GATE QUESTIONS

SUBJECT: COMMUNICATION THEORY

UNIT 1

AMPLITUDE MODULATION

1. In commercial TV transmission in India, picture and speech signals are modulated respectively

	(Picture)	(Speech)
(a)	VSB	VSB
(b)	VSB	SSB
(c)	VSB	FM
(d)	FM	VSB

Soln. Note that VSB modulation is the clever compromise between SSB and DSB. Since TV bandwidth is large so VSB is used for picture transmission. Also, FM is the best option for speech because of better noise immunity

Ans: Option (c)

2. In a double side-band (DSB) full carrier AM transmission system, if the modulation index is doubled, then the ratio of total sideband power to the carrier power increases by a factor of________.

Soln : The AM system is Double side band (DSB) with full carrier. The expression for total power in such modulation signal is

$$P_t = \frac{E_{c^2}}{2R} + \frac{\mu^2}{4}\frac{E_{c^2}}{2R} + \frac{\mu^2}{4}\frac{E_{c^2}}{2R} \qquad P_t = P_C + \frac{\mu^2}{2}P_C \qquad P_{SB} = \frac{\mu^2}{2}P_C$$

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

Now if μ (modulation index) is doubled then P_{SB}/P_C Will be 4 times

Ans: factor of 4

3. A 4 GHz carrier is amplitude-modulated by a low-pass signal of maximum cut off frequency 1 MHz. If this signal is to be ideally sampled, the minimum sampling frequency should be nearly

(A) 4 MHz (B)4 GHz (C) 8 MHz (D) 8 GHz

$f_s = 2f_m$; = 2 x 4 GHz ; = 8GHz

Ans : D

4. The maximum power efficiency of an AM modulator is

(A) 25% (B) 33% (C) 50% (D) 100%

Soln: Efficiency of modulation can be given as

$$\eta = \frac{P_S}{P_C + P_S} = \frac{\mu^2/_2 P_C}{P_C + \frac{\mu^2}{2} P_C} \qquad \frac{\mu^2/_2}{1 + \mu^2/_2} = \frac{\mu^2}{(2 + \mu^2)}$$

μ=1 is the optimum value

$$\eta = \frac{1}{2+1} = \frac{1}{3} \times 100 = 33\%$$

Ans: B

5. Consider sinusoidal modulation in an AM systems. Assuming no over modulation , the modulation index (μ) when the maximum and minimum values of the envelope, respectively, are 3V and 1V is ________
Sol: As given is the problem the modulation is sinusoidal this is also called tone modulation. There is no over modulation means that modulation index is less than or equal to 1. In such case the formula for modulation index is given by

$$\mu = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}$$

Where Emax is the maximum value of the envelope , Emin is the minimum value of the envelope.

$$\mu = \frac{3-1}{3+1} = \frac{2}{4} = \frac{1}{2} = 0.50$$

Ans : Modulation index is 0.50

6. An AM super heterodyne receiver with IF of 455 kHz is tuned to the carrier frequency of 1000 kHz. The image frequency is

(A) 545 kHz (B) 1 MHz (C) 1455 kHz (D)1910 kHz

$f_{si} = f_s + 2f_i$

= 1000 + 2 x 455

f_{si} = 1910 kHz

Ans : D

7. VSB modulation is preferred in TV because

A. it reduces the bandwidth requirement to half
B. it avoids phase distortion at low frequencies
C. it results in better reception
D. None of the above
Sol : VSB (vestigial side band) transmission transmits one side band fully and the other side band partially thus, reducing the bandwidth requirement.
Ans : A

8. In FM signal with a modulation index m_f is passed through a frequency tripler. The wave in the output of the tripler will have a modulation index of
A. m_f B. $3m_f$ C. $m_f/3$ D. $m_f/9$
Soln: Frequency multiplier increase the deviation,

$\beta = \Delta f/fm$
If multiplied by three,3 $\beta = 3\Delta f/fm$
Ans: B

9. Suppose that the modulating signal is (t) = 2 $\cos(2\pi f_m t)$ and the carrier signal is $x_C(t) = AC\cos(2\pi f_c t)$.Which one of the following is a conventional AM signal without over-modulation?
(a) (t) = $A_C m(t)\cos(2\pi f_c t)$
(b) (t) = $A_C[1 + m(t)]\cos(2\pi f_c t)$
(c) (t) = $A_C\cos(2\pi f_c t) + A_C/4\, m(t)\cos(2\pi f_c t)$
(d) (t) = $A_C\cos(2\pi f_m t)\cos(2\pi f_c t) + AC\sin(2\pi f_m t)\sin(2\pi f_c t)$
Sol:
Given
Modulation signal (t) = 2 $\cos(2\pi f_m t)$, Carrier signal $x_C(t) = AC\cos(2\pi f_c t)$. Note that conventional AM is DSB – FC (DSB full carrier) . Standard Expression is given by
$e(t) = E_c(t)\,[1+m(t)]\cos 2\pi f_c t$ – I
Option (b) is (t) = [1 + (t)] $\cos(2\pi f_c t)$
Comparing this expression with the standard one given equation (I) We get μ = 2 i.e. conventional AM with over modulation.
Option (c) (t) = $A_C\cos(2\pi f_c t) + A_C/4\, m(t)\cos(2\pi f_c t)$
(t) = $A_C\cos(2\pi f_c t)[1+ 1/4\ (2\cos(2\pi f_m t))\ ]$
(t) = $A_C\cos(2\pi f_c t)[1+ 1/2(\cos(2\pi f_m t))\ ]$
Here $\boldsymbol{\mu}$ = ½
So, this represents conventional AM without over modulation.
Ans: C

10. For a message signal (t) = $\cos(2\pi f_c t)$ and carrier of frequency f_c. Which of the following represents a single side-band (SSB) signal?
(a) $\cos(2\pi f_m t)\cos(2\pi f_c t)$ (b) $\cos(2\pi f_c t)$ (c) $\cos(2\pi(f_c + f_m)t$ (d) $[1 + \cos(2\pi f_m t)].\cos(2\pi f_c t)$
Sol:
Option (a) in the problem represents AM signal DSB-SC. If will have both side bands
option (b) represents only the carrier frequency
Option (c), $\cos(2\pi(f_c + f_m)t$ represents upper side band (SSB-SC). It represent SSB signal
Option (d) represents the conventional AM signal
Ans. Option (c)

11. A DSB-SC signal is generated using the carrier $\cos(2\pi f_c t + \theta)$ and modulating signal x(t). The envelop of the DSB-SC signal is
(a) x(t) (b) $|x(t)|$ (c) Only positive portion of x(t) (d) $x(t)\cos\theta$
Sol: Given
Carrier $c(t) = \cos(2\pi f_c t + \theta)$
Modulating signal m(t) = x(t)
DSB SC modulated signal is given by m(t).c(t) = s(t)
$= \cos(2\pi f_c t + \theta)x(t)$
$= x(t)\ \{\cos 2\pi f_c t\cos\theta - \sin 2\pi f_c t\sin\theta\}$
$= x(t)\cos 2\pi f_c t\cos\theta - x(t)\sin 2\pi f_c t\sin\theta$
Envelope = $\sqrt{[\ (\ )\ ] - [\ (\ )\ ]}$
= x(t)
Ans : b

12. A 1 MHz sinusoidal carrier is amplitude modulated by a symmetrical square wave of period 100 µsec. Which of the following frequencies will not be present in the modulated signal?
(a) 990 kHz (b) 1010 kHz (c) 1020 kHz (d) 1030 kHz
Soln. Frequency of carrier signal is 1MHz. Modulation signal is square wave of period 100 µS.

Frequency = 1/(100*10^-6) = 10KHz
ince modulation signal is symmetrical square wave it will contain only odd harmonics i.e. 10 KHz, 30 KHz, 50 KHz -----etc.
Thus the modulated signal has Fc+fm and fc – fm = 1000+10 =1010 ; 1000-10 = 990
Fc+3fm = 1000+30 = 1030
So (c) will not be available

13. A message signal given by m(t) = (1/2) cos ω_1t - (1/2) sin ω_2t is amplitude modulated with a carrier of frequency ω_c to generate S(t) = [1 + m(t)] cosω_c t. What is the power efficiency achieved by this modulation scheme?

