b) Multiplying with a 395 kHz local signal
(c) Multiplying with a 405 kHz local signal
(d) Low pass filtering with cut off at 400 kHz

[ESE-2009]

43. Which one of the following statements is correct?

(a) AGC in radio receivers will keep the total signal output fairly constant but the noise component will be reduced; with the result the S/N ratio will improve.
(b) AGC in radio receivers is a linear operation with respect to both signals and noise
(c) Sudden changes in the output while tuning, which may cause damage to the components, is an avoidable feature of AGC
(d) AGC operation is independent of the filter components used in AGC circuit

[ESE-2010]

44. Consider the following statements with regard to a PLL

1. The 'capture range' of PLL primarily depends upon the slope of transition band edge of the low-pass filter.
2. The 'lock range' is not affected by the slope of transition band of the low-pass filter.

Which of these statements is/are correct?

(a) Both 1 and 2 (b) 1 only
(c) 2 only (d) Neither 1 nor 2

[ESE-2010]

45. Consider the following statements:

1. The lock range of PLL is the difference between the highest and lowest frequencies that the PLL can remain in lock onto.
2. The capture range of a PLL is the range of frequencies that the voltage controlled oscillator of a PLL can produce.
3. PLL can be used to synchronize the horizontal and vertical oscillators of TV receivers to incoming sync pulses.

Which of these statements is/are correct?

(a) 1 only (b) 3 only
(c) 1 and 3 only (d) 1, 2 and 3

[ESE-2010]

46. Assertion (A): Frequency modulation and phase modulation both produce different set of frequency bands for the same modulation depth.
Reason (R): Frequency modulation and phase modulation vary the carrier phase angle or its rate.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2010]

47. Assertion (A): In amplitude modulation systems the value of modulation index should be around 1.
Reason (R): The power carried in the intelligence carrying sidebands increases with the modulation index.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2011]

48. In a PLL

(a) Capture range = Lock range ≠ Free running frequency
(b) Capture range = Lock range = Free running frequency
(c) Capture range > Lock range
(d) Capture range < Lock range

[ESE-2011]

49. What bandwidth is needed for an FM signal that has a peak deviation of $\pm 3\ kHz$ and handles audio signals from 200 Hz to 5 kHz?

(a) 6 kHz (b) 16 kHz
(c) 10 kHz (d) 9.6 kHz

[ESE-2011]

50. In a super heterodyne receiver arrange the following components sequentially from input to the output

1. Antenna
2. Mixer
3. IF amplifier
4. Audio amplifier

Codes:

(a) 1, 2, 3 and 4 (b) 4, 2, 3 and 1
(c) 1, 3, 2 and 4 (d) 4, 3, 2 and 1

[ESE-2012]

51. Statement (I): FM spectrum consists of a carrier and an infinite number of side band components.
Statement (II): FM signals are used only in TV transmission to ensure better picture quality.
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

[ESE-2012]

52. The threshold effect in demodulators is
(a) the rapid fall of output SNR when the input SNR falls below a particular value
(b) exhibited by all the demodulators when the input SNR is low
(c) exhibited by all AM suppressed carrier coherent demodulators
(d) exhibited by correlation receivers

[ESE-2012]

53. An amplitude modulated signal is $[A + 0.5A\cos\omega_m t]\cos\omega_c t$ where ω_m and ω_c are respectively, modulating and carrier frequencies. The power efficiency is
(a) 11.11% (b) 0.25%
(c) 4.32% (d) 50%

[ESE-2012]

54. The signal $x(t) = \sin(200\pi t) + 2\sin(400\pi t)$ is modulated to produce a signal
$$g(t) = x(t)\sin(400\pi t)$$
This is passed through a low pass filter having a cut-off frequency of 400π Hz and passband gain of 2. Then the output signal after the filter is
(a) 0 (b) $0.5\sin(200\pi t)$
(c) $\sin(200\pi t)$ (d) $2\sin(200\pi t)$

[ESE-2013]

55. What is the ratio of modulating power to the total power at 100% AM modulation?
(a) $1:3$ (b) $1:2$
(c) $2:3$ (d) $1:4$

[ESE-2013]

56. A bandwidth of 10 kHz is required for AM system. If the lowest frequency component in the modulated signal is 555 kHz, carrier frequency in kHz is
(a) 525 (b) 550
(c) 560 (d) 565

[ESE-2013]

57. Determine the bandwidth occupied by a sinusoidal frequency modulated carrier for which the modulation index is 2.4.
(a) $4.8f_m$ (b) $6.8f_m$
(c) $2.4f_m$ (d) $3.8f_m$

[ESE-2013]

58. An AM signal with a carrier of 1 kW has 200 W in each side band. The percentage of modulation is
(a) 20% (b) 89.4%
(c) 49.7% (d) 40%

[ESE-2013]

59. An audio signal, $15\sin(2\pi 1500t)$ amplitude modulates $60\sin(2\pi 10^3 t)$. The modulation index will be
(a) 20% (b) 50%
(c) 25% (d) 100%

[ESE-2014]

60. One of the main functions of the RF amplifiers in a super-heterodyne receiver is to
(a) provide improved tracking
(b) permit better adjacent channel rejection
(c) increase the tuning range of the receiver
(d) improve the rejection of the image frequency

[ESE-2014]

61. An FM signal has a carrier swing of 100 kHz when modulating signal has a frequency of 8 kHz. The modulation index is
(a) 12.5 (b) 7.5
(c) 6.25 (d) 15

[ESE-2014]

62. If a 400 Watt carrier is amplitude modulated to a depth of 75 percent, what is the total power in the modulated wave?
(a) 517.5 W (b) 463.3 W
(c) 448.5 W (d) 512.5 W

[ESE-2014]

63. The signal $m(t) = \text{sinc}(2 \times 10^4 t)$ is frequency modulated with $= 10^3$ Hz/V. What is the maximum instantaneous frequency of the modulated signal when carrier frequency is 1 MHz?
(a) 0.999 MHz (b) 0.998 MHz
(c) 1.002 MHz (d) 1.001 MHz

[ESE-2014]

64. Amplitude modulation is used for broadcasting because
(a) it is more noise immune than other modulation systems.
(b) compared with other system it require less transmitting power.

(c) its use avoids receiver complexity
(d) no other modulation system can provide the necessary BW for high fidelity.

[ESE-2014]

65. In a super heterodyne receiver, if the intermediate frequency is 450 kHz, and the signal frequency is 1000 kHz, then the local oscillator frequency and image frequency respectively are
(a) 1450 kHz and 100 kHz
(b) 550 kHz and 1900 kHz
(c) 1450 kHz and 1900 kHz
(d) 550 kHz and 1450 kHz

[ESE-2014]

66. What will be the total modulation index if a wave is amplitude modulated by three sine waves with modulation indices of $25\%, 50\%$ and 75% ?
(a) $M_t = 1.5$ (b) $M_t = 0.93$
(c) $M_t = 1.22$ (d) $M_t = 1$

[ESE-2014]

67. Boosting of higher frequency at the transmitter is done by using
(a) De-emphasis (b) AGC circuit
(c) Pre-emphasis (d) Armstrong method

[ESE-2014]

68. The power contained in single sideband in amplitude modulation is
(a) $\frac{m^2P_c}{2}$ (b) $2m^2P_c$
(c) $\frac{m^2P_c}{4}$ (d) $4m^2P_c$

[ESE-2015]

69. The selectivity of tuned radio frequency (TRF) recoiver is poor because
1. Q-factor requirement of tuned circuits in RF amplifier is not fixed.
2. Q-required for upper side of short wave is 2000.
3. Q-factor is zero.

Which of the above statements are correct?
(a) 1, 2 and 3 (b) 1 and 2 only
(c) 1 and 3 only (d) 3 only

[ESE-2015]

70. For an AM signal, the bandwidth is 20 kHz and the highest frequency component present is 800 kHz. The carrier frequency used for this AM signal is
(a) 710 kHz (b) 705 kHz
(c) 700 kHz (d) 790 kHz

[ESE-2015]

71. The aerial current of an AM transmitter is 18 A when unmodulated, but increases to 20 A when modulated. The modulation index is
(a) 0.68 (b) 0.73
(c) 0.89 (d) 0.98

[ESE-2015]

72. A carrier wave is phase modulated with frequency deviation of 20 kHz by a single tone frequency of 2 kHz. If the single tone frequency is increased to 2 kHz, assuming that phase deviation remains unchanged, bandwidth of the PM signal is
(a) 20 kHz (b) 32 kHz
(c) 22 kHz (d) 44 kHz

[ESE-2015]

73. A sinusoidal audio signal is given by $e_s = 15\sin 2\pi(2000t)$. It modulates a sinusoidal carrier wave $e_c = 60\sin 2\pi(10^5 t)$. The value of amplitude modulation index must be
(a) 0.5 (b) 4
(c) 0.6 (d) 0.25

[ESE-2015]

74. A signal of maximum frequency of 2 MHz modulated by 4 GHz carrier is DSB/SC. If the resultant signal is sampled ideally as low pass signal, the minimum sampling frequency should be
(a) 4 MHz (b) 8 MHz
(c) 4.004 GHz (d) 8.008 GHz

[ESE-2015]

75. For an angle modulated signal,
$x(t) = 6\cos[2\pi \times 10^6 t + 2\sin(8000\pi t) + 4\cos(8000\pi t)]$ V.
The average power of $x(t)$ is
(a) 10 W (b) 18 W
(c) 20 W (d) 28 W

[ESE-2015]

76. A single tone 4 kHz message signal is sampled with 10 kHz and 6 kHz. Aliasing effect will be seen in the reconstructed signal when the signal is sampled with
(a) 10 kHz
(b) 6 kHz
(c) Both 10 kHz and 6 kHz
(d) Neither 10 kHz nor 6 kHz

[ESE-2015]

77. A modulated signal is given by $s(t) = e^{-at}\cos[(\omega_c + \Delta\omega)t]u(t)$.
The complex envelop of $s(t)$ is
(a) $e^{-at}e^{[j(\omega_c+\Delta\omega)t]}u(t)$ (b) $e^{-at}e^{[j\Delta\omega t]}u(t)$
(c) $e^{[j\Delta\omega t]}u(t)$ (d) $e^{[j(\omega_c+\Delta\omega)t]}u(t)$
where a, ω_c and $\Delta\omega$ are positive constants and $\omega_c \gg \Delta\omega$.

[ESE-2015]

78. Statement (I): The bandwidth of AM signal depends on the bandwidth of the modulating signal.
Statement (II): The amplitude-modulated signal contains f_c, $f_c \pm f_m$ frequency signals.
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

[ESE-2016]

79. A carrier waveform $10\cos\omega_c t$ and modulating signal $3\cos\omega_m t$ have $f_c = 100$ kHz and $f_m = 4$ kHz. Given that sensitivity of FM is 4 kHz/V and FM spectra beyond J_6 is negligible, what are the channel bandwidth requirements for AM and FM, respectively?
(a) 12 kHz and 48 kHz (b) 8 kHz and 48 kHz
(c) 12 kHz and 24 kHz (d) 8 kHz and 24 kHz

[ESE-2016]

80. When the modulating frequency is doubled, the modulation index is halved, and the modulating voltage remains constant. The modulation system is
1. Amplitude modulation
2. Phase modulation
3. Frequency modulation
Select the correct answer from the codes given below:
(a) 1 only (b) 2 only
(c) 3 only (d) 1,2 and 3

[ESE-2016]

81. What is the modulation index of an FM signal having a carrier swing of 100 kHz and modulating frequency of 8 kHz?
(a) 4.75 (b) 5.50
(c) 6.25 (d) 7.50

[ESE-2016]

82. In the process of modulation
(a) Some characteristics of a high frequency sine wave are varied in accordance with the instantaneous value of a low frequency signal
(b) Parameters of carrier wave are held constant
(c) For proper and efficient radiation, the receiving antennas should have heights comparable to half-wavelength of the signal received
(d) The signal is converted first within the range of 10 Hz to 20 Hz

[ESE-2016]

83. In communication systems, modulation is the process of
(a) Improving frequency stability of transmitter
(b) Combining signal and radio frequency waves
(c) Generating constant frequency radio waves
(d) Reducing distortion in RF waves

[ESE-2016]

84. The Vestigial Side Band (VSB) modulation is preferred in TV systems because
1. It reduces the bandwidth requirement to half
2. It avoids phase distortion at low frequencies
Which of the above statement(s) is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

[ESE-2017]

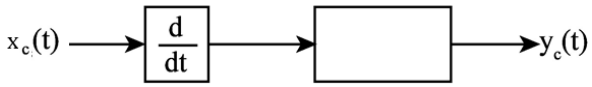
85. An FM broadcasting radio station transmits signals of frequency 100 MHz with a power of 10 kW. The bandwidth of the modulation signal is from 100 Hz to 1.5 kHz. If the maximum deviation set by the FCC, (δ), is 75 kHz, the range of the modulation index is
(a) 100 to 750 (b) 100 to 250
(c) 50 to 750 (d) 50 to 250

[ESE-2017]

86. An amplitude-modulated amplifier has a radio frequency output of 60 W at 100% modulation. The internal loss in the modulator is 6 W. What is the unmodulated carrier power?
(a) 33 W (b) 36 W
(c) 40 W (d) 44 W

[ESE-2017]

87. The figure shows the block diagram of a frequency discriminator. What does the second block represent?



(a) Envelope detector
(b) Low-pass filter
(c) Ratio detector
(d) Band-reject filter

[ESE-2017]

88. A receiver tunes signals from 550 kHz to 1600 kHz with an IF of 455 kHz. The frequency tuning range ratio for the oscillator section of the receiver is nearly
(a) 2.90 (b) 2.05
(c) 1.65 (d) 1.30

[ESE-2018]

89. The phase detector circuit in the phase-locked loop demodulators recognizes

(a) voltage changes between the input and VCO signals
(b) frequency changes between the input and VCO signals
(c) impedance changes between the input and VCO signals
(d) resistance changes between the input and VCO signals

[ESE-2018]

90. A signal $m(t) = 10\cos(2\pi 100t)$ is frequency-modulated. The resulting FM signal is $x(t) = 20\cos\left(2\pi 10^6 t + 15\sin(2\pi 100t)\right)$ The FM bandwidth is nearly
(a) 3.2 kHz (b) 9.6 kHz
(c) 32 kHz (d) 1000 kHz

[ESE-2018]

91. The minimum value of modulation index β for an FM system required to produce a noticeable improvement in SNR over a comparable AM system with $\mu = 1$ is
(a) 0.61 (b) 0.52
(c) 0.47 (d) 0.38

[ESE-2019]

92. An AM wave with modulation index 0.8 has total sideband power of 4.85 kW. The carrier power and the total power radiated will be nearly
(a) 12.2 kW and 20 kW (b) 15.2 kW and 20 kW
(c) 12.2 kW and 25 kW (d) 15.2 kW and 25 kW

[ESE-2019]

93. A 360 W carrier is simultaneously modulated by two audio waves with modulation percentages of 55 and 65 respectively. The effective modulation index and the total power radiated are
(a) 0.85 and 490.5 W (b) 0.65 and 490.5 W
(c) 0.85 and 450.5 W (d) 0.65 and 450.5 W

[ESE-2019]

94. An amplitude modulated amplifier has a radio frequency output of 50 W at 100% modulation. The internal loss in the modulator is 10 W. The unmodulated carrier power is
(a) 40 W (b) 50 W
(c) 60 W (d) 80 W

[ESE-2019]

95. For a PM modulator with a deviation sensitivity $K = 2.5\ \text{rad/V}$ and a modulating signal $V_m(t) = 2\cos(2\pi 2000t)$, the peak phase deviation m will be
(a) 1.25 rad (b) 2.5 rad
(c) 5.0 rad (d) 7.5 rad

[ESE-2020]

96. When unmodulated carrier alone is transmitted, the antenna current is 9 A. When sinusoidal modulation is present, the antenna current is 11 A. The modulation index used will be nearly
(a) 0.994 (b) 0.764
(c) 0.546 (d) 0.326

[ESE-2020]

97. Frequency modulated signal with single-tone modulation has a frequency deviation of 15 kHz and bandwidth of 50 kHz. The frequency of the modulating signal will be
(a) 05 kHz (b) 10 kHz
(c) 20 kHz (d) 30 kHz

[ESE-2020]

98. When the carrier and one of the sidebands are suppressed in an AM wave modulated to a depth of 50%, the power saving will be
(a) 84.4% (b) 88.6%
(c) 94.4% (d) 98.6%

[ESE-2020]

99. An output of balanced modulator contains
(a) Carrier, LSB and USB
(b) Modulation frequency, carrier frequency and LSB
(c) Modulation frequency, carrier frequency and USB
(d) Modulation frequency, LSB and USB

[ESE-2021]

100. The antenna current of an AM transmitter is 8 A when only the carrier signal is transmitted. What is the antenna current when the carrier signal is modulated by sinusoidal signal $V(t) = 1.4\sin(2\pi \times 500t)$ with modulation index 0.8?
(a) 3.2 A (b) 7.2 A
(c) 9.2 A (d) 11.2 A

[ESE-2021]

101. A 10 MHz carrier signal is frequency-modulated by analog-modulating signal. The maximum frequency deviation is 75 kHz. If the frequency of the modulating signal is 300 kHz, then the modulation index and the approximate transmission bandwidth of the FM signal are respectively,
(a) 0.25, 750 kHz (b) 0.25, 600 kHz
(c) 0.75, 750 kHz (d) 0.75, 450 kHz

[ESE-2022]

102. Which one of the following statements is not correct?
(a) The noise performance of a full AM receiver is always inferior to that of a DSB-SC receiver.
(b) The figure of merit of a DSB-SC receiver using coherent detection is always unity.