(a) 8.33% (b) 11.11% (c) 20% (d) 25%

Sol: Given
m(t) = (1/2) cos ω_1t - (1/2) sin ω_2t
s(t) = [1 + m(t)] cosω_c t
Note that the modulation frequency are $\boldsymbol{\omega}$1 and $\boldsymbol{\omega}$2i.e. multitone modulation
Net modulation index is μ = √
is μ = √ = 1/√2

$$\eta = \frac{\mu^2}{\mu^2+2} \times 100\% \quad = \frac{(1/\sqrt{2})^2}{(1/\sqrt{2})^2 +} \times 100\% = 20\%$$

Ans = c

14. A 4 GHz carrier is DSB-SC modulated by a low-pass message signal with maximum frequency of 2 MHz. The resultant signal is to be ideally sampled. The minimum frequency of the sampling impulse train should be

(a) 4 MHz (b) 8 MHz (c) 8 GHz (d) 8.004 GHz

Sol: Given fc = 4GHz and fm = 2 MHz
Such a signal is amplitude modulated (DSB-SC) i.e. two side bands = fc +fm and fc – fm
= 4002 and 3998 ; BW = 4 MHz
so, min. sampling frequency should be (Nyquist Rate) = 2 *4 MHz = 8MHz
Ans : b

15. AM broadcast station transmits modulating frequency upto 6KHz. If transmitting frequency is 810KHz, then maximum and lower sidebands are _________

a) 816KHz and 804KHz
b) 826KHz and 804KHz
c) 916KHz and 904KHz
d) Not possible

Sol:
Maximum frequency = 810 + 6 = 816KHz and Minimum frequency = 810 – 6 = 804KHz. Moreover it has a bandwidth of (816 – 804) = 12KHz.
Answer: a

16. Calculate power in each sideband, if power of carrier wave is 176W and there is 60% modulation in amplitude modulated signal?

a) 13.36W
b) 52W
c) 67W
d) 15.84W

Sol: Modulation index = 0.6 and Pc = 176W. Power in sidebands may be calculated as
$(m^2P_c)/4$ = 15.84 W
Ans: d

17. For 100% modulation, power in each sideband is________of that of carrier?
a) 50% b) 70% c) 60% d) 25%
Sol:
Modulation index = 1. Power in sidebands may be calculated as
$\frac{m^2 P_c}{4}$. So, power in each sideband is $\frac{1^2 P_c}{4}$ i.e. 25%.
Ans : d

18. Power of carrier wave is 500W and modulation index is 0.25. Find its total power?
a) 500W b) 415W c) 375W d) 516W
Sol: Total power, $P_t = 500(1+(0.25)^2/2) = 516W$.
Ans : d

19. A wave is modulated by two sin waves having modulation indices of 0.3 and 0.5. Find the total modulation index?
a) 0.1 b) 0.7 c) 0.58 d) 0.35
Sol:

Given that m1 = 0.3 and m2 = 0.5. Total modulation index will be equal to $\sqrt{m_1^2 + m_2^2}$. By substituting values we have $(\sqrt{0.3^2 + 0.5^2})$ which is equal to 0.58.
Ans : c

20. If modulation index of an AM wave is increased from 1.5 to 2, then the transmitted power ________
a) remains same
b) increases by 20%
c) increases by 41%
d) increases by 50%
Sol : When m=1.5, transmitted power
$(P_t) = P_c\ (1 + \frac{1.5^2}{2}) = 2.125P_c$ and when m = 2, $P_t = P_c\ (1 + \frac{2^2}{2}) = 3P_c$.

So increase = $\frac{3P_c - 2.125P_c}{2.125P_c} = 0.41$
Ans: c

21. . Consider the amplitude modulated (AM) signal $A_C \cos\omega_c t + 2\cos\omega_m t \cos\omega_c t$ For demodulating the signal using envelope detector, the minimum value of AC should be
(a) 2 (b) 1 (c) 0.5 (d) 0
Sol: Modulated signal is given as
$\varphi_A(t) = [A_C + 2\cos\omega mt]\ \cos\omega ct$
Note that for envelope detection the modulation should not go beyond full modulation i.e. $\mu = 1$, so amplitude of baseband signal has to be less than the carrier amplitude (Ac)
$|f(t)|max \le A_C$
$|2\cos\omega mt|max = 2 \le A_C$
Or $A_C >= 2$
Ans : a

22. Which of the following demodulator (s) can be used for demodulating the signal $x(t) = 5(1 + 2\cos 200\pi t)\cos 20000\pi t$
(a) Envelope demodulator (b) Square-law demodulator
(c) Synchronous demodulator (d) None of the above

Sol: If the given equation is compared with the standard equation

$X_{AM}(t) = A_c(1 + \mu \cos \omega_m t) \cos \omega_c t$ the value μ = 2

The modulation index is more than 1 here, so it is the case of over modulation. When modulation index is more than 1 (over modulation) then detection is possible only with, Synchronous modulation, such signal can not be detected with envelope detector.

Ans : (c)

23. The amplitude modulated wave form s(t) = $AC[1 + K_a m(t)] \cos\omega_C t$ is fed to an ideal envelope detector. The maximum magnitude of (t) is greater than 1. Which of the following could be the detector output?

(a) $A_c m(t)$ (b) $A_c^2[1 + K_a m(t)]^2$ (c) $|A_C[1 + K_a m(t)]|$ (d) $AC|1 + K_a m(t)|^2$

Sol: Given

| (t) |>| For the above condition the AM signal is over modulated. Envelope detector will not be able to detect over modulated signal correctly.

Ans: None of the above options

24. The diagonal clipping in Amplitude Demodulation (using envelope detector) can be avoided if RC time-constant of the envelope detector satisfies the following condition, (here W is message bandwidth and ω is carrier frequency both in rad/sec)

(a) $RC < 1/W$ (b) $RC > 1/W$ (c) $RC < 1/\omega$ (d) $RC > 1/\omega$

Sol: It is seen that to avoid negative peak clipping also said diagonal clipping the RC time constant of detector should be

$\tau < 1/f_m$

Note fm is maximum modulating frequency i.e. the bandwidth w

RC< 1/w

Ans: a

25. The image channel selectivity of super-heterodyne receiver depends upon

(a) IF amplifiers only

(b) RF and IF amplifiers only

(c) Pre selector, RF and IF amplifiers

(d) Pre selector and RF amplifiers

Sol: Image rejection depends on front end selectivity of receiver and must be achieved before If stage. So image channel selectivity depends upon pre selector & RF amplifier. If it enters IF stage it becomes impossible to remove it from wanted signal.

Ans: Option (d)

26. A super heterodyne radio receiver with an intermediate frequency of 455 KHz is tuned to a station operating at 1200 KHz. The associated image frequency is----------- KHz

Sol:

In most receivers the local oscillator frequency is higher than incoming signal i.e.

$f_0 = f_s + f_{si}$

f_0 – Local oscillator frequency f_s = Signal freq f_{si} = Image freq

$f_{si} = f_s + 2IF$

= 1200+910 = 2110 KHz

27. A message signal m(t) = cos 2000πt+4cos4000πt modulates the carrier c(t)= $\cos 2\pi f_c t$ and f_c= 1MHz to produce an AM Signal. For demodulating the generated AM signal using an envelope detector, the time constant RC of the detector circuit should satisfy

(a) 0.5 ms< RC < 1 ms (b) 1 μs << RC < 0.5 ms (c) RC<< 1 μs (d) RC >> 0.5 ms

Sol: Max frequency is 2KHz

So 1/fc << RC < 1/fm

⇨ 1/ 1 MHz << RC < 1/ 2KHz
⇨ 1μs << RC < 0.5 ms
⇨ Ans ..option (b)

28. The image channel selectivity of super- heterodyne receiver depends upon
(a) IF amplifiers only
(b) RF and IF amplifiers only
(c) Pre selector, RF and IF amplifiers
(d) Pre selector and RF amplifiers

Sol: Image rejection depends on front end selectivity of receiver and must be achieved before If stage. So image channel selectivity depends upon pre selector & RF amplifier. If it enters IF stage it becomes impossible to remove it from wanted signal.
Ans: Option (d)

29. An AM signal is detected using an envelope detector. The carrier frequency and modulation signal frequency are 1 MHz and 2 KHz respectively. An appropriate value for the time constant of the envelope detector is
(a) 500 μsec (b) 20 μsec (c) 0.2 μsec (d) 1 μsec
Sol: that the time constant RC should satisfy the following condition
1/fc << RC < 1/fm
⇨ 1/ 1 MHz << RC < 1/ 2KHz
⇨ 1μs < RC < 0.5 ms
⇨ Ans: option b

30. Which statement is true about emitter modulator amplifier for amplitude modulation?

a) operates in class A mode b) operates in class C mode c) has a high efficiency d) has a high output power

Answer: a

Explanation: Emitter modulator amplifier for AM operates in class A mode and also has a very low efficiency.

The output of this modulator is very small and therefore it is not suitable for modulation at high level.

UNIT 2

ANGLE MODULATION

1. Consider an FM wave $f(t) = \cos[2\pi f_c t + \beta_1 \sin 2\pi f_1 t + \beta_2 2\pi f_2 t]$. The maximum deviation of the instantaneous frequency from the carrier frequency fc is
(a) $\beta_1 f_1 + \beta_2 f_2$ (b) $\beta_1 f_2 + \beta_2 f_1$ (c) $\beta 1 + \beta 2$ (d) $f_1 + f_2$
Sol : The instantaneous value of the angular frequency
$\omega_i = \omega_c + d/dt(\beta_1 \sin 2\pi f_1 t + \beta_2 2\pi f_2 t)$
⇨ $\omega_c + \beta_1 2\pi f_1 \cos 2\pi f_1 t + \beta_2 2\pi f_2 \cos 2\pi f_2 t$
⇨ $f_i = f_c + \beta_1 f_1 \cos 2\pi f_1 t + \beta_2 f_2 \cos 2\pi f_2 t$
Frequency deviation $(\Delta_f)_{max} = \beta_1 f_1 + \beta_2 f_2$

Ans: Option (a)

2. A modulation signal is $y(t) = m(t) \cos(40000\pi t)$, where the baseband signal m(t) has frequency components less than 5 kHz only. The minimum required rate (in kHz) at which y(t) should be sampled to recover m(t) is ____
Sol: The minimum sampling rate is twice the maximum frequency called Nyquist rate
The minimum sampling rate (Nyquist rate) = 10K samples/sec

3. Consider an angle modulation signal x(t) = 6cos[$2\pi \times 10^3$ + 2 sin(8000πt) + 4 cos(8000πt)]V. The average power of x(t) is

(a) 10 W (b) 18 W (c) 20 W (d) 28 W

Sol: The average power of an angle modulated signal is

$A_c^2/2 = 6^2/2 = 18$ W

Ans: Option b

4. A 10 MHz carrier is frequency modulated by a sinusoidal signal of 500 Hz, the maximum frequency deviation being 50 KHz. The bandwidth required. as given by the Carson's rule is ___________

Sol: By carson's rule

BW = $2(\Delta_f + f_m)$

= 2(50+ 0.5)

= 101 KHz

5. v(t) = 5[cos($10^6\pi$t) – sin($10^3\pi$t) × sin($10^6\pi$t)] represents

(a) DSB suppressed carrier signal (b) AM signal (c) SSB upper sideband signal (d) Narrow band FM signal

Sol:

v(t) = 5[cos($10^6\pi$t) – 5/2 cos($10^6 - 10^3$)πt + 5/2 cos($10^6 + 10^3$)πt

Carrier and upper side band are in phase and lower side band is out of phase with carrier

The given signal is narrow band FM signal

Ans: Option (d)

6. The input to a coherent detector is DSB-SC signal plus noise. The noise at the detector output is

(a) the in-phase component (b) the quadrature-component (c) zero (d) the envelope

Sol:

The coherent detector rejects the quadrature component of noise therefore noise at the output has in phase component only.

Ans: Option (a)

7. Carrier swing is defined as

a. The total variation in frequency from the lowest to the highest point

b. Frequency deviation above or below the carrier frequency

c. Width of the side band

d. None of the above

Ans: (a) The total variation in frequency from the lowest to the highest point

8. Frequency deviation in FM is

a. Change in carrier frequency to the frequency above and below the centre frequency

b. Formation of side bands

c. The variation of the instantaneous carrier frequency in proportion to the modulating signal

d. All of the above

Ans: (d) All of the above

9. The amount of frequency deviation in FM signal depends on

a. Amplitude of the modulating signal

b. Carrier frequency

c. Modulating frequency

d. Transmitter amplifier

Ans: (a) Amplitude of the modulating signal

10. Amplitude limiter in FM receivers are used to

a. Remove amplitude variations due to noise b. Filteration

c. Demodulation d. Amplification

Ans: (a) Remove amplitude variations due to noise

11. Pre emphasis is done
a. For boosting of modulating signal voltage
b. For modulating signals at higher frequencies
c. In FM before modulation
d. All of the above
Ans: (d) All of the above

12. Pre emphasis is done before
a. Before modulation
b. Before transmission
c. Before detection at receiver
d. After detection at receiver
Ans: (a) Before modulation

13. What is the effect on the deviation d of an FM signal when it is passed through a mixer?
a. Doubles
b. Reduces
c. Becomes half
d. Remains unchanged
Ans: (d) Remains unchanged

14. The modulation index of FM is given by
a. μ = frequency deviation/ modulating frequency
b. μ = modulating frequency /frequency deviation
c. μ = modulating frequency/ carrier frequency
d. μ = carrier frequency / modulating frequency
Ans: (a) μ = frequency deviation/ modulating frequency

15. The audio signal having frequency 500Hz and voltage 2.6V, shows a deviation of 5.2KHz in a Frequency Modulation system. If the audio signal voltage changes to 8.6V, calculate the new deviation obtained.
a. 17.2 KHz
b. 19.6 KHz
c. 25.6 KHz
d. 14.6 KHz
Sol:

Deviation in FM is given by $\Delta f = k_f * A_m$
Therefore, $k_f = \Delta f / A_m$
= 5.2/2.6= 2
When voltage changes to 8.6V = A_m
New frequency deviation $\Delta f = k_f * A_m$
= 2* 8.6= 17.2 KHz

Ans: (a) 17.2 KHz

16. What is the change in the bandwidth of the signal in FM when the modulating frequency increases from 12 KHz to 24KHz?
a. 40 Hz
b. 58 Hz
c. 24 Hz
d. Bandwidth remains unaffected
Sol: According to Carson’s rule, the bandwidth required is twice the sum of the maximum frequency deviation and the maximum modulating signal frequency. Or,
$B=2(\Delta f + f_m)$ Hz
B= 2(Δf +12) Hz = 2 Δf + 24 Hz (1)
Assuming Δf to be constant,
B = 2 Δf + 48 Hz (2)
(2)-(1)= 24Hz
Therefore the bandwidth changes by 24Hz.
Ans: (c) 24 Hz

17. The range of modulating frequency for Narrow Band FM is
a. 30 Hz to 15 KHz
b. 30 Hz to 30 KHz
c. 30 Hz to 3 KHz
d. 3 KHz to 30 KHz
Ans: (c) 30 Hz to 3 KHz

18. Phase-locked loop can be used as
a. FM demodulator b. AM demodulator c. FM receiver d. AM receiver
Ans: (a) FM demodulator

19. Calculate the maximum frequency deviation for the FM signal
v(t) = 10 cos (6000t+ 5sin2200t)
a. 2200 Hz b. 6000 Hz c. 1750 Hz d. 11000 Hz
Sol: A standard FM signal is represented by
$v(t) = A_c \cos(2\pi f_c t + k_f \sin 2\pi f_m t)$
A_c = carrier amplitude
f_c = carrier frequency
k_f = modulation index
f_m = modulating frequency = 2200/2π = 350 Hz
k_f = frequency deviation/modulating frequency
5 = freq deviation/ 350
Therefore, deviation = 5 * 350
= 1750Hz