(c) The figure of merit of an SSB receiver using coherent detection is always unity.
(d) The figure of merit of an AM receiver using envelope detection is always greater than unity.

[ESE-2022]

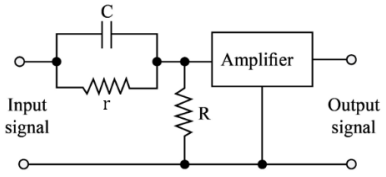
103. The RF carrier range and IF bandwidth corresponding to AM radio receiver are respectively
(a) 0.535 MHz-1.605 MHz and 100 kHz
(b) 53.5 MHz-160.5 MHz and 10 kHz
(c) 0.535 MHz-1.605 MHz and 10 kHz
(d) 53.5 MHz-160.5 MHz and 100 kHz

[ESE-2022]

104. For the same average transmitted or modulated signal power and the same average noise power in the message bandwidth, a coherent SSB receiver will have exactly the same output signal-to- noise ratio as
(a) a coherent DSB-SC receiver
(b) an AM receiver
(c) a VSB receiver
(d) an SSB receiver

[ESE-2022]

105. Identify the given circuit shown in the figure.



(a) Band-pass filter (b) De-emphasis filter
(c) Pre-emphasis filter (d) Band-reject filter

[ESE-2023]

106. The power transmitted by an SSB transmitter is 20 kW. It is required to be replaced by standard AM transmission having modulation index of 0.4 and same power. What is the transmission efficiency?
(a) 3·7% (b) 5.8%
(c) 7·4% (d) 21.6%

[ESE-2023]

107. An angle modulated signal is given as $x_c(t) = 20\cos\left[200\pi t + \frac{\pi}{4}\right]$. What is the instantaneous frequency?
(a) 50 Hz (b) 100 Hz
(c) 200 Hz (d) 400 Hz

[ESE-2023]

108. An FM modulator operates at carrier frequency of 250 kHz with frequency deviation sensitivity of 1.5 kHz/V. A PM modulator operates at carrier frequency of 500 kHz with phase deviation sensitivity of 1.5 rad/V. If both FM and PM modulators are modulated by the same modulating signal having peak amplitude of 5 V and modulating frequency of 5 kHz, then what is the relationship between frequency modulation index and phase modulation index?
(a) PM = FM (b) PM = 2FM
(c) PM = 4FM (d) PM = 5FM

[ESE-2023]

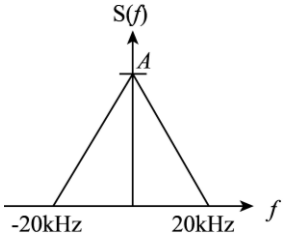
109. What is the relationship between the percentage efficiency saving when the carrier wave and one of the sidebands suppressed in an AM wave modulated to a depth of 100% modulation index?
(a) $\eta_{DSB} = 2.5\eta_{AM}$ (b) $\eta_{DSB} = 4\eta_{AM}$
(c) $\eta_{DSB} = 5\eta_{AM}$ (d) $\eta_{DSB} = 2\eta_{AM}$

[ESE-2023]

110. An FM audio signal with single-tone modulation has a frequency deviation of 25 kHz and a bandwidth of 75 kHz. What is the frequency of the modulating signal using Carson's rule?
(a) 12.5 kHz (b) 25 kHz
(c) 50 kHz (d) 75 kHz

[ESE-2023]

111. An audio signal s(t) is normalized, whose Fourier transform $S(f)$ is shown in the figure, so that $|s(t)| \leq 1$. This signal is to be transmitted using FM with a frequency deviation constant $k_f = 90\ kHz/V$. What is the bandwidth required for transmission of the FM audio signal?



(a) 140 kHz (b) 180 kHz
(c) 220 kHz (d) 260 kHz

[ESE-2023]

112. A collector modulated class-C power amplifier is giving an amplitude modulated signal of 220 W average power at the output, while operating with a collector circuit efficiency of 40%. What is the power to be supplied by the modulating amplifier when the modulation index is 0.4?
(a) 16.3 W (b) 40.75 W
(c) 203.7 W (d) 220 W

[ESE-2023]

113. By considering standard notations, the normalized power of the AM signal is
(a) $s^2(t) = \frac{1}{2}A_c^2 + \frac{1}{2}A_c^2[m^2(t)]$
(b) $s^2(t) = A_c^2 + \frac{1}{2}A_c^2[m^2(t)]$

(c) $s^2(t) = \frac{1}{2}A_c^2 + A_c^2[m^2(t)]$

(d) $s^2(t) = \frac{1}{4}A_c^2 + \frac{1}{4}A_c^2(m^2(t)]$

[ESE-2023]

114. A certain AM transmitter is radiating 125 kW when a certain audio sine wave is modulating it to a depth of 70% and 144.5 kW when a second sinusoidal audio wave also modulates it simul-taneously. What is the depth of the modulation for the second audio wave?

(a) $\sqrt{0.4}$ (b) $\sqrt{0.3}$

(c) $\sqrt{0.2}$ (d) $\sqrt{0.1}$

[ESE-2023]

115. Statement (I): A popular method for generating a VSB modulated wave is to use the frequency discrimination method.

Statement (II): One of the sidebands is partially suppressed and a vestige of the other sideband is transmitted to compensate for that suppression.

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

(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I)

(c) Statement (I) is true but Statement (II) is false

(d) Statement (I) is false but Statement (II) is true

[ESE-2024]

116. Which one of the following mid-band frequency of IF section is used in FM radio?

(a) 100.7 MHz (b) 10.7 MHz

(c) 0.455 MHz (d) 455 MHz

[ESE-2024]

117. Consider the following statements:

1. DSB-SC, SSB and VSB are examples of linear modulation.
2. DSB-SC modulation is well suited for point-to-point communication.
3. SSB-SC modulation scheme is less affected by frequency selective fading.

Which of the above statements is/are correct?

(a) 1 only (b) 2 and 3 only

(c) 1 and 3 only (d) 1, 2 and 3

[ESE-2024]

118. Which one of the following schemes is used for transmission of the video signal in commercial television broadcasting?

(a) SSB (b) DBB

(c) VSB (d) FM

[ESE-2024]

119. A carrier is frequency modulated with a sinusoidal signal of 2 KHz, resulting in a maximum frequency deviation of 5 KHz. The bandwidth of the modulated signal is

(a) 14 KHz (b) 24 KHz

(c) 10 KHz (d) 48 KHz

[ESE-2024]

120. In angle modulation, which of the following two factors limit the value of the modulation index β?

(a) Channel bandwidth and received power

(b) Pre-emphasis and de-emphasis

(c) Received noise power and signal power

(d) Pre-emphasis and received noise power

[ESE-2025]

121. An AM broadcast transmitter has a carrier power output of 50 kW. With 80% of modulation, the total power produced will be

(a) 66 kW (b) 58 kW

(c) 50 kW (d) 42 kW

[ESE-2025]

122. A transmitter operates from a 12 V supply with a collector current of 2 A. If the modulation transformer has a turns ratio of 4:1, the load impedance seen by the audio amplifier will be

(a) 78 Ω (b) 82 Ω

(c) 88 Ω (d) 96 Ω

[ESE-2025]

123. Five channels, each with a 100 kHz bandwidth, are to be multiplexed together. If there is a need for a guard band of 10 kHz between the channels to prevent interference, the minimum bandwidth of the link will be

(a) 540 kHz (b) 510 kHz

(c) 470 kHz (d) 440 kHz

[ESE-2025]

124. Which one of the following noise bandwidths is the bandwidth of that ideal bandpass system which produces the same noise power as the actual system?

(a) Equivalent noise bandwidth

(b) Linear noise bandwidth

(c) Actual noise bandwidth

(d) Generalized noise bandwidth

[ESE-2025]

125. Pulse Width Modulation (PWM) mode is commonly used in embedded system applications for

(a) controlling the speed of DC motors

(b) serial communication

(c) counting the electrical pulses

(d) recording the arrival time of either a rising or falling pulse

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

EXPLANATIONS

1. Explanation: (a)

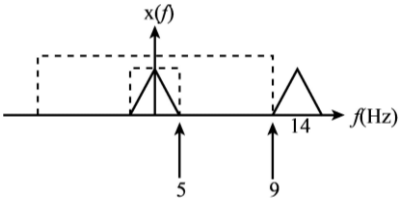
Modulation index is

$$\mu = \frac{V_{\max} - V_{\min}}{V_{\max} + V_{\min}} = \frac{10-5}{10+5} = \frac{5}{15} = 0.33$$

2. Explanation: (a)

$$f_m = \frac{10\pi}{2\pi} = 5 \text{ Hz}$$

f_c of LPF should lie between $5 < f_c < 9$ Hz



3. Explanation: (a)

Signal to Noise ratio of WBFM at 100% modulation is

$$(S/N)_{WBFM} = \frac{3}{2}\beta^2 = \frac{3}{2}m_f^2$$

Signal to Noise ratio of AM at 100% modulation is

$$\eta = 1/3$$

$$\frac{(S/N)_{WBFM}}{(S/N)_{AM}} = \frac{3}{\frac{2}{1/3}}m_f^2 = \frac{9}{2}m_f^2$$

4. Explanation: (b) When the resultant AM signal passed through the given filter, the output of the filter will be the sinusoidal carrier signal with 90° phase shift. When this resultant sinusoidal carrier signal is passed through an envelope detector, the output of the envelope detector will be a DC signal.

5. Explanation: (b)

Total power is

$$P_T = P_c\left(1 + \frac{m^2}{2}\right)$$

$$10 = P_c\left(1 + \frac{0.6^2}{2}\right)$$

$P_c = 8.47$ kW

6. Explanation: (a) In a low-level AM system, the amplifier must be linear device.

7. Explanation: (c)

$f_m = 1$ kHz, $\beta = 75$

Peak frequency deviation is

$\delta = \beta f_m = 75 \times 1 = 75$ kHz

8. Explanation: (d) The main common modulation technique used in telegraphy is Frequency Shift Keying. In telegraphy, the transmitting teletype writer produces a set of coded pulse when a given key is tapper. So, we can say, it is based on the Frequency Modulation.

9. Explanation: (d)
BW in FM is larger than that in AM.

10. Explanation: (a) An FM discriminator effectively differentiates the received phase $\theta(t)$. Differentiation multiplies the spectrum by j2πf, so the noise PSD at the demodulator output is proportional to f^2 within the message band $|f| < \omega$, i.e., parabolic. Hence both statements are true, and the reason correctly explains the assertion.

11. Explanation: (c) In FM, the spectrum has sidebands at $f_c \pm nf_m$ with amplitudes $J_n(\beta)$, as β increases beyond 0.25, **more** sidebands have non - negligible amplitude, so the assertion is true. However, there are **infinitely many** sidebands, so the reason claiming a finite number is false.

12. Explanation: (a) In SSB, the RF envelope $A(t) = \sqrt{m^2(t) + \hat{m}^2(t)}$ depends on the message $m(t)$ and its Hilbert transform $\hat{m}(t)$. For waveforms with **abrupt transitions**, $\hat{m}(t)$ exhibits large edge excursions, producing pronounced **envelope overshoots**. These horns make SSB poorly suited for rectangular pulse transmission. So both statements are true, and the reason explains the assertion.

13. Explanation: (d)

(i) TV receivers in the VHF band (54 to 223 MHz) and in the UHF band (470 to 940 MHz) use an IF between 26 and 46 MHz, with approximately 36 and 46 MHz the two most popular values.

(ii) The IF amplifier is a fixed-frequency amplifier, with the very important function of rejecting adjacent unwanted frequencies.
Whereas, FET and integrated circuit IF amplifiers generally are double - tuned at the input and at the output, BJT amplifiers often are single-tuned.

14. Explanation: (b) There are three main methods to remove unwanted sideband in SSB:

1. Filter method
2. Phase shift method
3. Third method

15. Explanation: (b) AM and NBFM both have three frequency components, carrier frequency component f_c and two sidebands at $f_c \pm f_s$.

16. Explanation: (c)
When $m = 0$, transmitted power is

$$P_{T_1} = P_c\left(1 + \frac{0}{2}\right) = P_c$$

When $m = 1$, transmitted power is

$$P_{T_2} = P_c\left(1 + \frac{1^2}{2}\right) = \frac{3P_c}{2}$$

% changed in transmitted power is

$$\%\,\Delta P_T = \frac{P_{T_2} - P_{T_1}}{P_{T_1}} \times 100$$

$$= \frac{\frac{3P_c}{2} - P_c}{P_c} \times 100 = 50\%$$

Thus, when the modulation index of AM wave is changed from 0 to 1, the transmitted power is increased by 50%.

17. Explanation: (c)
Class - B RF amplifier

18. Explanation: (d) The given circuit is Balanced Modulator. So carrier frequency will be suppressed and there will remain only two sidebands at $f_c + f_m$ and $f_c - f_m$.
Here,
$f_c = 100$ kHz
$f_m = 0.4$ kHz
So, output contains 1000.4 kHz and 999.6 kHz

19. Explanation: (a) In AM broadcasting, the transmitted signal bandwidth is **twice the maximum modulating frequency.** For broadcast standards, the **audio signal is limited to 5 kHz**, so that the transmitted bandwidth is about **10 kHz,** matching the allocated channel spacing in medium - wave and short - wave bands.

20. Explanation: (d)
A is false but R is true

21. Explanation: (d)

$$V(t) = 5[\cos(10^6\pi t) - \sin(10^3\pi t) \cdot \sin(10^6\pi t)]$$

$$V(t) = 5\cos(10^6\pi t) - \frac{5}{2}[\cos(10^6\pi t - 10^3\pi t)] + 5/2[\cos(10^6\pi t + 10^3\pi t)]$$

Hence, it is an NBFM signal.

22. Explanation: (b) Ratio detector have worse linearity than discriminators.

23. Explanation: (b)
Sidebands are $\omega_c \pm \omega_{m_1}$ and $\omega_c \pm \omega_{m_2}$
$6 \times 10^{10} \pm 5 \times 10^3$ and $6 \times 10^{10} \pm 9 \times 10^3$.
So, no answer is correct.
If $\omega_c = 6 \times 10^6$, then sidebands are
$6 \times 10^{10} \pm 5 \times 10^3$ and $6 \times 10^6 \pm 9 \times 10^3$ or $6.005 \times 10^6, 5.995 \times 10^6, 6.009 \times 10^6$ and 5.991×10^6

24. Explanation: (b)
Assertion (A): True
In AM stereo broadcasting, **quadrature carrier multiplexing** is indeed used, where left and right audio channels are combined using in - phase and quadrature carriers.
Reason (R): In QAM, the receiver must maintain **precise phase synchronization** between the local oscillator and the received carrier, since the in - phase (I) and quadrature (Q) components are separated based on carrier phase. This requires **more stringent synchronization** than conventional frequency - division multiplexing, where signals occupy distinct frequency bands and phase alignment is not critical. Hence it is **true**, and explains assertion.

25. Explanation: (b) It is an NBFM signal and can be demodulated by discriminator.

26. Explanation: (c) This is an example of nonlinear modulators to produce amplitude modulation.

27. Explanation: (d) A is false but R is true

28. Explanation: (a) $\mathrm{A}-1, \mathrm{B}-2, \mathrm{C}-3, \mathrm{D}-4$

29. Explanation: (c)

Assertion (A) is correct: the **capture range** is generally **≤ the lock/hold range**, and its value depends on loop dynamics - in particular the loop filter cutoff and damping - so it is tied to the low-pass filter in the loop.

Reason (R) is incorrect: the capture range is **not** the range of frequencies that the VCO can produce, rather it is the range of **input/reference frequencies** over which the PLL can acquire lock starting from an unlocked condition.

30. Explanation: (a)

Total power of AM is

$$\mathrm{P_t} = \mathrm{P_c}\left(1+\frac{\mathrm{m}^2}{2}\right)$$

Total Power of FM is

$$\mathrm{P_t} = \mathrm{P_c}$$

31. Explanation: (d) FM receivers contain slope detector but AM receivers don't.

32. Explanation: (c) In FM, the amplitude of higher frequency components reduces significantly. So the high frequency components are lost if not boosted before transmission. This boosting of frequency signals is called pre - emphasis.

33. Explanation: (c) In telephone **frequency - division multiplexing** systems, each voice channel (≈ 300 Hz – 3.4 kHz) is shifted to a distinct frequency slot. To conserve bandwidth and avoid redundancy, **single sideband suppressed carrier** modulation is used.

34. Explanation: (b)

Modulation index of FM is

$$\beta = \frac{\text{Maximum deviation of frequency } (\delta)}{\text{Maximum modulating frequency } (f_m)}$$

$$\beta = \frac{75}{15} = 5$$

35. Explanation: (a) FM receivers can be fitted with amplitude limiters to remove the amplitude variations caused by noise. This makes FM reception a good deal more immune to noise than AM reception.

36. Explanation: (d) The type of modulation is either amplitude modulation (DSB) or Narrow - band frequency modulation.

37. Explanation: (d)

Expression of WBFM is

$A_c\sum_{n=-\infty}^{\infty} J_n(\beta)\cos 2\pi(f_c \pm nf_m)t$

Side bands are present at $f_c \pm nf_m$

$Af_c = 100\mathrm{MHz}$ (Given)

$$f_m = 2\mathrm{kHz}$$

$100\ \mathrm{MHz} + \mathrm{n}2\ \mathrm{kHz}$, where $\mathrm{n} = 1, 2, \cdots$

38. Explanation: (c)

The total transmitted power in AM is

$$\mathrm{P_t} = \mathrm{P_c}\left(1+\frac{\mathrm{m}^2}{2}\right)$$

At $\mu = 0$

$$\mathrm{P_t} = \mathrm{P_c}$$

At $\mu = 1$

$$\mathrm{P_t} = \mathrm{P_c}\left(1+\frac{1}{2}\right) = 1.5\mathrm{P_c}$$

So the transmitted power increases by 50% when modulation index goes from 0 to 1.

39. Explanation: (c)

Armstrong modulator

40. Explanation: (d)

$\mathrm{A}-2, \mathrm{B}-4, \mathrm{C}-1, \mathrm{D}-3$

41. Explanation: (a)

Balanced modulator is used to suppress the carrier.

42. Explanation: (a) Standard AM (with carrier present) is easily demodulated with an **envelope detector**, then filtering the recovered audio.

43. Explanation: (c) Proper AGC design uses suitable time constants, limiting and filtering so that abrupt output jumps during tuning are **avoided**. Options (a), (b) and (d) are incorrect. AGC does **not** improve S/N, AGC action is nonlinear, and its behaviour depends on the AGC filter/time - constant components.

44. Explanation: (a) The LPF controls the capture range while VCO generates locking range.

45. Explanation: (c)

1 is correct - the **lock range** (hold range) is the span of input frequencies over which the PLL can **remain locked.**

2 is false - the **capture range** is the range of input/reference frequencies over which the PLL can **acquire lock** from an unlocked condition, not the range the VCO can produce.

3 is correct - PLLs are commonly used to **synchronize TV horizontal/vertical oscillators** to incoming sync pulses.

46. Explanation: (d) For a single-tone modulating signal, FM and PM produce the same type of spectrum. The only difference is how the modulation index is defined:

In FM, $\beta = \frac{\Delta \mathrm{f}}{\mathrm{f_m}}$

In PM, $\beta = \mathrm{k_p A_m}$

For a given modulation depth, the set of sidebands is same.

So Assertion is false.

The Reason is true: FM varies the rate of change of phase, while PM directly varies the carrier phase angle.

47. Explanation: (a)

$$\mathrm{P_{SB}} = \frac{\mu^2}{2}\mathrm{P_c}$$

48. Explanation: (d) The capture range is always less than or equal to the locking range.

49. Explanation: (b)

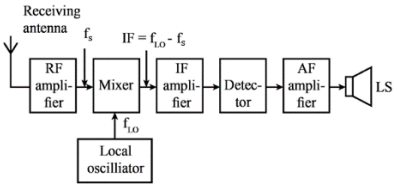
$\Delta f = 3\ \mathrm{kHz}$

$f_m = 5\ \mathrm{kHz}$

Bandwidth of FM signal is

$\text{BW} = 2(\Delta f + f_m) = 2(3+5)$
$= 16\ \text{kHz}$

50. Explanation: (a)



51. Explanation: (c) FM is used for audio transmission and VSB for video transmission.

52. Explanation: (a) The **threshold effect** is a phenomenon seen in **nonlinear demodulators**. When the **input SNR drops below a critical value**, the **output SNR falls off very rapidly,** much faster than in the high - SNR region.

53. Explanation: (a)

Amplitude modulated signal is

$x_{AM}(t)$
$= (A + 0.5A\cos\omega_m t)\cos\omega_c t$
$x_{AM}(t) = A(1 + 0.5\cos\omega_m t)\cos\omega_c t$

By comparing this equation with the standard amplitude modulated signal equation

$x_{AM}(t)$
$= A_C(1 + m_a\cos\omega_m t)\cos\omega_c t$
$m_a = 0.5$

Power efficiency

$$= \frac{\text{Total side band power}}{\text{Total transmitted power}}$$

$$\text{Power efficiency} = \frac{\frac{P_c m^2}{2}}{P_c\left(\frac{1+m^2}{2}\right)}$$

$$= \frac{m^2}{2+m^2} = \frac{(0.5)^2}{2+0.5^2} \times 100$$
$= 11.11\%$

54. Explanation: (∗)

$x(t) = \sin(200\pi t) + 2\sin(400\pi t)$
$g(t) = x(t)\sin(400\pi t)$
$g(t)$
$= [\sin(200\pi t)$
$+ 2\sin(400\pi t)]\sin(400\pi t)$

$$g(t) = \frac{1}{2}[\cos 200\pi t - \cos 600\pi t] + 1 - \cos 800\pi t$$

Now this signal is passed through LPF having cut off frequency of $400\pi\ \text{Hz} = 1256.64\ \text{Hz}$ and pass band gain of 2.

So, output signal $= 2g(t)$

None of the options is matching.

55. Explanation: (a)

Total power of AM is

$$P_T = P_c\left(1 + \frac{m^2}{2}\right)$$

Ratio of modulating power to total power is

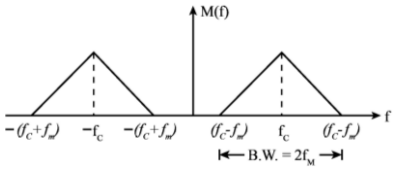
$$\frac{P_{\text{SB}}}{P_{\text{T}}} = \frac{P_c\frac{m^2}{2}}{P_c\left(1+\frac{m^2}{2}\right)} = \frac{m^2}{2+m^2}$$

At $m = 1$

$$\frac{P_{\text{SB}}}{P_{\text{T}}} = \frac{1}{2+1} = 0.33$$

56. Explanation: (c)

AM modulated signal in frequency domain is



Lowest frequency component is

$f_L = 555\ \text{kHz}$
Bandwidth $= 2f_m = 2 \times 5$
$= 10\ \text{kHz}$

Also, $f_c - f_m = 555\ \text{kHz} \Rightarrow f_c = 560\ \text{kHz}$

57. Explanation: (b)

By Carson's formula

$\text{BW} = 2(\Delta f + f_m) = 2f_m(\beta + 1)$
$\text{B.W.} = 2f_m(2.4+1) = 6.8f_m$

58. Explanation: (b)

$P_c = 1000\ \text{W}$

Power in each side band is

$$P_{\text{USB}} = P_{\text{LSB}} = \frac{P_C m^2}{4} = 200\ \text{W}$$

$$P_{\text{LSB}} = P_{\text{USB}} = \frac{P_c m^2}{4}$$

$$200 = 1000\frac{m^2}{4}$$

$$m^2 = \frac{800}{1000}$$

$m = 0.8944$
% modulation = 89.44%

59. Explanation: (c)

The modulating signal is

$m(t) = 15\sin(2\pi 1500t)$

Carrier signal is

$\alpha(t) = 60\sin(2\pi 10^3 t)$

Modulation index is

$$m = \frac{A_m}{A_c} = \frac{15}{60} \times 100 = 25\%$$

60. Explanation: (d) The main function of a RF amplifier is to increase selectivity, where selectivity is the ability to reject the unwanted frequency components.

61. Explanation: (c)

Carrier swing $= 100\ \text{kHz} = 2 \times \Delta f$
$\Delta f = 50\ \text{kHz}$ and $f_m = 8\ \text{kHz}$

Modulation index of FM is

$$\beta = \frac{\Delta f}{f_m} = \frac{50}{8} = 6.25$$

62. Explanation: (d)

$P_c = 400\ \text{W}, m = 75\%$

$$P_t = P_c\left(1 + \frac{m^2}{2}\right)$$

$$P_t = 400\left(1 + \frac{(0.75)^2}{2}\right) = 512.5\ \text{W}$$

63. Explanation: (d)

$m(t) = \text{sinc}(2 \times 10^4 t)$
$f_m = 20\ \text{kHz}$
$K = 10^3\ \text{Hz/v}$
$f_o = 1\ \text{MHz}$
$(f_i)_{\max} = f_c + K_1|m(t)|_{\max}$
$(f_i)_{\max} = 1 + 1 = 1.001\ \text{MHz}$

64. Explanation: (c) In A.M. modulation a simple envelope detector can be used to detect the received signal thus making a very cost efficient and simple receiver system.

65. Explanation: (c)

$f_l = f_{LO} - f_S$
$f_{LO} = f_I + f_S = 450 + 1000 = 1450\ \text{kHz}$
$f_i = f_S + 2f_I = 1000 + 900 = 1900\ \text{kHz}$

66. Explanation: (b)

$$M_t = \sqrt{M_1^2 + M_2^2 + M_3^2}$$

$$M_t = \sqrt{(0.25)^2 + (0.5)^2 + (0.75)^2}$$
$= 0.93$

67. Explanation: (c)

For boosting of higher frequency components a pre - emphasis circuit is used.

68. Explanation: (c)

$$\underbrace{P_t}_{\text{Total power}} = P_c\left(1 + \frac{m^2}{2}\right)$$

$$= \underbrace{P_c}_{\substack{\text{Power contained in carrier signal}}} + \underbrace{P_c\frac{m^2}{2}}_{\substack{\text{Power contained in two sidebands}}}$$

The power contained in a single side band is

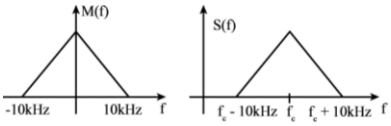
$$P_{ssb} = \frac{P_c m^2}{4}$$

69. Explanation: (b)

Selectivity of tuned radio frequency (TRF) receiver is poor because

- Q - factor requirement of tuned circuit varies with frequency.
- Q is very high for short waves and at upper side (say 20 MHz) it requires a Q -value of 2000.
- Q can't be zero.

70. Explanation: (*D*)



$$f_c + f_m = 800 \text{ kHz}$$
$$f_c = 800 - 10 = 790 \text{ kHz}$$

71. Explanation: (a)

$$P_t = P_c\left(1 + \frac{\mu^2}{2}\right)$$
$$P_t \propto I_t^2$$
$$P_c \propto I_c^2$$
$$I_t^2 = I_c^2\left(1 + \frac{\mu^2}{2}\right)$$
$$(20)^2 = (18)^2\left(1 + \frac{\mu^2}{2}\right)$$
$$\mu = 0.68$$

72. Explanation: (D)

$$\Delta f = 20 \text{ kHz}$$
$$f_m = 2 \text{ kHz}$$
$$\text{BW} = 2(\Delta f + f_m) = 2(20 + 2) \text{ kHz}$$
$$\text{BW} = 44 \text{ kHz}$$

73. Explanation: (D)

$$e_s = 15\sin(2\pi \times 2000t)$$
$$e_c = 60\sin(2\pi \times 10^5 t)$$
$$A_c = 60\,, A_m = 15$$
$$\mu = \frac{A_m}{A_c} = \frac{15}{60} = 0.25$$

74. Explanation: (b)

$$\text{BW} = \frac{2f_H}{k}$$
$$k = \frac{f_H}{f_H - f_L} = \frac{4.002}{0.004} = 1000.5$$
$$k = 1000$$
$$\text{BW} = \frac{2 \times 4.002}{1000}\text{GHz}$$
$$\text{BW} = 8 \text{ MHz}$$

75. Explanation: (b)

Average power of $x(t)$ is

$$P_{avg} = \frac{A^2}{2} = \frac{6^2}{2} = 18 \text{ W}$$

76. Explanation: (b)

To avoid aliasing

$$f_s \geq 2f_m$$
$$f_s \geq 2 \times 4$$
$$f_s \geq 8 \text{ Hz}$$

Aliasing effect is seen if f_s is 6 kHz

77. Explanation: (*B*)

$$s(t) = e^{-at}\cos[(\omega_c + \Delta(\omega)t]u(t)$$
Complex signal $= s(t) + j\hat{s}(t)$
$$\text{p(t)} = e^{-at}\cos[(\omega_c + \Delta\omega)t]u(t)$$
$$+je^{-at}\cos[(\omega_c + \Delta\omega)t - 90°]u(t)$$
$$\text{p(t)} = e^{-at}\cos[(\omega_c + \Delta\omega)t + j\sin[(\omega_c + \Delta\omega)t]u(t)$$
$$\text{p(t)} = [e^{-at}e^{j\Delta\omega t}u(t)]e^{j\omega_c t}$$
Complex envelope $= e^{-at}e^{[j\Delta\omega t]}u(t)$

78. Explanation: (a)

Bandwidth of AM signal depends on bandwidth of the modulating signal

$$BW_{AM} = 2t_m$$

Where f_m is bandwidth of modulating signal.

Amplitude modulated signal contains $f_c, f_o \pm f_m$ frequency signal.

highest frequency present $= f_c + f_m$

lowest frequency present $= f_c - f_m$

$$(BW)_{AM} = 2t_m$$

79. Explanation: (b)

Bandwidth of AM is

$$(BW)_{AM} = 2f_m = 8 \text{ kHz}$$

Bandwidth of FM is

$$(BW)_{FM} = 12f_m = 12 \times 4 = 48 \text{ kHz}$$

80. Explanation: (c)

Modulation index of FM signal is

$$\beta = \frac{k_f A_m}{f_m}$$

If modulating frequency is doubled, then modulation index is halved.

81. Explanation: (c)

Carrier swing is

$$2\Delta f = 100 \text{ kHz}$$
$$\Delta f = 50 \text{ kHz}$$
$$\beta = \frac{\Delta f}{f_m} = \frac{50}{8} = 6.25$$

82. Explanation: (a) Modulation is the process of varying one or more characteristics (amplitude, frequency, or phase) of a high - frequency carrier in accordance with the instantaneous value of a low-frequency information signal.

83. Explanation: (b) In communication systems, modulation is the process of impressing the information (low-frequency signal) onto a high - frequency carrier wave by varying one of its parameters (amplitude, frequency, or phase).

84. Explanation: (b)

(i) In TV systems, **Vestigial Sideband** modulation is used for video signals.