Ans: (c) 1750 Hz

20. Calculate the dissipation in power across 20Ω resistor for the FM signal
v(t)= 20 cos(6600t+ 10sin2100t)
a. 5W b. 20W c. 10W d. 400W
A standard FM signal is represented by
$v(t) = A_c \cos(2\pi f_c t + k_f \sin 2\pi f_m t)$
A_c = carrier amplitude f_c = carrier frequency
k_f = modulation index
f_m = modulating frequency
k_f = frequency deviation/modulating frequency
the power dissipated across 20Ω resistor is given by
V_{rms}^2/R
$=(20/\sqrt{2})^2/R$= 5W

Ans: (a) 5W
21. What is the value of carrier frequency in the following equation for the FM signal?
v(t)= 5 cos(6600t+ 12sin2500t)
a. 1150 Hz b. 6600 Hz c. 2500 Hz d. 1050 Hz
A standard FM signal is represented by
$v(t) = A_c \cos(2\pi f_c t + k_f \sin 2\pi f_m t)$
A_c = carrier amplitude
f_c = carrier frequency k_f = modulation index
f_m = modulating frequency
k_f = frequency deviation/modulating frequency
therefore, f_c = 6600/2π= 1050Hz

Ans: (d) 1050 Hz

22. Calculate the modulation index in an FM signal when f_m (modulating frequency) is 250Hz and Δf (frequency deviation) is 5KHz.
a. 20 b. 35 c. 50 d. 75
Sol:
Modulation index is the measure of how much the modulation parameter changes from its un modulated

value. The modulation index of FM is given by
μ = frequency deviation/ modulating frequency
= $\Delta f/ f_m$
Where Δf is the peak frequency deviation i.e. the deviation in the instantaneous value of the frequency with modulating signal.
f_m is the value of modulating frequency
μ = 5000/250 = 20
Ans: (a) 20

23. Maximum frequency deviation and the maximum bandwidth allowed for commercial FM broadcast is
a. 80KHz, 160Khz b. 75KHz, 200Khz c. 60KHz, 170Khz d. 75KHz, 250Khz
Ans: (b) 5KHz, 200Khz

24. Guard bands are provided in FM signal to
a. Prevent interference from adjacent channels b. To increase the noise
c. To increase bandwidth d. None of the above
Ans: (a) Prevent interference from adjacent channels

25. For a FM signal v(t) = 20 cos ($10 * 10^8 t + 30 \sin 3000t$), calculate the power dissipated by the FM wave in a 20Ω resistor.
a. 100 Watts b. 10 Watts c. 200 Watts d. 20 Watts
Sol:
Standard expression for FM signal is given by
$v(t) = A \cos (\Omega_c t + m_f \sin \Omega_m t)$
Comparing with the given equation,
A = 20
The dissipated power is given by $P = V^2_{rms}/R$
$= (20/\sqrt{2})^2/ 20$
= 10Watts

Ans: (b) 10 Watts

26. A 100MHz carrier is frequency modulated by 10 KHz wave. For a frequency deviation of 50 KHz, calculate the modulation index of the FM signal.
a. 100 b. 50 c. 70 d. 90
Sol:
Carrier frequency f_c = 100MHz
Modulating frequency f_m = 10 KHz
Frequency deviation Δf = 500 KHz
Modulation index of FM signal is given by
$m_f = \Delta f/f_m$
$= 500 * 10^3/ 10 * 10^3$
= 50

Ans: (b) 50

27. Narrow band FM has the characteristics:
a. The frequency sensitivity k_f is small b. Bandwidth is narrow
c. Both a and b d. None of the above
Ans: (c) Both a and b

28. Wide band FM has the characteristics:

a. The frequency sensitivity k_f is large
b. Bandwidth is wide
c. Both a and b
d. None of the above
Ans: (c) Both a and b

UNIT 3

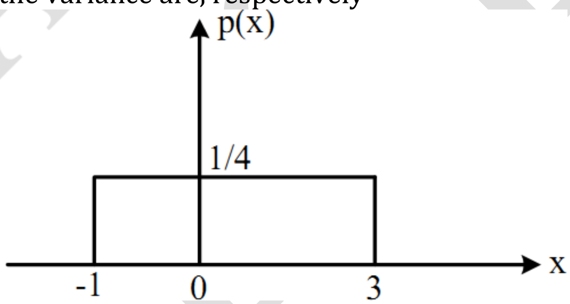
RANDOM PROCESSES

1. The variance of a random variable X is σ_x^2. Then the variance of −kX (where k is a positive constant) is
(a) σ_x^2 (b) $-k\,\sigma_x^2$ (c) $k\,\sigma_x^2\,2$ (d) $k^2\sigma_x^2$
Sol:
$\boldsymbol{V}ar(-kX) = E[(-kX)^2]$
$\boldsymbol{\sigma}^2 = E[k^2X^2] \quad = k^2E[X^2] \quad = k^2\sigma_x^2$
Ans: Option (d)

2. White Gaussian noise is passed through a linear narrow band filter. The probability density function of the envelope of the noise at the filter output is
(a) Uniform (b) Poisson (c) Gaussian (d) Rayleigh
Sol:
The narrow band representation of noise is $n(t) = n_c(t)\cos\omega_c t + n_s(t)\sin\omega_c t$
Its envelope is $\sqrt{n_c^2(t)+n_s^2(t)}$. $n_c(t)$ and $n_s(t)$are two independent zero mean Gaussian processes with same variance. The resulting envelope is Rayleigh variable
Ans: Option (d)

3. Events A and B are mutually exclusive and have nonzero probability.
Which of the following statement(s) are true?
(a) $(A\cup B) = P(A) + P(B)$
(b) $P(B^C) > P(A)$
(c) $(A\cap B) = P(A)P(B)$
(d) $P(B^C) < P(A)$
Sol
For mutually exclusive events A and B $(A\cup B) = (A) + P(B)$
Ans : a

4. For a random variable 'X' following the probability density function, p(x), shown in figure, the mean and the variance are, respectively



(a) 1/2 and 2/3 (b) 1 and 4/3 (c) 1 and 2/3 (d) 2 and 4/3
Sol
Mean or average of any random variable is known as expected value of random variable X

$$\boldsymbol{Mean = \mu_X = E[X] = \int_{-\infty}^{\infty} xP_X(x)dx}$$

$$= \int_{-1}^{3} x \frac{1}{4} dx = \frac{1}{4}\left[\frac{x^2}{2}\right]_1^3$$

$$= \frac{1}{4}\left[\frac{8}{2}\right] = 1$$

$$Variance = \sigma_x^2 = E[(X - \mu_X)] = \int_{-\infty}^{\infty} (x - \mu_X)^2 P_X(x) dx$$

$$= \int_{-1}^{3} (x-1)^2 \frac{dx}{4}$$

= 4/3

Ans : b

5. The auto-correlation function of an energy signal has

(a) no symmetry (b) conjugate symmetry (c) odd symmetry (d) even symmetry

Sol:

The auto correlation is the correlation of a function with itself. If the function is real, the auto orrelation function has even symmetry.

$R_x(\tau) = R_x(-\tau)$

The autocorrelation function has conjugate symmetry

$$R_X(\tau) = R_X^*(\tau)$$

Option (b) and (d)

6. The power spectral density of a deterministic signal is given by [sin(f)/f]^2, where 'f' is frequency the autocorrelation function of this signal in the time domain is

(a) a rectangular pulse (b) a delta function (c) a sine pulse (d) a triangular pulse

Sol: The Fourier transform of autocorrelation function $R_x(\tau)$

$$= \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega) F^*(\omega) e^{j\omega\tau} d\omega$$

$$R_X(\tau) = \frac{1}{2\pi} \int_{-\infty}^{\infty} |F(\omega)|^2 e^{j\omega\tau} d\omega$$

$$R_X(\tau) = F^{-1}[|F(\omega)|^2]$$

= Fourier inverse of power spectral density.

The auto correlation function and power spectral density make the Fourier transfer pair

$$R_X(\tau) \leftrightarrow G_X(\omega) \quad R_X(\tau) = F^{-1}\left[\frac{\sin f}{f}\right]^2$$

Inverse Fourier transform of square of sinc function is always a triangular signal in time domain

Ans: Option (d)

7. The amplitude spectrum of a Gaussian pulse is

(a) uniform (b) a sine function (c) Gaussian (d) an impulse function

Sol:

The Fourier transform of a Gaussian signal in time domain is also Gaussian signal in the frequency domain

Ans: Option c

8. A probability density function is given by $(x) = K\ x(-x2/2), -\infty < x < \infty$. The value of K should be
(a) $1/\sqrt{2\pi}$ (b) $\sqrt{2}/\pi$ (c) $1/2\sqrt{\pi}$ (d) $1/\pi\sqrt{2}$
Sol: Gaussian Probability density of a random variable X is given by

$$P_X(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\left[\frac{(x-\mu)^2}{2\sigma^2}\right]}$$

When σ = 1 and μ=0

$$P_X(x) = \frac{1}{\sqrt{2\pi}} e^{\frac{-x^2}{2}}$$

$$Given\ P_{(x)} = ke^{\frac{-x^2}{2}}$$

$$So, k = \frac{1}{\sqrt{2\pi}}$$

Option (a)

9. The ACF of a rectangular pulse of duration T is
(a) a rectangular pulse of duration T
(b) a rectangular pulse of duration 2T
(c) a triangular pulse of duration T
(d) a triangular pulse of duration 2T
Sol: Autocorrelation function of a rectangular pulse of duration T is a triangular pulse of duration 2T
The autocorrelation function is an even function of $\boldsymbol{\tau}$
Ans: Option (d)

10. The probability density function of the envelope of narrow band Gaussian noise is
(a) Poisson
(b) Gaussian
(c) Rayleigh
(d) Rician

Soln. The Probability density function of the envelope of narrowband Gaussian noise is Rayleigh.
Ans: Option (c)

11. The PDF of a Gaussian random variable X is given by $P_X(x) = \frac{1}{3\sqrt{2\pi}} e^{\frac{-(x-4)^2}{18}}$

The probability of the event {X=4} is
(a) 1/2 (b) $1/(3\sqrt{2\pi})$ (c) 0 (d) 1/4
Sol: The probability of a Gaussian random variable is defined for the interval and not at a point. So at X = 4, it is zero
Ans: Option (c)

12. A random variable X with uniform density in the interval 0 to 1 is quantized as follows:
If $0 \le X \le 0.3$ $xq = 0$
If $0.3 < X \le 1,$ $xq = 0.7$
Where xq is the quantized value of X . The root-mean square value of the quantization noise is
(a) 0.573 (b) 0.198 (c) 2.205 (d) 0.266
Mean square value of the quantization noise

$$= E\left[\left(X - x_q\right)^2\right]$$

$$= \int_0^1 (x - x_q)^2 f_X(x) dx$$

$$= \int_0^{0.3} (x - 0)^2 dx + \int_{0.3}^1 (x - 0.7)^2 dx \quad \sigma^2 = 0.039$$

Root mean square value of the quantization noise

$\sigma = \sqrt{0.039} = 0.198$

Ans: Option (b)

13. A zero-mean white Gaussian noise is passed through an ideal lowpass filter of bandwidth 10 KHz. The output is then uniformly sampled with sampling period tS = 0.03 msec. The samples so obtained would be

(a) correlated (b) statistically independent

(c) uncorrelated (d) orthogonal

Soln. White noise contains all frequency components, but the phase relationship of the components is random. When white noise is sampled, the samples are uncorrelated. If white noise is Gaussian, the samples are statistically independent

Ans: Option (b)

14. Noise with uniform power spectral density of $N_0(W/Hz)$ is passed through a filter $H(\omega) = 2exp(-j\omega td)$ followed by an ideal low pass filter of bandwidth B Hz. The output noise power in Watts is

(a) 2 N_0B (b) 4 N_0B (c) 8 N_0B (d) 16 N_0B

The output power spectral density of Noise is

$$N_{out} = |H(\omega)|^2 N_i$$

$$= 4 N_0$$

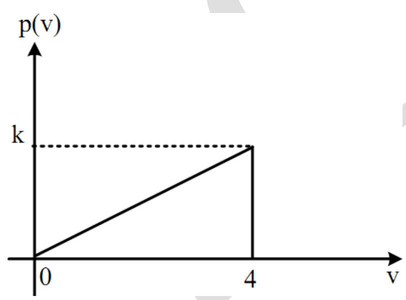
The output noise power $P_N = 4N_0B$

Ans: Option (b)

15. An output of a communication channel is a random variable v with the probability density function as shown in the figure. The mean square value of v is

(a) 4 (b) 6

(c) 8 (d) 9



Soln. Area under the probability density function = 1

So ½*4*k = 1

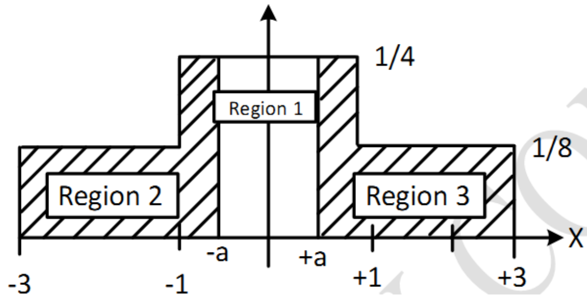
And K = ½. The mean square value of the random variable X

$$E[X^2] = \int_0^4 x^2 f_X(x) dx \quad Y = mx + C = \frac{k}{4}x \quad = \int_0^4 x^2 . \frac{x}{8} dx$$

= 8

Ans: Option C

16. If the probability density function is divided into three regions as shown in the figure, the value of a in the figure is



(a) 1/3 (b) 2/3 (c) 1/2 (d) ¼

Soln. The area under the Pdf curve must be unity. All three regions are equi -probable, thus area under each region must be 1/3

Area of region 1 = 2a *1/4

2a/4 = 1/3 = 2/3

Ans: Option (b)

17. The quantization noise power for the quantization region between –a and +a in the figure is

(a) 4/81 (b) 1/9 (c) 5/81 (d) 2/81

Sol: The quantization noise power for the region between –a and +a in the above figure is

$$N_q = \int_{-a}^{a} x^2 P_{(X)} dx = 2\int_{0}^{a} x^2 \frac{1}{4} dx \quad = \frac{2}{4}\left[\frac{x^3}{3}\right]_0^a$$

$$= \frac{2}{4} \times \frac{a^3}{3} = \frac{a^3}{6}$$

A=2/3

$$So, \quad N_q = \frac{2^3}{27 \times 6} = \frac{4}{81}$$

Option (a)

18. If the variance σ_x^2 of d(n) = x(n) − x(n − 1) is one-tenth the variance σ_x^2 of a stationary zero-mean discrete-time signal x(n), then the normalized autocorrelation function $R_{xx}(X)/\sigma_x^2$at k = 1 is

(a) 0.95 (b) 0.90 (c) 0.10 (d) 0.05

Soln. The variance $\sigma_x^2 = E[(X - \boldsymbol{\mu}_x)^2]$

Where $\boldsymbol{\mu}_x$ (mean value) = 0

$$\sigma_d^2 = E[\{X(n) - X(n-1)\}^2]$$

$$\sigma_d^2 = E[X(n)]^2 + E[X(n-1)]^2 - 2E[X(n)X(n-1)]$$

$$\frac{\sigma_X^2}{10} = \sigma_X^2 + \sigma_X^2 - 2R_{XX}(1)$$

$$\frac{R_{XX}}{\sigma_X^2} = \frac{19}{20} = 0.95$$

Ans: Option a

19. Let Y and Z be the random variables obtained by sampling X(t) at t = 2 and t = 4 respectively. Let W = Y – Z. The variance of W is