(ii) VSB **does not reduce the bandwidth to half**. Instead, it transmits one full sideband and a **vestige** of the other, saving bandwidth compared to full AM but not as much as pure SSB. So statement **1 is false.**

(iii) The vestige of the second sideband ensures that **low - frequency components** of the video signal are preserved without severe phase distortion. Hence statement **2 is correct.**

85. Explanation: (c)

$$\Delta\text{f} = 75 \text{ kHz}$$
$$\beta = \frac{\Delta\text{f}}{\text{f}_\text{m}}$$
For $\text{f}_\text{m} = 100$ Hz
$$\beta = \frac{75000}{100} = 750$$
For $\text{f}_\text{m} = 1.5$ kHz
$$\beta = \frac{75000}{1500} = 50$$

86. Explanation: (d)

$$\text{P}_\text{t} = 60 + 6 = 66 \text{ W}$$
$$\mu = 1$$

$$P_t = P_c\left[1+\frac{\mu^2}{2}\right]$$

$$66 = P_c\left[1+\frac{1}{2}\right]$$

$$P_c = 44\ \text{W}$$

87. Explanation: (a)

Envelope detector

88. Explanation: (b)

$$\text{IF} = 455\ \text{kHz}$$

$$f_l = f_s + \text{IF}$$

$$\frac{f_{l\,max}}{f_{l\,min}} = \frac{2055}{1005} = 2.044$$

89. Explanation: (b)

The phase detector circuit in the phase-locked loop demodulators recognizes frequency changes between the input and VCO signals.

90. Explanation: (a)

$$\text{BW} = 2f_m(\beta+1)$$

$$= 2\times 100[15+1] = 3.2\ \text{kHz}$$

91. Explanation: (c)

$$(\text{SNR})_{FM} > (\text{SNR})_{AM}$$

$$\frac{3}{2}\beta^2 = \frac{\mu^2}{2+\mu^2}$$

$$\frac{3}{2}\beta^2 > \frac{1}{3}$$

$$\beta > \sqrt{\frac{2}{9}}$$

$$\beta > 0.47$$

92. Explanation: (b)

$$\mu = 0.8$$

$$P_{SB} = P_C\frac{\mu^2}{2}$$

$$4.85 = P_C \times \frac{(0.8)^2}{2}$$

$$P_C = 15.15\ \text{kW}$$

$$P_t = P_C + P_{SB} = 20\ \text{kW}$$

93. Explanation: (a)

$$\mu_t = \sqrt{\mu_1^2+\mu_2^2} = 0.85$$

$$P_t = P_C\left[1+\frac{\mu_t^2}{2}\right] = 360\left[1+\frac{(0.85)^2}{2}\right]$$

$$= 490.5\ \text{W}$$

94. Explanation: (a)

$$P_t = 60\ \text{W}$$

$$P_t = P_C\left[1+\frac{\mu_t^2}{2}\right]$$

$$60 = P_C[1+0.5] = 40\ \text{W}$$

95. Explanation: (c)

Peak phase deviation is

$$\Delta\Phi = K_pA_m = 2.5\times 2 = 5\ \text{rad}$$

96. Explanation: (a)

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

$$11 = 9\sqrt{1+\frac{\mu^2}{2}}$$

$$\mu = 0.99$$

97. Explanation: (b)

By Carson's rule

$$\text{BW} = 2[\Delta f + f_m]$$

$$50 = 2[15+f_m]$$

$$f_m = 10\ \text{kHz}$$

98. Explanation: (c)

$$\mu = 0.5$$

$$\eta = \frac{\mu^2+2}{2\mu^2+4}$$

$$\eta = \frac{(0.5)^2+2}{2(0.5)^2+4} = 94.5\ \%$$

99. Explanation: (d)

An output of balanced modulator contains modulation frequency, LSB and USB.

100. Explanation: (c)

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

$$I_t = 8\sqrt{1+\frac{(0.8)^2}{2}} = 9.2\ \text{A}$$

101. Explanation: (b)

The modulation index of FM signal is

$$\beta = \frac{\Delta f}{f_m} = \frac{75}{300} = 0.25 < 1$$

Since, it is Narrow – Band FM signal. So,

$$(\text{BW})_{NBFM} = 2f_m = 600\ \text{kHz}$$

102. Explanation: (d)

Figure of Merit is defined as the ratio of the output SNR to the input SNR for a receiver. It represents how efficiently a modulation scheme uses the input signal in terms of noise performance. In reality, for AM with envelope detection, the **FoM is always less than 1**, because part of the transmitted power is in the carrier, which does not carry useful information, and envelope detection is not optimal in terms of noise performance.

103. Explanation: (c)

1. RF Carrier Range of AM Radio (Medium Wave Band):

- In AM broadcasting (especially in the medium wave band, used for standard AM radio):
- Frequency Range: 0.535 MHz to 1.605 MHz (or 535 kHz to 1605 kHz)
- This is the standard range used worldwide for AM broadcasting.

2. IF Bandwidth:

- The Intermediate Frequency (IF) for AM receivers is typically 455 kHz.
- The channel bandwidth is typically:
- 10 kHz (standard AM channel spacing and bandwidth for audio signal transmission).
- So, IF bandwidth = 10 kHz in standard AM receivers.

104. Explanation: (a)

Coherent SSB (Single Sideband) Receiver:

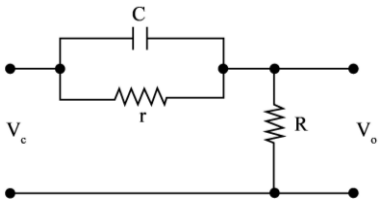
- Very efficient: transmits only one sideband.
- No power wasted in carrier or redundant sideband.
- Uses **coherent detection**.
- **Figure of Merit** $= 1$
- **Output SNR** $=$ **Input SNR**

Coherent DSB-SC Receiver:

- Transmits both sidebands, but no carrier.
- Uses coherent detection.
- Also has **Figure of Merit** $= 1$
- **Output SNR** $=$ **Input SNR**

So, both **SSB with coherent detection** and **DSB-SC with coherent detection** offer **identical noise performance** under the same average power and noise conditions.

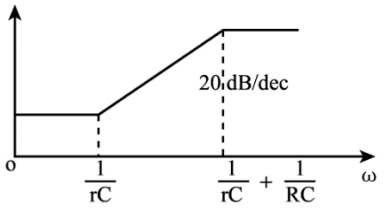
105. Explanation: (c)



$$\frac{V_o(s)}{V_i(s)} = \frac{R}{R + \frac{\left(r \times \frac{1}{Cs}\right)}{r + \frac{1}{Cs}}}$$

$$\frac{V_o(s)}{V_i(s)} = \frac{1 + rCs}{1 + rCs + \frac{r}{R}}$$

The Bode – plot of TF is



The given circuit boosts the higher frequency components of the signal. Hence, it is a pre – emphasis filter.

106. Explanation: (c)

$\mu = 0.4$

AM Power = SSB Power

$P_{SSB} = P_t = 20$ kW

Transmission efficiency is

$$\eta = \frac{\mu^2}{2 + \mu^2} = \frac{(0.4)^2}{2 + (0.4)^2} = 7.4\%$$

107. Explanation: (b)

$$x_c(t) = 20\cos\left[200\pi t + \frac{\pi}{4}\right]$$

$$= A_c \cos[\theta_i(t)]$$

$$f_i = \frac{1}{2\pi}\frac{d\theta_i(t)}{dt} = \frac{1}{2\pi}[200\pi]$$

$= 100$ Hz

108. Explanation: (d)

For FM

$f_c = 250$ kHz, $k_f = 1.5$ kHz/volt

For PM

$f_c = 500$ kHz, $k_p = 1.5$ rad/volt

$A_m = 5$ V, $f_m = 5$ kHz

Modulation index is

$$\beta_{FM} = \frac{k_f A_m}{f_m} = \frac{1.5 \times 1000 \times 5}{5000}$$

$$= 1.5$$

$$\beta_{PM} = k_p A_m = 1.5 \times 5 = 5\beta_{FM}$$

109. Explanation: (d)

$$\frac{\eta_{DSB}}{\eta_{AM}} = \frac{P_c\mu^2/2}{P_c\mu^2/4} = 2$$

$$\eta_{DSB} = 2\eta_{AM}$$

110. Explanation: (a)

$\Delta_f = 25$ kHz

FM BW = 75 kHz

$BW = 2[\Delta f + f_m]$

$75 = 2[25 + f_m]$

$f_m = 12.5$ kHz

111. Explanation: (c)

$k_f = 90$ kHz/V

$BW = 2[\Delta f + f_m]$

$\Delta f = k_f|m(t)|_{max} = 90$ kHz

$|m(t)|_{max} = 1$

$BW = 2[90 + 20] = 220$ kHz

112. Explanation: (b)

$P_t = 220$ W, $\mu = 0.4$

$$P_t = P_c\left[1 + \frac{\mu^2}{2}\right]$$

$P_c = 203.7$ W

Power supplied by modulating amplifier gets converted into output SB power.

Power to be supplied by class C power amplifier is

$P_a = 220 - 203.7 = 16.29$ W

η_{cce} = collector circuit efficiency

$= 0.4$

DC power is

$$P = \frac{16.29}{0.4} = 40.7 \text{ W}$$

113. Explanation: (a)

$$S_{AM}(t) = A_c[1 + k_a m(t)]\cos 2\pi f_c t$$

$$P_{AM} = \frac{A_c^2}{2} + \frac{A_c^2 k_a^2 m^2(t)}{2}$$

$$k_a = \frac{1}{A_c}$$

$k_a = 1$ (By default)

$$P_{AM} = \frac{A_c^2}{2} + \frac{A_c^2 m^2(t)}{2}$$

114. Explanation: (a)

$$P_t = P_c\left[1 + \frac{\mu_t^2}{2}\right] = P_c\left[1 + \frac{\mu_1^2}{2}\right] + \frac{P_c\mu_2^2}{2}$$

$$144.5 = 125 + \frac{P_c\mu_2^2}{2}$$

$$\frac{P_c\mu_2^2}{2} = 19.5$$

$$39 = \frac{125}{1.245} \times \mu_2^2$$

$$\mu_2 = \sqrt{0.388}$$

115. Explanation: (d)

Statement (I) is false but Statement (II) is true

116. Explanation: (b)

In FM radio receivers, the Intermediate Frequency (IF) is standardized to 10.7 MHz. This is the mid-band frequency of the IF section used for super heterodyne FM receivers.

117. Explanation: (d)

Statement 1: DSB-SC, SSB, and VSB are examples of linear modulation.

- Linear modulation: The amplitude of the carrier is varied in proportion to the message signal.
- DSB-SC, SSB, and VSB all belong to AM-based linear modulation schemes.
- The modulated signal is a linear function of the message signal.

Statement 2: DSB-SC modulation is well suited for point-to-point communication.

- DSB-SC requires coherent detection, which is feasible in controlled point-to-point links where synchronization between transmitter and receiver is manageable.
- It is power-efficient, as no carrier is transmitted.

Statement 3: SSB-SC modulation scheme is less affected by frequency-selective fading.

- SSB occupies less bandwidth, so the probability of experiencing frequency-selective fading across its narrow spectrum is lower than broader-bandwidth schemes like DSB.
- This makes SSB more robust in multipath or fading channels.

Hence, all the statements are correct.

118. Explanation: (c)

Commercial Television Broadcasting – Video Signal Transmission:

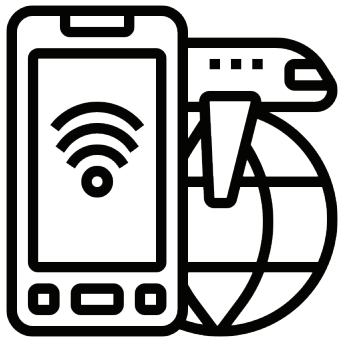
- The **video signal** in analog television broadcasting is transmitted using:

COMPUTER ORGANIZATION & ARCHITECTURE

SECTION 3

SYLLABUS

Basic architecture, CPU, I/O organisation, memory organisation, peripheral devices, trends; Hardware /software issues; Data representation& Programming; Operating systems-basics, processes, characteristics, applications; Memory management, virtual memory, file systems, protection & security; Data bases, different types, characteristics and design; Transactions and concurrency control; Elements of programming languages, typical examples.



NUMBER OF QUESTIONS ASKED IN ESE ELECTRONICS ENGINEERING VOLUME-II (2001 TO 2025)

Computer Organization and Architecture		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
3.1	Basics of Computer Organization and Architecture	2	3	3	1	1	-	4	2	3	3	3	2	1	1	-	4	-	-	1	2	2	2	2	1	-
3.2	Pipelining, Input - Output and Memory Organization	-	3	2	5	2	2	5	3	4	7	3	7	4	6	5	4	1	4	4	4	5	2	5	6	7
3.3	Data structures, Representation and Programming	4	5	9	7	7	5	5	5	9	6	7	2	2	11	-	4	1	3	2	1	3	2	-	2	1
3.4	Operating Systems and Data Bases	1	1	-	2	1	-	3	2	-	2	-	1	2	-	1	-	6	5	5	5	-	1	4	2	4
3.5	Miscellaneous	1	2	2	-	-	1	2	1	1	1	3	-	-	1	-	-	-	-	-	-	-	1	-	1	-

CHAPTER-3 COMPUTER ORGANIZATION & ARCHITECTURE

Unit 3.1: Basics of Computer Organization and Architecture

Previous Year Exam Questions

[ESE-2001]

1. Assertion (A): A processor can reference a memory stack without specifying an address.
Reason (R): The address is always available and automatically updated in the stack pointer.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2001]

2. Effective address is calculated by adding or subtracting displacement value to
(a) immediate address (b) relative address
(c) absolute address (d) base address

[ESE-2002]

3. Consider the following:
1. Input device
2. Arithmetic and logic unit
3. Control unit
4. Auxiliary memory
5. Main memory
6. Active hub

Which of these form part of CPU?
(a) 1, 4 and 6 (b) 2, 3 and 6
(c) 2, 4 and 5 (d) 2, 3 and 5

[ESE-2002]

4. A microprocessor has 24 address lines and 32 data lines. If it uses 10 bits of opcode, the size of its Memory Buffer Register is
(a) 22 bits (b) 24 bits
(c) 32 bits (d) 14 bits

[ESE-2002]

5. The following micro operations are part of interrupt cycle of a control unit:
1. MAR←save-address
   PC← routine-address
2. MBR←(PC)
3. Memory←(MBR)

Which of the following is the correct order of their occurrence?
(a) 1, 2 and 3 (b) 2, 3 and 1
(c) 2, 1 and 3 (d) 3, 1 and 2

[ESE-2003]

6. Which of the following are included in the architecture of computer?
1. Addressing modes, design of CPU.
2. Instruction set, data formats.
3. Secondary memory, operating system.

Select the correct answer using the codes given below:
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

[ESE-2003]

7. In a microprocessor when a CPU is interrupted, it
(a) Stops execution of instructions
(b) Acknowledges interrupt and branches of subroutine
(c) Acknowledges interrupt and continues
(d) Acknowledges interrupt and waits for the next instruction from the interrupting device

[ESE-2003]

8. The content of which of the following determines the state of the CPU at the end of the execute cycle (when the interrupt is recognized)?
1. Program counter
2. Processor register
3. Certain status conditions

Select the correct answer using the codes given below:
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

[ESE-2004]

9. Consider a hypothetical processor with largest instruction length being 32-bit and 16 registers $R_0 - R_{15}$. Processor supports only following instructions:

ADD	Ri, Rj
SUB	Ri, Rj
AND	Ri, Rj
NOT	Ri
MOV	Ri, Rj
LOAD	Address//Loads with register R_0
STORE	Address//Stores the content of R_0
JUMP	Address

JZ Address

What is the maximum number of address pins on this processor?

(a) 27 (b) 28
(c) 29 (d) 30

[ESE-2005]

10. Assertion (A): There is no overflow after an addition, if one number is positive and the other is negative.
Reason (R): Adding a positive number to a negative number always produces a result which is smaller than the larger of the two.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2007]

11. Which of the following are included in the architecture of computer?
1. Addressing modes, design of CPU
2. Instruction set, data formats
3. Secondary memory, operating system
Which of the statements given above are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

[ESE-2007]

12. Assertion (A): Neumann machines are called Control Flow Computers.
Reason (R): Instructions are executed sequentially as controlled by a program counter.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2007]

13. Assertion (A): Data-flow computers exploit maximum parallelism.
Reason (R): Data-flow computers require no program counter.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and Rare true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2007]

14. The following micro-operations are part of interrupt cycle of a control unit:
1. MAR ← save-address
   PC ← routine address
2. MBR ← (PC)
3. Memory ← (MBR)

Which one of the following is the correct order of their occurrence?

(a) 1-2-3 (b) 2-3-1
(c) 2-1-3 (d) 3-1-2

[ESE-2008]

15. Which one of the following is correct?
A micro program

(a) is usually written in high level language
(b) is a program for micro computers
(c) is a program written in assembly language
(d) is a sequencing program for the control unit of any processor

[ESE-2008]

16. Which one of the following is correct?
A micro program is

(a) any source program run on micro computers
(b) any set of instructions for primitive operation in a system
(c) a general name for 'macros' used in assemble language programming
(d) any program of a very small size

[ESE-2009]

17. Which of the following is/are correct statements (s)?
1. Bus is a group of wires carrying information.
2. Bus is needed to achieve reasonable speed of operation.
3. Bus can carry data or address.
4. A bus can be shared by more than one device.
Select the correct answer from the codes given below:

(a) 1 only (b) 1 and 2 only
(c) 2, 3 and 4 only (d) 1, 2, 3 and 4

[ESE-2009]

18. Which of the following are included in the architecture of a computer?
1. Addressing modes, CPU
2. Instruction set, data formats
3. Secondary memory, operating system
Select the correct answer from the codes given below:

(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 3 only

[ESE-2009]

19. Identification of highest priority interrupt can be achieved in a minimum time by which of the following schemes?

(a) Hardwired polling
(b) Priority encoder circuit
(c) Software polling
(d) Subdivision of interrupt register into a number of sub-registers which are checked parallely

[ESE-2010]

20. On receiving an interrupt from an I/O device, the CPU

(a) Halts for a predetermined time.
(b) Branches off to the interrupt service routine after completion of the current instruction.
(c) Branches off to the interrupt service routine immediately.
(d) Hands over control of address bus and data bus to the interrupting device.

[ESE-2010]

21. A single bus structure is primarily found in

(a) Main frames
(b) Mini and micro computers
(c) Super computers
(d) High performance machines

[ESE-2010]

22. Consider the following statements:

1. Compilers
2. Design
3. Evaluation
4. Instruction set architecture

Which of these are included in the present definition of computer architecture to design a full computer system?

(a) 1, 2 and 3 (b) 1, 3 and 4
(c) 2, 3 and 4 (d) 1, 2, 3 and 4

[ESE-2011]

23. Which of the following are the problems with using Millions Instructions Per Second (MIPS) as a measure for comparing computer performance?

1. **It does not take into account the capabilities of the instructions.**
2. **MIPS can vary inversely with performance.**
3. **MIPS varies between programs on the same computer.**

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

[ESE-2011]

24. A bus organized processor consists of 15 registers. The number of selection lines in each multiplexer and in the destination decoder are respectively

(a) 2 and 4 (b) 4 and 2
(c) 4 and 4 (d) 4 and 8

[ESE-2011]

25. In writing the micro-program, there are two situations in which a field of the micro instruction can be kept blank when it

1. Controls a functional unit
2. Causes state to be written
3. Specifies the control of a multiplexer

Which of these statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

[ESE-2012]

26. The incorrect match (when $n > 1$) is

(a) SISD model of computer : 1 control unit and 1 ALU
(b) SIMD model of computer : 1 control unit and n ALUS
(c) MISD model of computer : n control units and n ALUs
(d) MIMD model of computer : n control units and 1 ALU

[ESE-2012]

27. In case the code is position dependent, the most suitable addressing mode is

(a) Direct mode (b) Indirect mode
(c) Relative mode (d) Indexed mode

[ESE-2013]

28. Statement (I): The data path contains all the circuits to process data within the CPU with the help of which data is suitably transformed.

Statement (II): It is the responsibility of the control path to generate control and timing signals as required by the opcode.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

[ESE-2014]

29. The addressing mode that permits relocation, without any change whatsoever in the code, is

(a) Indirect addressing
(b) Base register addressing
(c) Indexed addressing
(d) PC relative addressing

[ESE-2016]

30. Data transfer between the main memory and the CPU register takes place through two registers, namely,
(a) General purpose register and MDR
(b) Accumulator and Program counter
(c) MAR and MDR
(d) MAR and Accumulator

[ESE-2016]

31. A processor has 32-bit architecture. Each instruction is 1 word long (32 bits). It has 64 registers. It supports 50 instructions, which have 2 register operands $+1$ immediate operand. Assuming that the immediate operand is an unsigned integer, what is its maximum value?
(a) 16383 (b) 32767
(c) 65536 (d) 1024

[ESE-2016]

32. Consider the following:
1. Operation code
2. Source operand reference
3. Result operand reference
4. Next instruction reference

Which of the above are typical elements of machine instructions?
(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 3 and 4 only (d) 1, 2, 3 and 4

[ESE-2016]

33. Which addressing mode helps to access table data in memory efficiently?
(a) Indirect mode
(b) Immediate mode
(c) Auto-decrement or Auto-increment mode
(d) Index mode

[ESE-2019]

34. Consider the following statements:
1. A computer will have a multiply instruction.
2. Multiply instruction will be implemented by a special multiply unit.

Which of the following is correct?
(a) Both 1 and 2 are not architectural design issues.
(b) Both 1 and 2 are not organizational issues.
(c) 1 is an architectural design issue while 2 is an organizational issue.
(d) 1 is an organizational issue while 2 is an architectural design issue.

[ESE-2020]

35. A core of processor chip consists of
1. ALU
2. Instruction logic
3. Load/store logic
4. L3 cache
5. L1 data cache
(a) 1, 2, 3 and 4 only
(b) 1, 2, 3 and 5 only
(c) 2, 3, 4 and 5 only
(d) 1, 4 and 5 only

[ESE-2020]

36. Superscalar processor consists of
(a) Single pipeline for instruction execution
(b) Multiple-instruction pipelines for instruction execution
(c) No pipelines for instruction execution
(d) Multiple combination of hardware for execution

[ESE-2021]

37. Which one of the following characteristics is correct regarding RISC processor?
(a) Relatively very large addressing modes
(b) Multi-cycle instruction execution
(c) All operations are not done within the registers of the CPU
(d) Relatively few instructions

[ESE-2021]

38. Which one of the following instructions in a stack computer consists of an operation code only with no address field?
(a) PUSH X (b) POP X
(c) ADD (d) LOAD A

[ESE-2022]

39. Which of the following basic steps are needed in order to perform a memory read operation?
1. The address of the location from which the word is to be read is loaded into the memory address register (MAR).
2. A signal, called read (issued by the CPU indicating that the word whose address is in the MAR) is to be read into the MDR.
3. Corresponding to the memory delay in reading the specified word, the required word will be loaded by the memory into the MDR ready for use by the CPU.

Select the correct answer using the code given below.
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

[ESE-2022]

40. Which of the following instructions are long and allow maximum parallelism since each bit controls a single control line?

(a) Horizontal microinstructions
(b) Vertical microinstructions
(c) Diagonal microinstructions
(d) Jumbled microinstructions

[ESE-2023]

41. What is the overall number of Clock cycles Per Instruction (CPI) for a machine A for which the following performance measures were recorded when executing a set of benchmark programs? (Assume the clock rate of the CPU as 200 MHz and execution of 100 instructions)

Instruction category	Percentage of occurrence	No. of cycles per instruction
ALU	38	1
Load and store	15	3
Branch	42	4
Others	5	5

(a) 2.76 (b) 4.76
(c) 6.76 (d) 8.76

[ESE-2023]

42. Which one of the following is a program that takes an object file generated and generates a file in a binary code called COM file or EXE file?

(a) Editor (b) Assembler
(c) Loader (d) Debugger

[ESE-2024]

43. Non-uniform memory access belongs to

(a) SISD (b) SIMD
(c) MISD (d) MIMD

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(a)	(d)	(d)	(c)	(c)	(a)	(d)	(c)	(b)	(a)
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
(a)	(a)	(a)	(c)	(d)	(b)	(d)	(a)	(b)	(b)
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
(b)	(c)	(c)	(c)	(a)	(d)	(c)	(a)	(d)	(d)
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
(a)	(d)	(c)	(c)	(b)	(b)	(d)	(c)	(d)	(a)
41	**42**	**43**							
(a)	(c)	(d)							

EXPLANATIONS

1. Explanation: (a)
Assertion (A): A processor can reference a memory stack without specifying an address.
True → Because stack operations like PUSH and POP don't require the programmer to explicitly provide an address. The CPU uses the **stack pointer (SP)** to keep track of the current top f stack location.
Reason (R): The address is always available and automatically updated in the stack pointer.
True → The stack pointer register holds the top - of - stack address and is automatically incremented/decremented by the processor during stack operations.
R is the correct explanation of A
Yes → The reason explains, that the processor doesn't need an explicit address: the stack pointer already provides it.

2. Explanation: (d)
Effective address - base address + displacement

3. Explanation: (d)
ALU and control unit forms are the basic parts of a CPU. Main and primary memories are also parts of CPU.

4. Explanation: (c)
Size of MBR depends on data pins

5. Explanation: (c)
2. MBR ← (PC)
1. MAR ← save - address
PC ← routine - address
3. Memory ← (MBR)

6. Explanation: (a)
Architecture → Attributes of a system visible to a programme.
Examples: instruction set, addressing modes, data formats, I/O mechanisms.
Organization → Hardware implementation details(control signals, memory hierarchy, etc.).
System software (OS, compilers) → Not part of architecture.

7. Explanation: (d)
When a CPU is interrupted, it acknowledges interrupt and waits for the next instruction from the interrupting device.

8. Explanation: (c) At the end of the execute cycle, the CPU checks for an interrupt, if interrupt has occurred then the address of Program Counter (PC) is moved to Memory Address Register and PC is updated with interrupt routine address. Meanwhile, certain status conditions (flags) may also determine state of CPU.

9. Explanation: (b)
There are 9 distinct instructions → opcode needs $\lceil \log_2 9 \rceil = 4$ bits.
The address - bearing instructions (LOAD, STORE, JUMP, JZ) use only opcode + address, so address bits = 32 − 4 = **28**

10. Explanation: (a)
Addition of positive and negative numbers will not overflow, because result is always less than the larger of two.

11. Explanation: (a)
Computer Architecture → attributes visible to the programmer (instruction set, addressing modes, data formats, CPU design).
Not included → Operating system and specific hardware devices like secondary memory.
1. Addressing modes, design of CPU → part of architecture.
2. Instruction set, data formats → part of architecture.
3. Secondary memory, operating system → not part of architecture.

12. Explanation: (a)
In Von - Neumann machines, the execution of next instruction is decided by the program counter (PC), which is updated with sequential addresses.

13. Explanation: (a)
Assertion (A): Data-flow computers exploit maximum parallelism.
True → In data - flow architecture, an instruction executes as soon as its input data is available, so many instructions can run in parallel.
Reason (R): Data - flow computers require no program counter.
True → Execution is data - driven, not instruction – sequence - driven, so there is no program counter.
R is the correct explanation of A
Because the absence of a program counter allows instructions to fire as soon as operands arrive, that is the basis of parallelism.

14. Explanation: (c)
2. MBR ← (PC)
1. MAR ← save - address
PC ← routine - address
3. Memory ← (MBR)

15. Explanation: (d)
Micro program is program for control unit c processor

16. Explanation: (b)
Micro program is the set of instructions for primitive operation in a system.

17. Explanation: (d)
Bus is group of wires, carrying information.
Bus is needed to achieve reasonable speed of operation.
Bus can carry data or address.
Bus can be shared by more than one device
Hence, all statements are correct.

18. Explanation: (a)
Computer architecture = programmer - visible attributes → instruction set, addressing modes, CPU design, data formats.
Not included = secondary memory and operating system.
Now check each:
1. Addressing modes, CPU → included.
2. Instruction set, data formats → included.
3. Secondary memory, operating system → not part of architecture.

19. Explanation: (b)
(a) Hardwired polling → Sequential hardware checking, faster than software, but still slower than priority encoding.
(b) Priority encoder circuit → Directly encodes the highest priority interrupt in hardware → **fastest method.**
(c) Software polling → Slowest, since CPU must check in software.
(d) Subdivision of interrupt register into sub - registers checked in parallel → Improves speed compared to linear polling, but still not as fast as a **priority encoder.**

20. Explanation: (b)
On receiving an interrupt from an I/O device, the CPU branches off to the interrupt service routine after completion of the current instruction.

21. Explanation: (b)
A single bus structure is simple and inexpensive but becomes a bottleneck for high - speed systems.
- Mainframes/supercomputers/high - performance machines → usually use multiple - bus or crossbar/network interconnects to avoid bottlenecks.
- Mini and microcomputers → commonly used single bus structures due to lower cost and simpler design.

22. Explanation: (c)
Compiler is never part of architecture and output is assembly code, which can be executed on any architecture.

23. Explanation: (c)
Architecture like RISC and CISC are different CISC: Complex and more number of instructions.
RISC: Simple and reduced number of instructions are not compared using MIPS, so 1 is true. Since CPU inserts variable delay cycles as per priorities, hence MIPS varies between programs on the same computer.
As per previous example of RISC and CISC, since they have different MIPS for executing a program. So, statement 2 is not a problem.

24. Explanation: (c)
A bus organized processor with 15 registers means each multiplexer must be able to select among 15 inputs.

For a multiplexer with 15 inputs:
Number of selection lines = $\log_2 15 = 4$.
For the destination decoder (to enable writing into one of the 15 registers):
Decoder needs 15 outputs, so number of selection lines = $\log_2 15 = 4$.

25. Explanation: (a)
There are two situations in which micro instructions can be kept blank, when it controls a functional unit, and causes state to be written.

26. Explanation: (d)
MIMD model has n - control units, so in multiprocessing, it requires n ALU units.

27. Explanation: (c)
If the code is position dependent, then suitable addressing mode is relative addressing mode. The effective address computed from X(PC), X bytes away from the address pointed by program counter.
Relative addressing mode and indexed addressing mode use program counter and some general purpose register respectively.

28. Explanation: (a)
Statement (I): The data path contains all the circuits to process data within the CPU with the help of which data is suitably transformed.
True → The data path includes ALU, registers, buses etc. that perform operations on data.
Statement (II): It is the responsibility of the control path to generate control and timing signals as required by the opcode.
True → The control unit generates signals that orchestrate how the data path operates.
Statement (II) is the correct explanation of statement (I), because the data path processes data, but it does so only under the control signals generated by the control path, which depend on the opcode.

29. Explanation: (d)
PC relative addressing

30. Explanation: (d)
Data transfer between the main memory and the CPU register takes place through two registers are MAR and Accumulator.

31. Explanation: (a)
- Instruction length = 32 bits
- Registers = 64 ⇒ need $\log_2(64)$ = 6 bits per register
- Operands = 2 registers + 1 immediate
- Instruction set = 50 ⇒ opcode bits = $\log_2(50) \approx 6$ bits.

So far:
- Opcode = 6 bits
- Register 1 = 6 bits
- Register 2 = 6 bits

Total used = 18 bits
Remaining bits = 32 − 18 = 14 bits for the immediate operand.
Maximum unsigned value with 14 bits = $2^{14} - 1 = 16383$

32. Explanation: (d)
The typical elements of machine instructions are:
1. Operation code
2. Source operand reference
3. Result operand reference
4. Next instruction reference

33. Explanation: (c)
Both Auto-decrement or Auto-increment modes help to access table data in memory efficiently

34. Explanation: (c) 1 is an architectural design issue while 2 is an organizational issue.

35. Explanation: (b) A core of processor chip consists of ALU, instruction logic, load logic and L1 data cache.

36. Explanation: (b) Superscalar processor consists of multiple-instruction pipelines for instruction execution.

37. Explanation: (d)
RISC contains simple addressing modes and more number of general purpose registers for faster execution of the instruction, and also has limited number of instructions. Hence, option (D) is correct.

38. Explanation: (c)
ADD instruction consists of an operation code only with no address field.

39. Explanation: (d)
1. The address of the location from which the word is to be read is loaded into the memory address register (MAR).
2. A signal, called read (issued by the CPU indicating that the word whose address is in the MAR) is to be read into the MDR.
3. Corresponding to the memory delay in reading the specified word, the required word will be loaded by the memory into the MDR ready for use by the CPU.

Hence, all the three steps are needed to perform a memory read operation.

40. Explanation: (a)
Horizontal microinstructions: It uses one bit for each control signal. So, it allows maximum parallelism and length of the microinstruction is also high.
Vertical microinstructions: The encoded binary format represents the encoded signal, so it has low instruction length and low parallelism.