(a) 13.36 (b) 9.36 (c) 2.64 (d) 8.00

Soln. $W = Y - Z$ *Given* $R_{XX(\tau)} = 4\left(e^{-0.2|\tau|} + 1\right)$

$$\text{Variance}[W] = E[Y - Z]^2$$

$$\sigma_W^2 = E[Y^2] + E[Z^2] - 2E[YZ]$$

Y and Z are samples of X(t) at t = 2 and t = 4

$$E[Y^2] = E[X^2(2)] = R_{XX(0)}$$

$$= 4\left[e^{-.2|0|} + 1\right] = 8$$

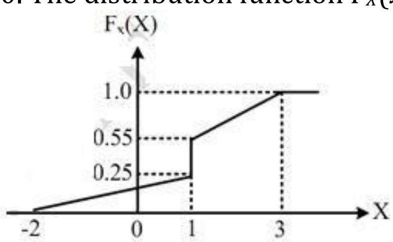
$$E[Z^2] = E[X^2(4)] = 4\left[e^{-0.2|0|} + 1\right] = 8$$

$$E[YZ] = R_{XX(2)} = 4\left[e^{-0.2(4-2)} + 1\right] = 6.68$$

$$\sigma_W^2 = 8 + 8 - 2 \times 6.68 = 2.64$$

Ans: Option C

20. The distribution function $F_X(x)$ of a random variable X is shown in the Figure. The probability that X = 1 is



(a) Zero (b) 0.25 (c) 0.55 (d) 0.30

Soln. The probability that $X = 1 = F_X(x = 1^+) - F_X(x = 1^-)$

$$P(x = 1) = 0.55 - 0.25 = 0.30$$

Option (d)

21. If E denotes expectation, the variance of a random variable X is given by

(a) $E[X^2] - E^2[X]$ (b) $E[X^2] + E^2[X]$ (c) $E[X^2]$ (d) $E^2[X]$

Soln. The variance of random variable X

$\sigma_x^2 = E[(X - \mu_x)^2]$

Where μ_x is the mean value = E[X]

$$\sigma_X^2 = E[X^2] + E[\mu_X]^2 - 2\,\mu_X E[X]$$

$$= E[X^2] + \mu_X^2 - 2\,\mu_X \mu_X$$

$= E[X^2] - \mu_x^2$

= mean square value – square of mean value

Ans: Option (a)

22. If $R(\tau)$ is the auto-correlation function of a real, wide-sense stationary random process, then which of the following is NOT true?

(a) $R(\tau) = R(-\tau)$ (b) $|R(\tau)| \le R(0)$

(c) $R(\tau) = -R(-\tau)$ (d) The mean square value of the process is R(0)

Soln. If all the statistical properties of a random process are independent of time, it is known as stationary process.

The autocorrelation function is the measure of similarity of a function with it's delayed replica.

$$R(\tau) = \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{T/2} f(t-\tau) f^*(t) dt$$

$$for \quad \tau = 0, \; R(0) = \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{T/2} f(t) f^*(t) dt$$

$$= \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{T/2} |f(t)|^2 \, dt$$

R(0) is the average power P of the signal.

$R(\tau) = R^*(-\tau)$ exhibits Conjugate symmetry

$R(\tau) = R(-\tau)$ for real function

$R(0) \geq R(\tau)$ for all τ

$R(\tau) = -R(-\tau)$ is not true (since it has even symmetry)

Ans: Option (c)

23. If S(f) is the power spectral density of a real, wide-sense stationary random process, then which of the following is ALWAYS true?

(a) $S(0) \geq S(f)$ (b) $S(f) \geq 0$ (c) $S(-f) = -S(f)$ (d) $\int S(f)df = 0$

Soln. Power spectral density is always positive $S(f) \geq 0$

Ans: Option (b)

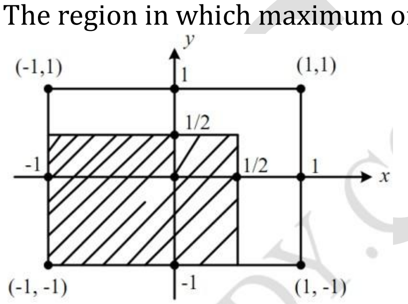
24. Two independent random variables X and Y are uniformly distributed in the interval [−1,1]. The probability that max [�, �] is less than 1/2 is

(a) 3/4 (b) 9/16 (c) 1/4 (d) 2/3

Sol:

$-1 \leq X \leq 1$ and $-1 \leq X \leq 1$

The region in which maximum of [X, Y] is less than 1/2 is shown as shaded region inside the rectangle.



$$P\left[\max(X,Y) < \frac{1}{2}\right] = \frac{Area\ of\ shaded\ region}{Area\ of\ entire\ region}$$

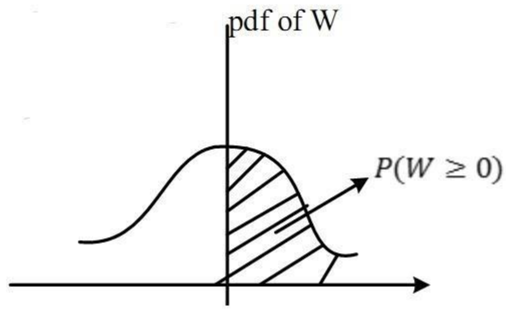
$$= \frac{\frac{3}{2} \times \frac{3}{2}}{2 \times 2} = \frac{9}{4 \times 4}$$

= 9/16

Ans: Option b

25. Let U and V be two independent zero mean Gaussian random variables of variances ¼ and 1/9 respectively. The probability $P(3V \geq 2U)$ is

(a) 4/9 (b) 1/2 (c) 2/3 (d) 5/9



$\boldsymbol{P}$(3V – 2U) = $\boldsymbol{P}$(3V – 2U ≥ 0)

= $\boldsymbol{P}$(W ≥ 0)

W = 3V – 2U

W is the Gaussian Variable with zero mean having pdf curve as shown below

$\boldsymbol{P}$(W ≥ 0) = 1/2(area under the curve from 0 to ∞)

Ans: Option (b)

UNIT 4

NOISE CHARACTERIZATION

1. For a three stage cascade amplifier, calculate the overall noise figure when each stage has a gain of 12 DB and noise figure of 8dB.

a. 12 b. 24 c. 13.55 d. 8

Sol:

As the signal passes through various stages of an amplifier, the output has the original signal and some noise that gets amplified at different stages of amplifiers. So the final noise figure of the cascaded amplifier is obtained by

$F_N = F_1 + (F_2 - 1)/ G_1 + (F_3 - 1)/ G_1G_2 + \ldots\ldots + (F_N - 1)/ G_1G_2G_3\, G_N$

$F_1, F_2, F_3 .. F_N, G_1, G_2, G_3 .... G_N$ are the noise figures and the gains respectively of the amplifiers at different stages.

$F_1 = 12, F_2 = 12, F_3 = 12$

$G_1 = 8, G_2 = 8, G_3 = 8$

$F_N = 12 + (12- 1)/ 8+ (12- 1)/ 8 * 8$

= 12 + 11/8 + 11/64

= 13.55

Ans: (c) 13.55

2. The Hilbert transform of the signal sinω1t + $\sin\omega_2 t$ is

a. $\sin\omega_1 t + \sin\omega_2 t$ b. $\cos\omega_1 t + \cos\omega_2 t$ c. $\sin\omega_2 t + \cos\omega_2 t$ d. $\sin\omega_1 t + \sin\omega_1 t$

Sol:

In Hilbert transform, the signal gets shifted by 900.