41. Explanation: (a) Average CPI is

$$\text{Average CPI} = \frac{\text{Number of Cycles/program}}{\text{Number of Instruction/program}}$$

$$\text{Average CPI} = \frac{(38 \times 1) + (15 \times 3) + (42 \times 4) + (5 \times 5)}{100} = 2.76$$

42. Explanation: (c)
Loader converts object file into hex file and dumps program to memory.

43. Explanation: (d)
Non-Uniform Memory Access (NUMA) is a memory architecture used in multiprocessor systems, particularly in MIMD systems. In NUMA, memory access time depends on the memory location relative to a processor i.e., a processor can access its own local memory faster than non-local memory.

1. SISD: Traditional single-core systems, NUMA doesn't apply here.
2. SIMD: Used in vector processors or GPUs, not typically involving complex memory architectures like NUMA.
3. MISD: Rare and mostly theoretical, not used in practical NUMA setups.

Hence, option (D) is correct.

Unit 3.2: Pipelining, Input - Output and Memory Organization

Previous Year Exam Questions

[ESE-2002]

1. Which of the following is not a characteristic of transparent DMA mode of I/O operation?
(a) The external logic steals cycles from the CPU
(b) The normal rate of execution is slowed down
(c) Only one word can be transferred at a time
(d) Data is transferred to/from memory directly

[ESE-2002]

2. Which one of the following is not a characteristic of RISC processor design?
(a) One instruction per cycle
(b) Register-to-register operations only
(c) Simple address modes
(d) Register-to-memory operations only

[ESE-2002]

3. The use of a cache in a computer system increases the
(a) available memory space for the program
(b) available memory space for data
(c) average speed of memory access
(d) addressing range of CPU

[ESE-2003]

4. Assertion (A): Reduced Instruction Set Computers (RISC) use pipelined control unit.
Reason (R): Pipelining reduces memory requirements of programs.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and Rare true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2003]

5. Match List-I (Type of Memory) with List-II (Used as) and select the correct answer using the code given below the lists:

List - I	List - II
A. DRAM	1. Cache memory
B. SRAM	2. Main memory
C. Parallel Access	3. BIOS memory
D. ROM	4. CPU registers

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	2	1	4	3
(c)	1	2	4	3
(d)	2	1	3	4

[ESE-2004]

6. A particular parallel program computation requires 100 seconds when executed on a single processor. If 40 percent of this computation is 'inherently sequential', then what are the theoretically best elapsed times for this program running with 2 and 4 processors, respectively?
(a) 20 and 10 seconds
(b) 30 and 15 seconds
(c) 50 and 25 seconds
(d) 70 and 55 seconds

[ESE-2004]

7. Match List-I (Characteristic) with List-II (Processor Architecture) and select the correct answer using the code given below the lists:

List - I	List - II
A. Micro-code for several instructions	1. Both RISC and CISC
B. Lack of indirect addressing	2. CISC only
C. Presence of on-chip cache	3. Neither RISC nor CISC
D. Simple optimizing compiler	4. RISC only

Codes:

	A	B	C	D
(a)	2	4	1	3
(b)	1	3	2	4
(c)	2	3	1	4
(d)	1	4	2	3

[ESE-2004]

8. Assertion (A): The DMA technique is more efficient than the Interrupt-driven technique for high volume I/O data transfer.
Reason (R): The DMA technique does not make use of the Interrupt mechanism.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2004]

9. Consider the following statements:
The advantage of cycle stealing in DMA is that
1. it increases the maximum I/O transfer rate
2. it reduces the interference by the DM controller in the CPU's memory access.
3. it is beneficially employed for I/O devices with shorter bursts of data transfer.
Which of the statements given above are correct?
(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

[ESE-2004]

10. Given a 32-bit processor with 16-MB main memory, 32-kB 4-way set-associative on-chip cache and a cache block size (or line size) of 16 words. What is the total number of tag bits in the memory address format?
(a) 9 (b) 20
(c) 11 (d) 24

[ESE-2005]

11. Consider the following statements:
1. Cache memory is low cost and fast memory
2. Cache memory is fast but costly memory.
3. Performance of cache during program execution is measured by hit ratio.

Which of the following statements given above are correct?
(a) 1 and 2 (b) 2 and 3
(c) 3 and 4 (d) 1 and 4

[ESE-2005]

12. Which one of the following correctly defines temporal locality?
(a) Adjacent instructions for current instruction may be needed soon
(b) Current instruction being fetched may be needed again soon
(c) Instructions temporarily residing in memory
(d) None of the above

[ESE-2006]

13. For which of the following devices, is DMA the most suitable?
(a) Keyboard (b) Mouse
(c) Joy stick (d) Hard disk

[ESE-2006]

14. Which block replacement algorithm is not generally used in cache operation?
(a) LIFO (b) FIFO
(c) LRU (d) Random

[ESE-2007]

15. In a microcomputer, why are wait states used?
(a) To make the processor wait during a DMA operation
(b) To make the processor wait during an interrupt processing
(c) To make the processor wait during a power shutdown
(d) To interface slow peripherals to the processor

[ESE-2007]

16. Assertion (A): DMA is faster than either Interrupt initiated I/O or Polling based I/O for very large data transfers.
Reason (R): DMA takes control of the system buses and needs no processor intervention during the data transfer.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2007]

17. Three memory chips are of size 1 KB, 2 kB and 4 KB. Their address bus is 10 bits. What are the data bus sizes of the chips?
(a) 8 bits, 16 bits and 24 bits respectively
(b) 8 bits, 16 bits and 32 bits respectively
(c) 8 bits, 16 bits and 64 bits respectively
(d) 8 bits, 16 bits and 128 bits respectively

[ESE-2007]

18. In which unit is the performance of cache memory measured?
(a) Hz (b) Bits/s
(c) Cache constant (d) Hit ratio

[ESE-2007]

19. Match List-I (Type of Memory) with List-II (Used as) and select the correct answer using the code given below the lists:

List - I	List - II
A. DRAM	1. Cache memory
B. SRAM	2. Main memory
C. Parallel Access	3. BIOS memory
D. ROM	4. CPU Registers

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	2	1	4	3
(c)	1	2	4	3
(d)	2	1	3	4

[ESE-2008]

20. The parallel computers are divided into which of the following architecture configurations?

1. Array processors
2. Data processors
3. Multi processor systems
4. Pipeline computers

Select the correct answer using the code given below:

(a) 1, 2 and 3 only (b) 2, 3 and 4 only
(c) 1, 3 and 4 only (d) 1, 2 and 4 only

[ESE-2008]

21. What is an interrupt in which the external device supplies its address as well as the interrupt request known as?

(a) Vectoral interrupt
(b) Maskable interrupt
(c) Non-maskable interrupt
(d) None of the above

[ESE-2008]

22. Match List-I (Type of Memory) with List-II (Access time in usec/nsec) and select the correct. answer using the code given below the lists:

List - I	List - II
A. DRAM	1. 1
B. SRAM	2. 10
C. Hard Disk	3. 100000
D. Magnetic Tape	4. 10000000

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	1	2	4	3
(c)	2	1	3	4
(d)	2	1	4	3

[ESE-2009]

23. What is the purpose of DMA facility in microprocessor based system?

(a) To increase the speed of data transfer between the microprocessor and I/O devices.
(b) To increase the speed of data transfer between the μP and the memory
(c) To increase the speed of data transfer between the memory and the I/O devices
(d) To improve the reliability of the system

[ESE-2009]

24. Match List-I (Type of Memory) with List-II (Used as) and select the correct answer using the code given below the lists:

List – I	List - II
A. DRAM	1. Cache memory
B. SRAM	2. Main memory
C. Parallel Access Registers	3. BIOS memory
D. ROM	4. CPU registers

Codes:

	A	B	C	D
(a)	1	4	2	3
(b)	3	4	2	1
(c)	1	2	4	3
(d)	3	2	4	1

[ESE-2009]

25. Which of the following are the memory performance parameters?

1. Access time and latency
2. Block size and Block access time
3. Cycle time and Bandwidth

Select the correct answer from the codes given below:

(a) 1 only (b) 1 and 2 only
(c) 2 and 3 only (d) 1, 2 and 3

[ESE-2009]

26. A 3 x 8 decoder with two enable inputs is to be used to address 8 blocks of memory. What will be the size of each memory block when addressed from a sixteen bit bus with two MSBS used to enable the decoder?

(a) 2 K (b) 4 K
(c) 16 K (d) 64 K

[ESE-2010]

27. Match List-I with List-II and select the correct answer using the codes given below the lists:

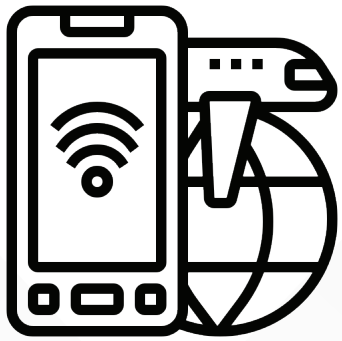
List - I	List - II
A. Pipelined ALU	1. RISC
B. Simpler compiler	2. CISC

ADVANCED ELECTRONICS TOPICS

SECTION 5

SYLLABUS

VLSI technology: Processing, lithography, interconnects, packaging, testing; VLSI design: Principles, MUX/ROM/PLA-based design, Moore & Mealy circuit design; Pipeline concepts & functions; Design for testability, examples; DSP: Discrete time signals/systems, uses; Digital filters: FIR/IIR types, design, speech/audio/radar signal processing uses; Microprocessors & microcontrollers, basics, interrupts, DMA, instruction sets, interfacing; Controllers & uses; Embedded systems.



NUMBER OF QUESTIONS ASKED IN ESE ELECTRONICS ENGINEERING VOLUME-II (2001 TO 2025)

Advanced Electronics Topics		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
5.1	VLSI Technology and Digital Design	1	1	3	3	5	2	1	3	2	1	3	1	1	-	1	-	1	1	3	4	5	5	2	5	5
5.2	8085 and 8086 Microprocessors	2	6	5	4	6	1	-	4	3	10	3	14	7	4	7	2	2	4	4	3	1	4	6	1	2
5.3	Interfacing Devices and Microcontrollers	-	1	-	-	-	-	-	-	2	4	-	3	-	-	1	-	3	1	2	1	5	5	-	2	-
5.4	Digital Filters	2	-	-	1	-	-	-	-	-	-	-	1	-	-	-	1	3	2	2	4	2	2	1	2	3

CHAPTER-5 ADVANCED ELECTRONICS TOPICS

Unit 5.1: VLSI Technology and Digital Design

Previous Year Exam Questions

[ESE-2001]

1. In the fabrication of a buried layer n-p-n transistor, the processes involved are

1. diffusion
2. oxidation
3. epitaxy
4. lithography

The correct sequence in which these processes are to be carried out, is

(a) $2, 4, 3, 1$ (b) $4, 2, 1, 3$
(c) $2, 4, 1, 3$ (d) $4, 2, 3, 1$

[ESE-2002]

2. Moor's law relates to

(a) speed of operation of bipolar devices
(b) speed of operation of MOS devices
(c) power rating of MOS devices
(d) level of integration of MOS devices

[ESE-2003]

3. In fabricating silicon BJT in ICs by the epitaxial process, the number of diffusions used is usually

(a) 2 (b) 3
(c) 4 (d) 6

[ESE-2003]

4. In the fabrication of $\mathbf{n-p-n}$ transistor in an IC, the buried layer on the p-type substrate is

(a) p^+-doped
(b) n^+-doped
(c) Used to reduce the parasitic capacitance
(d) Located in the emitter region

[ESE-2003]

5. The scaling factor of a MOS device is α. Using constant voltage scaling model, the gate area of the device will be scaled as

(a) $1/\alpha$ (b) $1/\alpha^2$
(c) $1/\alpha^3$ (d) $1/\alpha^4$

[ESE-2004]

6. Which one of the following statements is correct?
In the context of IC fabrication, metallisation means

(a) connecting metallic wires
(b) formation of interconnecting conduction pattern and bonding pads
(c) doping SiO_2 layer
(d) covering with a metallic cap

[ESE-2004]

7. Consider the following:

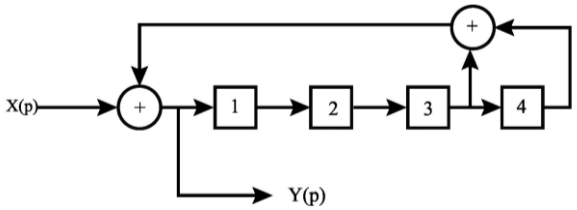
1. Cheaper method
2. Low residual oxygen content in the grown crystal is possible
3. Uniform doping is possible
4. Larger diameter crystals can be grown

Which of the above are the advantages of the float zone (FZ) method over the Czochralski (CZ) method in single crystal growth of silicon?

(a) 1 and 2 (b) 2 and 3
(c) 3 and 4 (d) 1 and 4

[ESE-2004]

8. Consider the following circuit of a scrambler:



$X(p) \triangleq$ input data stream polynomial

$Y(p) \triangleq$ output data stream polynomial

$\boxdot$'s $\triangleq$ shift-register stages

$\oplus'$ s $\triangleq$ XOR gates

Which one of the following relates $X(p)$ and $Y(p)$?

(a) $Y(p) = X(p)/[p^4 + p^3 + 1]$
(b) $Y(p) = p^4X(p)/[p^4 + p^3 + 1]$
(c) $Y(p) = X(p)/[p^4 + p + 1]$
(d) $Y(p) = p^4X(p)/[p^4 + p + 1]$

[ESE-2005]

9. Diffusion of impurities in a semiconductor is carried out in a furnace through which a steady stream of impurity atoms is passed during the entire diffusion process. What would be the type of the profile of the impurity atoms inside the semiconductor?

(a) Linear
(b) Gaussian
(c) Complementary error function
(d) Exponential

[ESE-2005]

10. Match List-I (Isolation Technique in IC) with List-II (Related Characteristic) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Reverse bias p-n junction isolation	1. Requires large area of the wafer, thereby increasing the IC size
B. Resistive isolation using the bulk resistivity of the layer	2. Best choice for silicon ICs with low parasitic capacitance
C. Native oxide isolation	3. Suitable for ICs of III-V semiconductors
D. Oxide (other than native isolation)	4. Introduces bias-dependent parasitic capacitance

Codes:

	A	B	C	D
(a)	4	1	2	3
(b)	2	3	4	1
(c)	4	3	2	1
(d)	2	1	4	3

[ESE-2005]

11. Consider the following statements:

X-rays are used for lithography in IC technology because

1. high resolution is achievable.
2. scattering effects are small.
3. they can be focussed easily
4. they can be deflected easily.

Which of the statements given above are correct?

(a) 1 and 2 (b) 1 and 3

(c) 1 and 4 (d) 2 and 3

[ESE-2005]

12. The basic function of buried n^+ layer in an $n-p-n$ transistor in IC is to

(a) Reduce the magnitude of the base spreading resistance

(b) Reduce the collector series resistance

(c) Reduce the base width of the transistor

(d) Increase the gain of the transistor

[ESE-2005]

13. Which one of the statements concerning IC fabrication is not correct?

(a) A typical wafer of doped Si may be $400\ \mu m$ thick, of diameter $5-15$ cm. The purity of the wafer does not matter and can be even polycrystalline in nature.

(b) Resistors are obtained by utilizing the bulk resistivity of one of the regions; for example, the DS channel of a MOSFET can serve as a resistor.

(c) Semiconductors lack magnetic properties, so they cannot exhibit inductance. However, the inductors can be realized by combination of active and passive components.

(d) In a reverse biased p-n junction, the positive and negative ions exist on opposite sides of the $p-n$ junction; because of that $p-n$ junction behaves like a parallel plate capacitor.

[ESE-2006]

14. Assertion (A): An IC is more reliable as compared to its discrete circuit equivalent.

Reason (R): All the joints in an IC are soldered simultaneously.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE-2006]

15. In integrated circuits, the design of electronic circuits is based on the approach of use of

(a) maximum number of resistors in the circuit

(b) large sized capacitor

(c) minimum chip area irrespective of the type of components in the design

(d) use of only bipolar transistors

[ESE-2007]

16. Assertion (A): The resistors and capacitors fabricated using IC technology have poor tolerances with respect to their absolute values.

Reason (R): As all the components of the IC are fabricated simultaneously, their ratio of tolerances is very low.

(a) Both (A) and (R) are individually true and (R) is the correct explanation of (A).

(b) Both (A) and (R) are individually true but (R) is not the correct explanation of (A).

(c) (A) is true but (R) is false.

(d) (A) is false but (R) is true.

[ESE-2008]

17. Which of the following capacitors are made use of widely for a capacitance application in monolithic ICs.

1. MOS capacitor
2. Collector Substrate capacitor
3. Collector-Base capacitor

4. Base-Emitter capacitor

Select the correct answer using the code given below:

(a) 1 and 2 only (b) 2 and 3 only
(c) 3 and 4 only (d) 1 and 4 only

[ESE-2008]

18. Why is silicon dioxide (SiO_2) layer used in ICs?

(a) To protect the surface of the chip from external contaminants and to allow for selective formation of the n and p regions by diffusion
(b) Because it facilitates the penetration of the desired impurity by diffusion
(c) To control the concentration of the diffused impurities
(d) Because of its high heat conduction

[ESE-2008]

19. Why is the term 'planer technology' for fabrication of devices in ICs used?

(a) The variety of manufacturing processes by which devices are fabricated, takes place through a single plane
(b) The aluminium contacts to the collector, base and emitter regions of the tran-sistors in the ICs are laid in the same plane
(c) The collector, base and emitter regions of the transistors in ICs are laid in the same plane
(d) The device looks like a thin plane wafer

[ESE-2009]

20. The process of extension of a single-crystal surface by growing a film in such a way that the added atoms form a continuation of the single - crystal structure is called

(a) Ion implantation
(b) Chemical vapour deposition
(c) Electroplating
(d) Epitaxy

[ESE-2009]

21. The maximum concentration of the element which can be dissolved in solid silicon at a given temperature is termed as

(a) Solid solubility
(b) Dissolution coefficient
(c) Solidification index
(d) Concentration index

[ESE-2010]

22. Assertion (A): Si is mainly used for making ICs and not Ge.

Reason (R): In Si, SiO_2 layer which acts as an insulator can be formed for isolation purposes. Corresponding oxide layer cannot be formed in Ge.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2011]

23. The p-type epitaxial layer grown over an n-type substrate for fabricating a bipolar transistor will function as

(a) The collector of a $p-n-p$ transistor
(b) The base of an $n-p-n$ transistor
(c) The emitter of a $p-n-p$ transistor
(d) The collector contact for a $p-n-p$ transistor

[ESE-2011]

24. The biasing of an IC BJT is done by the following biasing scheme:

(a) Potential-divider biasing scheme
(b) Fixed biasing scheme
(c) Current mirror biasing scheme
(d) Collector to base feedback biasing scheme

[ESE-2011]

25. Statement (I): Concentration of acceptor atoms in the region between isolation islands will be much higher p^+ than in the p-type substrate in an integrated circuit.

Statement (II): This is to prevent the depletion region of the reverse-biased isolation to substrate junction from extending into p^+-type material.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

[ESE-2012]

26. Statement (I): Concentration of acceptor atoms in the region between isolation islands in a monolithic integrated circuit will be much higher than in the p-type substrate.

Statement (II): The higher density is provided to prevent the depletion region of the reverse biased isolation to substrate junction from extending into the p^+-type material.

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

(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

[ESE-2013]

27. When the photo resist coating (during IC fabrication) is exposed to ultraviolet light the photo resist becomes
(a) oxidized (b) ionized
(c) polymerized (d) brittle

[ESE-2015]

28. Statement (I): All passive components can be fabricated in a single chip.
Statement (II): As opposed to discrete circuits where all components are separately inserted and connected, in an integrated circuit, they are simultaneously created on a chip of semiconductor material during manufacturing.
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

[ESE-2017]

29. In VLSI n-MOS process, the thinox mask
(a) patterns the ion within the thinox region
(b) deposits polysilicon all over the thinox region
(c) patterns thickox regions to expose silicon where source, drain or gate areas are required
(d) grows thickox over thinox regions in gate areas

[ESE-2018]

30. In a 3-input CMOS NAND gate, the substrate terminals of NMOS transistors are grounded (lowest potential available in the circuit) and the substrate terminals of PMOS transistors are connected. to V_{DD} (maximum positive potential available in the circuit). Which of the following transistors may suffer in this circuit from body bias effect?
(a) 2 NMOS transistors
(b) 2 PMOS transistors
(c) 1 NMOS transistor
(d) 1 PMOS transistor

[ESE-2019]

31. The finite state machine in which
1. the output is a function of the current state and inputs
2. the output is a function of only the current state

Which of the following machines are respectively correct for these styles?
(a) Mealy machine and Moore machine
(b) Moore machine and Mealy machine
(c) State machine and Mealy machine
(d) State machine and State machine

[ESE-2019]

32. Which of the following are the advantages of Silicon over Insulator (SOI)?
1. Lower diffusion capacitance
2. Smaller parasitic delay and lower dynamic power consumption
3. Lower threshold voltages

Select the correct answer using the code given below.
(a) 1, 2 and 3 (b) 1 and 2 only
(c) 1 and 3 only (d) 2 and 3 only

[ESE-2019]

33. In EPROMs, applying a high voltage to the upper gate causes electrons to jump through the thin oxide onto the floating gate through the process known as
(a) mask programming
(b) one - time programming
(c) avalanche injection or Fowler - Nordheim tunneling
(d) erasing

[ESE-2020]

34. Which of the following steps are followed by HIS during synthesis?
1. Data model generation
2. Data flow analysis
3. Scheduling and allocation
4. Data path optimization
5. Control optimization
(a) 1, 3 and 5 only (b) 2, 4 and 5 only
(c) 1, 2, 3 and 4 only (d) 1, 2, 3, 4 and 5

[ESE-2020]

35. Pipelining
1. Reduces clock period of long combinational operations
2. Allows large combinational functions to be broken down into pieces whose delays are balanced with the rest of the system components
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

[ESE-2020]

36. Statement (I):
Control logic in CMOS is constructed using two-level SOP logic and multilevel logic.
Statement (II): Typical PLA uses multilevel logic.
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

[ESE-2020]

37. Silicon dioxide (SiO_2) is used in ICs, because it
(a) Facilitates the penetration of diffusants
(b) Has high heat conduction
(c) Prevents diffusion of impurities
(d) Controls the concentration of diffusants

[ESE-2021]

38. Consider the following statements regarding the Moore and Mealy models:
1. In the Mealy circuit, the final output depends only on the present state of memory elements.
2. In the Moore circuit, output can change in between the clock edges if the external inputs change.
3. The implementation of a logic function in Mealy circuit needs more number of states than Moore circuit.

Which of the above statements are not correct?
(a) 1 and 2 only (b) 1 and 3 only
(c) 1, 2 and 3 (d) 2 and 3 only

[ESE-2021]

39. Consider the following statements for Poly-Si deposition:
1. Poly-Si layer is used for gate electrode of MOSFET because it has similar lattice constants with SiO_2.
2. Poly-Si layer used for gate electrode of MOSFET for the better mechanical stability due to different thermal expansion coefficients.
3. In VLSI circuits, interconnects can be completed in one or two metal levels.
4. Poly-Si is used for short interconnects.

Which of the above statements are correct?
(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 4 only
(d) 2, 3 and 4 only

[ESE-2021]

40. If each core in a 16-core processor has a yield of 90% and nothing else on the chip fails, what is the yield of the chip?
(a) $(0.9)^8$ (b) $(0.9)^{16}$
(c) $(0.1)^8$ (d) $(0.1)^{16}$

[ESE-2021]

41. Consider the following statements regarding Epitaxial Growth:
1. Thin layers are grown on a substrate wafer, this technique is known as epitaxial growth.
2. Physical vapour deposition is also called vapour phase epitaxy.
3. OMCVD is a technique to grow epitaxial layers from metalorganic compounds.
4. High throughout and slow deposition rate are the disadvantages of the CVD technique.

Which of the above statements are correct?
(a) 2 and 3 only (b) 1 and 3 only
(c) 1, 3 and 4 only (d) 1, 2 and 3 only

[ESE-2021]

42. Which one of the following statements is correct regarding integrated circuit fabrication?
(a) IC offers increased reliability, improved performance, high speed and lower power consumption.
(b) IC is a miniature, low cost electronic circuit fabricated on a multi crystal chip of silicon.
(c) IC is a miniature, high cost electronic circuit fabricated on a multi crystal chip of silicon.
(d) IC offers decreased reliability, improved performance, low speed and higher power consumption.

[ESE-2022]

43. Which one of the following technologies consumes less power?
(a) Surface-mount technology
(b) CMOS
(c) NMOS
(d) PMOS

[ESE-2022]

44. Which one of the following requires additional process steps in their fabrication?
(a) Thin film resistor (b) Epitaxial resistor
(c) Pinched resistor (d) Junction resistor

[ESE-2022]

45. In monolithic integrated circuits, the concentration of acceptor atoms in the region between isolation islands will be

(a) much higher than in the p-type substrate
(b) much lesser than in the p-type substrate
(c) equal to the p-type substrate
(d) not equal to the p-type substrate

[ESE-2022]

46. Consider the following statements regarding MOS circuit design process:

1. MOS circuits are formed on four basic layers: n-diffusion, p-diffusion, polysilicon and metal, which are isolated from one another by thick or thin silicon dioxide insulating layers.
2. Thin oxide (thinox) mask region includes n-diffusion, and transistor channels, p-diffusion
3. Polysilicon and thinox regions interact so that a transistor is formed where they cross one another.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

[ESE-2022]

47. The ratio of total number of transistors on the chip to the number of transistor circuits that must be designed in detail is known as

(a) capacity
(b) regularity
(c) design efficiency
(d) design density

[ESE-2023]

48. The power dissipation under constant field after scaling on MOS device characteristics is

(a) $\frac{P}{S}$ (b) $\frac{2P}{S^2}$
(c) $\frac{P}{S^2}$ (d) $\frac{P}{2S^2}$

[ESE-2023]

49. Source/Drain region's doping concen-tration value used for analysis and simulation of short-channel SOI MESFET is

(a) $10^{10}\ cm^{-3}$ (b) $10^{20}\ cm^{-3}$
(c) $10^{15}\ cm^{-3}$ (d) $10^{25}\ cm^{-3}$

[ESE-2024]

50. In which one of the following is it used that the particular operating wavelength can be selected at the time of device fabrication by an appropriate choice of the reflector spacing?

(a) Distributed feedback laser
(b) Fabry-Perot laser
(c) Tunable lasers
(d) A vertical cavity surface emitting laser

[ESE-2024]

51. Consider the following statements for an edge-emitting laser:

1. For small threshold current, Γ should be small to make the best use of the material gain.
2. A thick low band gap active region. (large Γ) leads to increased losses by internal absorption α_i.
3. For large material gain, the quantum well thickness should be large.
4. Absorption losses are often caused by absorption in the high band gap outer barriers forming the waveguide.

Which of the above statements are correct?

(a) 1 and 4 only (b) 1, 2, 3 and 4
(c) 1 and 3 only (d) 2 and 4 only

[ESE-2024]

52. Consider the following statements:

1. The VLSI circuit (all the devices and their interconnections) is fabricated on a die. In a single wafer, there are always two dies. The complete one VLSI circuit is equally distributed (fabricated) on each die.
2. Modern technologies use a diamond saw to separate the dies from the wafer.
3. A suitable compound material is used to package the die to provide protection to the die from environmental damage, to prevent the interface to the outside world, to provide the cooling of heat generated due to power dissipation.

Which of the above statements is/are correct?

(a) 1 and 2 (b) 2 and 3
(c) 2 only (d) 3 only

[ESE-2024]

53. Consider the following statements regarding the VLSI design:

1. Parallelism and pipelining have been effective ways to reduce power consumption.
2. Replacing a single functional unit with an N-stage pipelined unit reduces the amount of logic in a lock cycle at the expense of more registers.
3. When leakage is unimportant, parallelism offers a slight edge because the multiplexer has less overhead than the pipeline registers.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

[ESE-2024]

54. Consider the following statements regarding the sequential circuit:

1. The Moore model sequential circuit is called transition-assigned circuit.
2. In the Mealy model sequential circuit, the output is associated with the state transitions, that is, the arcs in the state diagram.
3. In the Moore model sequential circuit, outputs are the functions of both, the inputs and the present state.

Which of the above statements are not correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

[ESE-2025]

55. Which one of the following, a polycrystalline material of high purity, is the raw material for the preparation of single-crystal silicon?

(a) Electronic Grade Silicon (EGS)
(b) Metallurgical Grade Silicon (MGS)
(c) Float Zone Silicon (FZS)
(d) Raw Silicon (RS)

[ESE-2025]

56. For a 1000 μm long bond pad locus, the number of bond pads placed on a 100 μm pitch along a bond pad will be

(a) 10 (b) 11
(c) 12 (d) 13

[ESE-2025]

57. Which one of the following incorporates both level sensitivity and the scan path approach using shift registers?

(a) Built-in logic block observer
(b) Built-in test
(c) Level-sensitive scan design
(d) I_{DQ} test

[ESE-2025]

58. Which kind of deposition has traditionally been done at higher temperatures to ensure that all the Si atoms deposited are incorporated into lattice sites in order to obtain a single-crystal thin film?

(a) Epitaxial Si deposition
(b) Polysilicon deposition
(c) Silicon nitride deposition
(d) Silicon dioxide deposition

[ESE-2025]

59. Statement (I): Electron lithography offers higher resolution than optical lithography.
Statement (II): Electron lithography has small wavelength of the 10-50 keV electrons.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(b)	(d)	(a)	(b)	(b)	(b)	(b)	(d)	(c)	(a)
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
(a)	(b)	(a)	(c)	(c)	(b)	(a)	(a)	(a)	(d)
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
(a)	(a)	(a)	(c)	(a)	(a)	(c)	(d)	(c)	(a)
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
(a)	(a)	(c)	(d)	(c)	(c)	(c)	(c)	(c)	(b)
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
(b)	(a)	(b)	(a)	(a)	(d)	(b)	(c)	(b)	(a)
51	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	
(d)	(b)	(d)	(b)	(a)	(a)	(c)	(a)	(a)	

EXPLANATIONS

1. Explanation: (b)
The correct sequence is
1. Lithography
2. Oxidation
3. Diffusion
4. Epitaxy

2. Explanation: (d)
Moore's law states that, the number of transistors on an integrated circuit (IC) doubles approximately every 18 - 24 months. This is about the level of integration of MOS devices.

3. Explanation: (a)
For fabricating BJT in IC by epitaxial process, Number of diffusion required is 2

4. Explanation: (b)
The heavily doped n^+ buried layer on the p - type substrate is the method to reduce the collector series resistance.

5. Explanation: (b)
Step 1: Recall constant voltage scaling
- Scaling factor $= \alpha > 1$
- Dimensions → scaled by 1/α
- Supply voltage remains constant

Step 2: Gate area scaling
Gate area $A_g = L \times W$
- L → L/α
- W → W/α

So:

$$A_g \rightarrow \frac{L}{\alpha} \times \frac{W}{\alpha} = \frac{LW}{\alpha^2}$$

6. Explanation: (b)

In IC fabrication, metallization refers to depositing a thin metal layer to create the interconnection pattern that connects transistors, resistors, and capacitors on the chip, along with bonding pads for external connections.

7. Explanation: (b)

- **CZ method**: melt in quartz crucible → introduces oxygen contamination**.**
- **FZ method**: uses RF heating, no crucible → gives very low oxygen content**.**
- **FZ method**: allows precise and uniform doping by controlling the molten zone.
- **CZ method**: more suitable for large diameter crystals.
- **CZ method**: cheaper.

8. Explanation: (d)

$$Y(p) = \frac{p^4 X(p)}{[p^4 + p + 1]}$$

9. Explanation: (c)

Key facts about diffusion profiles are

- Constant source diffusion:
  → Surface concentration remains constant.
  → Impurity concentration profile follows the complementary error function.
- Limited source diffusion:
  → Dopants redistribute.
  → Profile follows a Gaussian distribution.