So the signal $\sin\omega_1 t + \sin\omega_2 t$ gets shifted by 900

$\sin\omega_1(t+900) + \sin\omega_2(t+900)$

= $\cos\omega_1 t + \cos\omega_2 t$

Ans: (b) $\cos\omega_1 t + \cos\omega_2 t$

3. The noise due to random behaviour of charge carriers is

a. Shot noise b. Partition noise c. Industrial noise d. Flicker noise

Ans: (a) Shot noise

4. Transit time noise is

a. Low frequency noise b. High frequency noise c. Due to random behavior of carrier charges
d. Due to increase in reverse current in the device
Ans: (b) High frequency noise

5. Figure of merit γ is
a. Ratio of output signal to noise ratio to input signal to noise ratio
b. Ratio of input signal to noise ratio to output signal to noise ratio
c. Ratio of output signal to input signal to a system
d. Ratio of input signal to output signal to a system
Ans: (a) Ratio of output signal to noise ratio to input signal to noise ratio

6. Signum function sgn(f), for f>0, f=0 and f<0, has the values:
a. -1 to +1 b. +1, 0, -1 respectively c. -∞ to + ∞ d. 0 always
Sol:
The sgn(f) is a signum function that is defined in the frequency domain as
sgn(f) = 1, f> 0
= 0, f = 0 = -1, f< 0
Mathematically, the sign function or signum function is an odd mathematical function which extracts the sign of a real number and is often represented as sgn
Ans: (b) +1, 0, -1 respectively

7. In Hilbert transform of a signal, the phase angles of all components of a given signal are shifted by

a. +/- π b. +/- π/4 c. +/- π/2 d. Any angle from 00 to 3600
Ans: (c) +/- π/2

8. The noise voltage (V_n) and the signal bandwidth (B) are related as
a. V_n is directly proportional to bandwidth b. V_n is directly proportional to √bandwidth
c. V_n is inversely proportional to absolute temperature d. V_n is inversely proportional to bandwidth
Ans: (b) V_n is directly proportional to √bandwidth

9. Noise factor for a system is defined as the ratio of
a. Input noise power (P_{ni}) to output noise power (P_{no})
b. Output noise power (P_{no}) to input noise power (P_{ni})
c. Output noise power (P_{no}) to input signal power (P_{si})
d. Output signal power (P_{so}) to input noise power (P_{ni})
Ans: (b) Output noise power (P_{no}) to input noise power (P_{ni})

10. Noise Factor(F) and Noise Figure(NF) are related as
a. $NF = 10 \log_{10}(F)$ b. $F = 10 \log_{10}(NF)$ c. NF = 10 (F) d. F = 10 (NF)
Ans: (a) $NF = 10 \log_{10}(F)$

11. The Noise Factor for cascaded amplifiers (F_N) is given by (F_1, F_2, F_3 .. F_N, G_1, G_2, G_3....G_N) are the noise factors and the gains of the amplifiers at different stages:
a. $F_N = F_1 + F_2/ G_1 + F_3/ G_1G_2 + .. + F_N/ G_1G_2G_3G_N$
b. $F_N = F_1 + (F_2 - 1)/ G_1 + (F_3 - 1)/ (G1+G2) + .. + (F_N - 1)/ (G1+G2+G3+ \ldots +G_N)$
c. $F_N = F_1 + F_2/ G_1 + F_3/ (G1+G2) + \ldots + F_N/ (G1+G2+G3+ \ldots +G_N)$
d. $F_N = F_1 + (F_2 - 1)/ G_1 + (F_3 - 1)/ G_1G_2 + \ldots + (F_N - 1)/G_1G_2G_3G_N$
Ans: (d) $F_N = F_1 + (F_2 - 1)/ G_1 + (F_3 - 1)/ G_1G_2 + \ldots + (F_N - 1)/ G_1G_2G_3G_N$

12. For a two stage amplifier, first amplifier has Voltage gain = 20, Input Resistance R_{in1}=700Ω, equivalent Resistance R_{eq1}=1800Ω and Output Resistor R_{o1} = 30KΩ. The corresponding values of second amplifier are :

25, 80 KΩ, 12 KΩ, 1.2 MΩ respectively. What is the value of equivalent input noise resistance of the given two stage amplifier?

a. 2609.1Ω b. 2607.1Ω c. 107.1Ω d. 2107.1Ω

Sol:

$R_1 = R_{in1} + R_{eq1} = 700 + 1800 = 2500\Omega$

$R_2 = (R_{o1} R_{in2}) / (R_{o1} + R_{in2}) + R_{eq2} = 30 * 80/(30 + 80) + 12 = 40.92K\Omega$

$R_3 = R_{o2} = 1.2M\Omega$

Equivalent input noise resistance of a two stage amplifier is given by

$R_{eq} = R_1 + R_2/ A^2{}_1 + R_3/ (A^2{}_1 A^2{}_2)$

$= 2500 + 40.92 * 10^3/(20)^2 + 1.2 * 10^6/(20)^2(25)^2$

$= 2607.1\Omega$

Ans: (b) 2607.1Ω

13. The noise temperature at a resistor depends upon

a. Resistance value

b. Noise power

c. Both a and b

d. None of the above

Ans: (b) Noise power

14. Noise voltage V_n and absolute temperature T are related as

a. $V_n = 1/ \sqrt{(4RKTB)}$ b. $V_n = \sqrt{(4RK)}/ (TB)$ c. $V_n = \sqrt{(4RKTB)}$ d. $V_n = \sqrt{(4KTB)}/R$

Ans: (c) $V_n = \sqrt{(4RKTB)}$

15. Notch filter is a

a. Band pass filter b. Band stop filter c. Low pass filter d. High pass filter

Ans: (b) Band stop filter

16. Noise is added to a signal in a communication system

a. At the receiving end b. At transmitting antenna

c. In the channel d. During regeneration of the information

Ans: (c) In the channel

17. Noise power at the resistor is affected by the value of the resistor as

a. Directly proportional to the value of the resistor

b. Inversely proportional to the value of the resistor

c. Unaffected by the value of the resistor

d. Becomes half as the resistance value is doubled

Ans: (c) Unaffected by the value of the resistor

18. Low frequency noise is

a. Transit time noise b. Flicker noise c. Shot noise d. None of the above

Ans: b) Flicker noise

19. Hilbert transform may be used in

a. Generation of SSB signals b. Representation of band pass signals

c. Designing of minimum phase type filters d. All of the above

Ans: (d) All of the above

20. At a room temperature of 300K, calculate the thermal noise generated by two resistors of 10KΩ and 20 KΩ when the bandwidth is 10 KHz.

a. $4.071 * 10^{-6}$ V, $5.757 * 10^{-6}$ V b. $6.08 * 10^{-6}$ V, $15.77 * 10^{-6}$ V

c. $16.66 * 10^{-6}$ V, $2.356 * 10^{-6}$ V d. $1.66 * 10^{-6}$ V, $0.23 * 10^{-6}$ V

Ans: (a) $4.071 * 10^{-6}$ V, $5.757 * 10^{-6}$ V
Sol: Noise voltage $V_n = \sqrt{(4R\ KTB)}$

Where, $K = 1.381\times10^{-23}$ J/K, joules per Kelvin, the Boltzmann constant

B is the bandwidth at which the power P_n is delivered.

T noise temperature

R is the resistance

Noise voltage by individual resistors

$V_{n1} = \sqrt{(4R1\ KTB)}$

$= \sqrt{(4 * 10 * 10^3 * 1.381 * 10^{-23} * 3000 * 10 * 10^3)}$

$= \sqrt{16.572 * 10^{-12}}$

$= 4.071 * 10^{-6}$ V

$V_{n2} = \sqrt{(4R_2\ KTB)}$

$= \sqrt{(4 * 20 * 10^3 * 1.381 * 10^{-23} * 3000 * 10 * 10^3)}$

$= \sqrt{33.144 * 10^{-12}}$

$= 5.757 * 10^{-6}$ V

21. At a room temperature of 293K, calculate the thermal noise generated by two resistors of 20KΩ and 30 KΩ when the bandwidth is 10 KHz and the resistors are connected in series.
a. $300.66 * 10^{-7}$ b. $284.48 * 10^{-7}$ c. $684.51 * 10^{-15}$ d. $106.22 * 10^{-7}$
Sol:
Noise voltage $V_n = \sqrt{(4R\ KTB)}$
Where, $K = 1.381 \times 10^{-23}$ J/K, joules per Kelvin, the Boltzmann constant
B is the bandwidth at which the power P_n is delivered.
T noise temperature
R is the resistance
Noise voltage by resistors when connected in series is
$V_n = \sqrt{\{4(R_1 + R_2)\ KTB\}}$
$= \sqrt{\{4(20 * 10^3 + 30 * 10^3) * 1.381 \times 10^{-23} * 293 * 10 * 10^3\}}$
$= 284.48 * 10^{-7}$
Ans: (b) $284.48 * 10^{-7}$