10. Explanation: (a)

A. Reverse bias p - n junction isolation

- Uses reverse - biased p - n junctions to isolate devices.
- Characteristic: introduces bias-dependent parasitic capacitance.
- So A → 4

B. Resistive isolation using bulk resistivity

- Uses high - resistivity substrate to separate devices.
- Characteristic: requires large area, increases IC size.
- So B → 1

C. Native oxide isolation

- Thin oxide grown naturally on silicon surface.
- Characteristic: best for silicon ICs with low parasitic capacitance.
- So C → 2

D. Oxide isolation

- Thick oxide grown for isolation, can be used in III-V ICs.
- So D → 3

11. Explanation: (a)

Facts about X - ray lithography

1. High resolution

- X-rays have very short wavelength, so features as small as tens of nm can be patterned.

2. Scattering effects

- Compared to UV light, X - rays scatter less in the resist, so edge blurring is reduced.

3. Can be focused easily

- X - rays cannot be easily focused using lenses.

4. Can be deflected easily

- X - rays are difficult to deflect; mirrors or gratings are needed, so not easy.

12. Explanation: (b)

- The buried n^+ layer is heavily doped and placed under the collector**.**
- Its purpose is to provide a low - resistance path from the collector to the substrate contact.
- This reduces the collector series resistance, improving transistor performance.

13. Explanation: (a)

A typical wafer of doped Si may be 400 µm thick, 5 - 15 cm diameter, because purity matters a lot in ICs. Only high - purity single - crystal Si is used, polycrystalline or impure Si is not suitable. Hence, This statement is incorrect.

14. Explanation: (c)

Assertion (A): *An IC is more reliable than its discrete circuit equivalent.*

- True. ICs have fewer interconnections, no hand - soldered joints, and are less prone to mechanical failures.

Reason (R): *All the joints in an IC are soldered simultaneously.*

- False. In ICs, the internal connections are made by metallization and diffusion, not by soldering. Soldering is only for connecting IC package pins externally.

Hence, A is true but R is false

15. Explanation: (c)

In IC design, the primary goal is to minimize chip area, because smaller chips:

- Reduce cost
- Improve yield
- Improve performance

The choice of components is made to achieve functionality with minimum area**.**

16. Explanation: (b)

Assertion (A): *Resistors and capacitors in ICs have poor tolerances with respect to their absolute values.*

True. Absolute values of resistors/capacitors vary due to process variations.

Reason (R): *As all components are fabricated simultaneously, their ratio of tolerances is very low.*

True. While absolute values vary, ratios of components are very accurate, because they are fabricated together.

- The reason explains that A is not a problem for circuit design - ratios are important, absolute values are less critical.
- So R is not the explanation of A.

17. Explanation: (a)

MOS capacitor and Collector Substrate capacitor

18. Explanation: (a)

- SiO_2 is used as a masking layer during diffusion or ion implantation.
- It protects the silicon surface from contaminants.
- It allows selective formation of n^- and p^- regions, because windows can be opened in SiO_2 where diffusion is desired.

19. Explanation: (a)

The variety of manufacturing processes by which devices are fabricated, takes place through a single plane

20. Explanation: (d)

Epitaxy: Deposition of a thin layer of semiconductor on a single - crystal substrate so that the deposited layer follows the crystal orientation of the substrate.

Other processes:

- Ion implantation → introduces dopants into the crystal lattice, does not grow a layer
- Chemical vapor deposition → can deposit layers, but not necessarily single - crystal continuation unless it is epitaxial CVD
- Electroplating → metal deposition, not single - crystal semiconductor

21. Explanation: (a)

The maximum concentration of an element that can dissolve in solid silicon at a given temperature is called solid solubility**.** The maximum concentration of a dopant that can be incorporated in a solid semiconductor without forming a second phase. Other terms are not standard in semiconductor physics.

22. Explanation: (a)

Assertion (A): Si is mainly used for making ICs and not Ge.

True. Most ICs are made using silicon.

Reason (R): Si forms SiO_2 for isolation; Ge cannot form a corresponding oxide.

True. SiO_2 is an excellent insulator, GeO_2 is water - soluble and not suitable for IC isolation. Hence, R correctly explains that Si is preferred over Ge.

23. Explanation: (a)

The p - type epitaxial layer grown over an n - type substrate functions as the collector of $p-n-p$ transistor.

24. Explanation: (c)

Current mirror biasing scheme is used in an IC BJT to reduce fabrication space.

25. Explanation: (a)

The depletion width in a region decreases, because doping concentration increases. Since, concentration of acceptor atoms is higher, depletion region does not extend more into the p^+ substrate.

26. Explanation: (a)

Statement (I): *Concentration of acceptor atoms in the region between isolation islands in a monolithic IC will be much higher than in the p - type substrate.*

True. This **p^+ region** is heavily doped to prevent unwanted conduction paths.

Step 2: Statement (II): *The higher density is provided to prevent the depletion region of the reverse - biased isolation - to - substrate junction from extending into the p^+-type material.*

- True. A heavily doped p^+ region ensures that the depletion region extends mainly into the lightly doped substrate, not the p^+ region, preventing leakage and parasitic conduction.
- Hence, Statement (II) correctly explains Statement (I).

27. Explanation: (c)

Photoresist is a light - sensitive material used in lithography.

There are two types:

1. Positive photoresist → UV exposure breaks polymer chains, making the exposed region soluble in developer.
2. Negative photoresist → UV exposure polymerizes the exposed region, making it insoluble in developer.

Since, the question is about the photoresist coating, it refers to negative photoresist, that polymerizes upon UV exposure.

28. Explanation: (d)

Statement (I): *All passive components can be fabricated in a single chip.*

False. While resistors, capacitors, and inductors can be fabricated on-chip, some inductors and high-value capacitors are difficult to fabricate in ICs. So, not all passive components can be fabricated.

Statement (II): *In an IC, components are simultaneously created on a semiconductor chip during manufacturing, unlike discrete circuits.*

True. This is the **main advantage of IC fabrication**, devices are fabricated simultaneously using photolithography, diffusion, etc.

Correct Answer: (d) Statement (I) is false but Statement (II) is true

29. Explanation: (c)

In VLSI n-MOS process, the thinox mask implantation patterns thickox regions to expose silicon where source, drain or gate areas are required

30. Explanation: (a)

2 NMOS transistors

31. Explanation: (a)

In digital design, finite state machines are classified based on how their outputs depend on inputs and states:

1. Mealy Machine

- Output is a function of the current state *and* inputs
- Output can change immediately with input changes.

- More responsive, but can be more complex to design.

2. Moore Machine

- Output is a function of the current state *only*
- Output changes only on state transitions, making it simpler and more stable.

32. Explanation: (a)

The advantages of Silicon over Insulator are

1. Lower diffusion capacitance
2. Smaller parasitic delay and lower dynamic power consumption
3. Lower threshold voltages

33. Explanation: (c)

In EPROMs programming is done by applying a high voltage to the control gate. This causes electrons to be injected onto the floating gate. The electrons pass through a thin oxide layer using Avalanche injection or Fowler - Nordheim tunnelling. These are quantum mechanical processes used to trap charge on the floating gate, effectively storing data.

34. Explanation: (d)

In High-Level Synthesis - also known as Behavioral Synthesis - the following key steps are involved:

1. **Data Model Generation:** This step involves converting high-level code into an **intermediate representation** suitable for analysis and transformation.
2. **Data Flow Analysis:** This step analyzes the **dependencies and flow of data** in the design. It's essential for **understanding the operations and their timing relationships**, enabling optimizations.
3. **Scheduling and Allocation:** Involves determining **when** and **where** operations should occur:

- Scheduling: Assigning operations to control steps or clock cycles.
- Allocation: Assigning hardware resources like ALUs, registers, and buses.

4. **Data Path Optimization:** After scheduling and allocation, **optimizing the data path** improves **area, speed, and power**.
5. **Control Optimization:** Focuses on generating an **efficient control unit**, which manages the sequencing of operations. Optimizations help **reduce complexity and improve timing**.

35. Explanation: (c)

Pipelining is a fundamental technique used in digital design to improve performance by dividing a long combinational operation into smaller stages separated by registers.

Statement 1: Reduces clock period of long combinational operations

- By breaking a long combinational path into shorter segments and inserting registers, each stage has less delay.
- This allows the system to operate with a shorter clock period.

Statement 2: Allows large combinational functions to be broken down into pieces whose delays are balanced with the rest of the system components

- One of the goals in pipelining is delay balancing across all pipeline stages.
- Ensures that no single stage becomes a bottleneck, improving overall throughput and efficiency.

Hence, both statements are correct.

36. Explanation: (c)

Statement (I): Control logic in CMOS is constructed using two-level SOP logic and multilevel logic.

- CMOS control logic can be designed using both two-level logic and multilevel logic.
- Two-level SOP is common for smaller or straightforward logic, while multilevel logic is used for optimizing performance, area, or power in complex circuits.

Statement (II): Typical PLA uses multilevel logic.

- PLA is based on two-level logic — typically implemented as:
- First level: AND plane to form minterms
- Second level: OR plane to sum those minterms
- It's a classic example of two-level SOP implementation, not multilevel logic.

Hence, statement (I) is true but statement (II) is false

37. Explanation: (c)

Silicon dioxide plays a crucial role in integrated circuits due to its excellent insulating and diffusion barrier properties. It acts as a mask during diffusion and ion implantation processes, preventing unwanted impurities from penetrating into certain regions of the silicon substrate. It also serves as a gate dielectric in MOSFETs due to its insulating nature.

38. Explanation: (c)

Statement 1: In the Mealy circuit, the final output depends only on the present state of memory elements.

- In a Mealy machine, the output depends on both the present state and the current input.
- So, this statement is false - it's actually describing a Moore machine behavior incorrectly as a Mealy one.

Statement 2: In the Moore circuit, output can change in between the clock edges if the external inputs change.

- In a Moore machine, the output depends only on the current state, which is updated on clock edges.

- Hence, outputs in a Moore machine do not change between clock edges - they only change when the state changes, i.e., on clock transitions.
- So this statement is also false.

Statement 3: The implementation of a logic function in Mealy circuit needs more number of states than Moore circuit.

- It's the other way around: Moore machines often need more states than Mealy machines because outputs are tied to states only, not inputs.
- Mealy machines can often achieve the same functionality with fewer states by using inputs in the output logic.

Hence, all the three statements are incorrect.

39. Explanation: (c)

1. Polysilicon has similar lattice constants with sio_2.
2. Polysilicon is used for short interconnect only for long interconnect metal is used.
3. Metallization interconnection is completed in multiple levels of metals.

Hence, statement 1 and 4 are correct.

40. Explanation: (b) Given:

- Each core has a 90% yield ⇒ Probability that a single core is functional = 0.9
- The chip has 16 cores, and the chip is only considered functional if all 16 cores work.
- No other part of the chip affects the yield.

So, the total chip yield = Probability that all 16 cores work This is

Yield of chip = $(0.9)^{16}$

41. Explanation: (b) Statement 1: Thin layers are grown on a substrate wafer, this technique is known as epitaxial growth.

- This is the definition of epitaxy: a crystalline layer grown on a crystalline substrate, where the grown layer maintains the crystal orientation.

Statement 3: OMCVD is a technique to grow epitaxial layers from metalorganic compounds.

- OMCVD stands for Organometallic Chemical Vapor Deposition, used for epitaxial growth using organometallic precursors.

Hence, statement 1 and 3 are correct.

42. Explanation: (a)

Advantages of Integrated Circuits are

- Increased reliability – Fewer interconnections means fewer failure points.
- Improved performance – High-speed signal transmission and close packing of components.
- High speed – Due to small size and reduced parasitic elements.
- Lower power consumption – Smaller components and shorter interconnects reduce power needs.

43. Explanation: (b)

CMOS technology is known for very low static power consumption because power is consumed only during switching, and in the steady state very little current flows. This makes CMOS ideal for battery-powered and energy-efficient devices.

44. Explanation: (a)

Thin film resistors are fabricated by depositing a thin layer of resistive material onto an insulating substrate or directly on silicon. This process requires:

- Additional photolithography and masking steps
- Vacuum deposition
- Trimming to achieve precise resistance values

These are the steps required for IC fabrication, making thin film resistors more accurate but also more complex to fabricate.

45. Explanation: (a) The region between isolation islands is the p^+ region used to isolate n-wells or devices. This p^+ region has a much higher acceptor concentration than the original p-type substrate. A high concentration is necessary to form a good reverse-biased junction for electrical isolation. So, substrate and isolation regions should be lightly doped p-type and heavily doped p^+ respectively. Hence, the acceptor concentration between isolation islands is much higher than in the substrate.

46. Explanation: (d) Statement 1

- These are the primary layers in MOS fabrication.
- The insulating layers separate conducting layers such as metal, polysilicon, and diffusion regions.

Statement 2

- The thin oxide region is where transistors are formed - it includes:

- n-diffusion and p-diffusion for source/drain terminals
- transistor channels, where the gate controls conduction

- The thinox region defines where the gate oxide is thin enough for proper transistor operation.

Statement 3

- A MOS transistor is formed where polysilicon crosses over the thin oxide region on the substrate. This is the active area of the transistor.

Hence, all the given statements are correct.

47. Explanation: (b) Regularity

48. Explanation: (c)

The power dissipation under constant field after scaling on MOS device is $\frac{P}{S^2}$.

49. Explanation: (b)

Source/Drain region's doping concentration value used for analysis and simulation of short-channel SOI MESFET is $10^{20}\ \text{cm}^{-3}$.

50. Explanation: (a)

In a Distributed Feedback Laser:

- A grating is embedded along the length of the laser cavity.
- This grating acts as a distributed Bragg reflector, providing feedback at a specific wavelength.
- The operating wavelength is determined by the grating period and the effective refractive index.

Hence, by choosing the grating space during fabrication, the laser wavelength is fixed and precisely selected.

51. Explanation: (d)

Statement 2: A thick low band gap active region (large Γ) leads to increased losses by internal absorption α_i.

A **thick active region** with **low band gap** may absorb more photons outside the lasing transition, leading to **higher internal absorption (α_i)**. So, while increasing Γ can help gain, it can also increase loss if the active region is too thick or not properly designed.

Statement 4: Absorption losses are often caused by absorption in the high band gap outer barriers forming the waveguide. Although the outer barriers are typically made of higher band gap materials**,** defects, impurities, or tail states can cause residual absorption**.** So, absorption in waveguide layers can contribute to internal loss, especially in imperfectly grown structures.

Hence, statements 2 and 4 are correct.

52. Explanation: (b)

Statement 2: *Modern technologies use a diamond saw to separate the dies from the wafer.*

- A diamond saw is commonly used to dice the wafer into individual dies.
- Diamond is used due to its hardness and precision.

Statement 3: *A suitable compound material is used to package the die to provide protection to the die from environmental damage, to prevent the interface to the outside world, to provide the cooling of heat generated due to power dissipation.*

- The main roles of IC packaging include:
  - Protection from physical and environmental damage
  - Electrical interface to the outside world
  - Heat dissipation

Hence, statements 2 and 3 are correct.

53. Explanation: (d)

Statement 1: *Parallelism and pipelining have been effective ways to reduce power consumption.*

- While these techniques are often used to increase performance, they also help in reducing power when:
  - Operating at lower clock frequencies
  - Spreading computation over time or multiple units
- Power ∝ Capacitance × Voltage² × Frequency → Lowering frequency reduces power.

Statement 2: *Replacing a single functional unit with an N-stage pipelined unit reduces the amount of logic in a clock cycle at the expense of more registers.*

Pipelining splits a long logic path into shorter stages.

- This reduces logic depth per stage, enabling higher clock frequency.
- However, each stage requires pipeline registers, adding area and some dynamic power.

Statement 3: *When leakage is unimportant, parallelism offers a slight edge because the multiplexer has less overhead than the pipeline registers.*

- If leakage power is negligible, parallelism can be more power-efficient than pipelining.
- This is because parallel units use multiplexers while pipelining introduces registers at every stage.
- So, in such cases, parallelism has an edge.

Hence, All the statements are correct.

54. Explanation: (b)

Statement 1: *The Moore model sequential circuit is called transition-assigned circuit.*

- In the Moore model, outputs depend only on the present state, not on transitions.
- The term transition-assigned is typically associated with the Mealy model, where outputs are assigned on transitions**.**

Statement 2: *In the Mealy model sequential circuit, the output is associated with the state transitions, that is the arcs in the state diagram.*

- In the Mealy model, output is a function of the present state and input**.**
- Hence, the output is indeed associated with the transitions.

Statement 3: *In the Moore model sequential circuit, outputs are the functions of both, the inputs and the present state.*

- In the Moore model, the output is only a function of the present state**,** not the inputs.

Hence, statement (I) and statement (III) both are true.