22. At a room temperature of 300K, calculate the thermal noise generated by two resistors of 10KΩ and 30 KΩ when the bandwidth is 10 KHz and the resistors are connected in parallel.
a. $30.15 * 10^{-3}$ b. $8.23 * 10^{-23}$ c. $11.15 * 10^{-7}$ d. $26.85 * 10^{-7}$
Sol:
Noise voltage $V_n = \sqrt{(4R\ KTB)}$ Where, $K = 1.381 \times 10^{-23}$ J/K, joules per Kelvin, the Boltzmann constant
B is the bandwidth at which the power P_n is delivered.
T noise temperature, R is the resistance
Noise voltage by resistors when connected in parallel is
$V_n = \sqrt{\{4R\ KTB\}}$
Here for resistors to be in parallel,
$1/R = 1/R_1 + 1/R_2$
$= 1/10K + 1/30K = 0.1333$ R = 7.502KΩ
$V_n = \sqrt{\{4 * 7.502 * 10^3 * 1.381\times10^{-23} * 300 * 10 * 10^3\}}$
$= \sqrt{124.323 * 10^{-14}} = 11.15 * 10^{-7}$

Ans: (c) $11.15 * 10^{-7}$

23. A 1 mW video signal having a bandwidth of 100 MHz is transmitted to a receiver through a cable that has 40 dB loss. If the effective one-sided noise spectral density at the receiver is 10^{-20} Watt/Hz, then the signal-to-noise ratio at the receiver is

(a) 50 dB (b) 30 dB (c) 40 dB (d) 60 dB

Sol: Soln. Signal power = P_s = 1mW Noise power = P_N = N_0B
N_0B = Noise spectral density = 10^{-20}
B = bandwidth = 100 MHz

$$SNR = \frac{P_S}{P_N} = \frac{10^{-3}}{10^{-20} \times 100 \times 10^6}$$

$$= 10^9 = 90dB$$

Cable loss = 40 dB
SNR at receiver = 90 – 40 = 50 dB
Ans: Option (a)

UNIT 5

INFORMATION THEORY AND CODING

1) In discrete memoryless source, the current letter produced by a source is statistically independent of ______

a. Past output b. Future output c. Both a and b d. None of the above

Ans: c. Both a and b

2. Huffman coding technique is adopted for constructing the source code with_________redundancy.

a. Maximum b. Constant c. Minimum d. Unpredictable

Ans: c. Minimum

3. Which type of channel does not represent any correlation between input and output symbols?
a. Noiseless Channel b. Lossless Channel c. Useless Channel d. Deterministic Channel

Ans: c. Useless Channel

4. In digital communication system, smaller the code rate,_________are the redundant bits.

a. less b. more c. equal d. unpredictable

Ans: b. more

5. If the channel is bandlimited to 6 kHz & signal to noise ratio is 16, what would be the capacity of channel?

a. 15.15 kbps b. 24.74 kbps c. 30.12 kbps d. 52.18 kbps

Ans: 24.74 kbps

6. According to Shannon's second theorem, it is not feasible to transmit information over the channel with ______error probability, although by using any coding technique.

a. small b. large c. stable d. unpredictable

Ans: small

7. Which among the following is/are the essential condition/s for a good error control coding technique?
a. Faster coding & decoding methods
b. Better error correcting capability
c. Maximum transfer of information in bits/sec
d. All of the above
Ans: d. All of the above

8. In a linear code, the minimum Hamming distance between any two code words is______minimum weight of any non-zero code word.
a. Less than b. Greater than c. Equal to d. None of the above
Ans: Equal to

9. For a Gaussian channel of 1 MHz bandwidth with the signal power to noise spectral density ratio of about 10^4 Hz, what would be the maximum information rate?
a. 12000 bits/sec b. 14400 bits/sec c. 28000 bits/sec d. 32500 bits/sec
Ans: 14400 bits/sec

10. For fixed symbol rate, increase in bits/symbol ultimately improves r_b/B bits/s/Hz & hence, regarded as _____.
a. Power efficiency
b. Spectral efficiency
c. Transmission efficiency
d. Modulation eficiency
Ans: Spectral efficiency

11. Which decoding method involves the evaluation by means of Fano Algorithm?

a. Maximum Likelihood Decoding
b. Sequential Decoding
c. Both a and b
d. None of the above
Ans: Sequential Decoding

12. On which factor/s do/does the channel capacity depend/s in the communication system?

a. Bandwidth b. Signal to Noise Ratio c. Both a and b d. None of the above

Ans: Both a and b

13. Assuming that the channel is noiseless, if TV channels are 8 kHz wide with the bits/sample = 3Hz and signalling rate = 16 x 10^6 samples/second, then what would be the value of data rate?

a. 16 Mbps b. 24 Mbps c. 48 Mbps d. 64 Mbps
Ans: 48 Mbps

14. If a noiseless channel bandlimited to 5 kHz is sampled every 1msec, what will be the value of sampling frequency?

a. 250 samples/sec b. 500 samples/sec c. 800 samples/sec d. 1000 samples/sec
Ans: d. 1000 samples/sec

15. Information rate basically gives an idea about the generated information per ______by source.
a. Second b. Minute c. Hour d. None of the above
Ans: Second

16. Which among the following is used to construct the binary code that satisfies the prefix condition?
a. Information Rate
b. Noiseless Channel
c. Channel Coding Theorem
d. Kraft Inequality
Ans: Kraft Inequality

17. Which coding technique/s exhibit/s the usability of fixed length codes?
a. Lempel Ziv b. Huffman c. Both a and b d. None of the above
Ans: Lempel Ziv

18. Which lossy method for audio compression is responsible for encoding the difference between two consecutive samples?
a. Silence Compression
b. Linear Predictive Coding (LPC)
c. Adaptive Differential Pulse Code modulation (ADPCM)
d. Code Excited Linear Predictor (CELP)
Ans: Adaptive Differential Pulse Code modulation (ADPCM)

19. With respect to power-bandwidth trade-off, for reducing the transmit power requirement, the bandwidth needs to be________.
a. Increased b. Constant c. Decreased d. None of the above
Ans: Increased

20. For a Gaussian channel of 1 MHz bandwidth with the signal power to noise spectral density ratio of about 10^4 Hz, what would be the maximum information rate?
a. 12000 bits/sec b. 14400 bits/sec c. 28000 bits/sec d. 32500 bits/sec
Ans: 14400 bits/sec

21. For a baseband system with transmission rate 'r_s' symbols/sec, what would be the required bandwidth?
a. r_s / 2 Hz b. r_s / 4 Hz c. r_s / 8 Hz d. r_s / 16 Hz
ANSWER: r_s / 4 Hz

22. The unit of average mutual information is
a) Bits b) Bytes c) Bits per symbol d) Bytes per symbol

Ans: a
Explanation: The unit of average mutual information is bits.

23. Entropy of a random variable is
a) 0 b) 1 c) Infinite d) Cannot be determined

Ans: c
Explanation: Entropy of a random variable is also infinity.

24. Which is more efficient method?
a) Encoding each symbol of a block
b) Encoding block of symbols
c) Encoding each symbol of a block & Encoding block of symbols
d) None of the mentioned

Ans: b
Explanation: Encoding block of symbols is more efficient than encoding each symbol of a block.

25. Lempel-Ziv algorithm is
a) Variable to fixed length algorithm
b) Fixed to variable length algorithm
c) Fixed to fixed length algorithm
d) Variable to variable length algorithm

Ans: a
Explanation: Lempel-Ziv algorithm is a variable to fixed length algorithm.

26. When X and Y are statistically independent, then I (x,y) is

a) 1 b) 0 c) Ln 2 d) Cannot be determined

Ans: b

Explanation: When X and Y are statistically independent the measure of information I (x,y) is 0.

27. When the base of the logarithm is 2, then the unit of measure of information is

a) Bits b) Bytes c) Nats d) None of the mentioned

Ans: a

Explanation: When the base of the logarithm is 2 then the unit of measure of information is bits.