UNIT 8
Communication Systems

2011 **ONE MARK**

MCQ 8.1

An analog signal is band-limited to 4 kHz, sampled at the Nyquist rate and the samples are quantized into 4 levels. The quantized levels are assumed to be independent and equally probable. If we transmit two quantized samples per second, the information rate is

(A) 1 bit/sec (B) 2 bits/sec

(C) 3 bits/sec (D) 4 bits/sec

MCQ 8.2

The **Column -1** lists the attributes and the **Column -2** lists the modulation systems. Match the attribute to the modulation system that best meets it.

	Column -1		Column -2
P.	Power efficient transmission of signals	1.	Conventional AM
Q.	Most bandwidth efficient transmission of voice signals	2.	FM
R.	Simplest receiver structure	3.	VSB
S.	Bandwidth efficient transmission of signals with significant dc component	4.	SSB-SC

(A) P-4, Q-2, R-1, S-3

(B) P-2, Q-4, R-1, S-3

(C) P-3, Q-2, R-1, S-4

(D) P-2, Q-4, R-3, S-1

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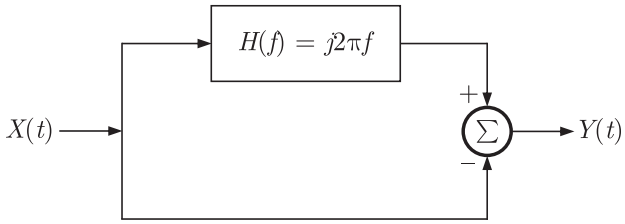
2011 **TWO MARKS**

MCQ 8.3

$X(t)$ is a stationary random process with auto-correlation function $R_X(\tau) = \exp(-\pi\tau^2)$. This process is passed through the system shown below. The power spectral density of the output process $Y(t)$ is



(A) $(4\pi^2 f^2 + 1)\exp(-\pi f^2)$ (B) $(4\pi^2 f^2 - 1)\exp(-\pi f^2)$

(C) $(4\pi^2 f^2 + 1)\exp(-\pi f)$ (D) $(4\pi^2 f^2 - 1)\exp(-\pi f)$

MCQ 8.4

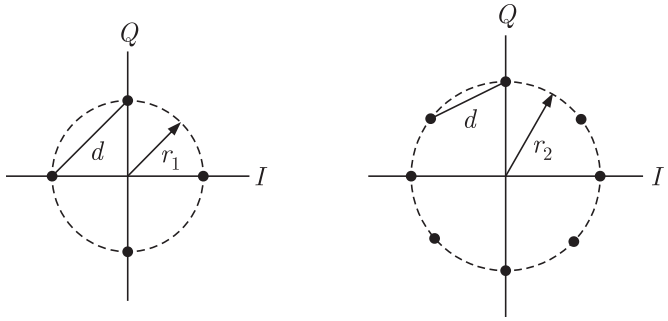
A message signal $m(t) = \cos 2000\pi t + 4\cos 4000\pi t$ modulates the carrier $c(t) = \cos 2\pi f_c t$ where $f_c = 1\,\text{MHz}$ to produce an AM signal. For demodulating the generated AM signal using an envelope detector, the time constant RC of the detector circuit should satisfy

(A) 0.5 ms $<$ RC $<$ 1 ms (B) 1 μs $<<$ RC $<$ 0.5 ms

(C) RC $<<$ 1 μs (D) RC $>>$ 0.5 ms

Statement for Linked Answer Questions: 8.5 & 8.6

A four-phase and an eight-phase signal constellation are shown in the figure below.



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MCQ 8.5

For the constraint that the minimum distance between pairs of signal points be d for both constellations, the radii r_1, and r_2 of the circles are

(A) $r_1 = 0.707d$, $r_2 = 2.782d$ (B) $r_1 = 0.707d$, $r_2 = 1.932d$

(C) $r_1 = 0.707d$, $r_2 = 1.545d$ (D) $r_1 = 0.707d$, $r_2 = 1.307d$

MCQ 8.6

Assuming high SNR and that all signals are equally probable, the additional average transmitted signal energy required by the 8-PSK signal to achieve the same error probability as the 4-PSK signal is

(A) 11.90 dB (B) 8.73 dB

(C) 6.79 dB (D) 5.33 dB

2010 ONE MARK

MCQ 8.7

Suppose that the modulating signal is $m(t) = 2\cos(2\pi f_m t)$ and the carrier signal is $x_C(t) = A_C \cos(2\pi f_C t)$, which one of the following is a conventional AM signal without over-modulation

(A) $x(t) = A_C m(t)\cos(2\pi f_C t)$

(B) $x(t) = A_C[1 + m(t)]\cos(2\pi f_C t)$

(C) $x(t) = A_C \cos(2\pi f_C t) + \frac{A_C}{4} m(t)\cos(2\pi f_C t)$

(D) $x(t) = A_C \cos(2\pi f_m t)\cos(2\pi f_C t) + A_C \sin(2\pi f_m t)\sin(2\pi f_C t)$

MCQ 8.8

Consider an angle modulated signal

$$x(t) = 6\cos[2\pi \times 10^6 t + 2\sin(800\pi t)] + 4\cos(800\pi t)$$

The average power of $x(t)$ is

(A) 10 W (B) 18 W

(C) 20 W (D) 28 W

MCQ 8.9

Consider the pulse shape $s(t)$ as shown below. The impulse response

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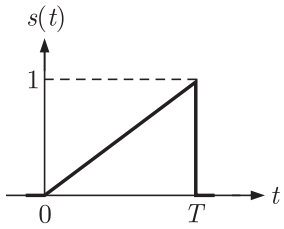
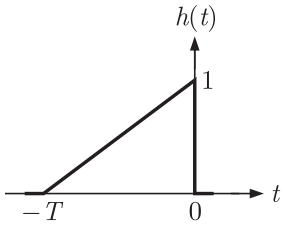
$h(t)$ of the filter matched to this pulse is



(A)



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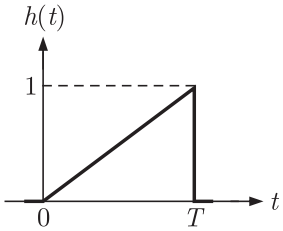

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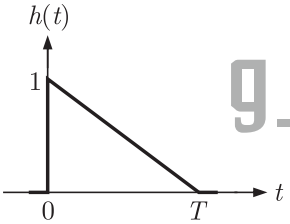

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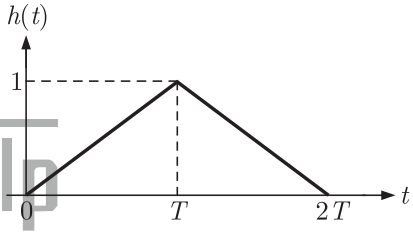

2010 **TWO MARKS**

Statement for linked Answer Question : 8.10 & 8.11 :

Consider a baseband binary PAM receiver shown below. The additive channel noise $n(t)$ is with power spectral density $S_n(f) = N_0/2 = 10^{-20}$ W/Hz. The low-pass filter is ideal with unity gain and cut-off frequency 1 MHz. Let Y_k represent the random variable $y(t_k)$.

$Y_k = N_k$, if transmitted bit $b_k = 0$

$Y_k = a + N_k$ if transmitted bit $b_k = 1$

Where N_k represents the noise sample value. The noise sample has a probability density function, $P_{Nk}(n) = 0.5\alpha e^{-\alpha|n|}$ (This has mean zero and variance $2/\alpha^2$). Assume transmitted bits to be equiprobable and threshold z is set to $a/2 = 10^{-6}$ V.

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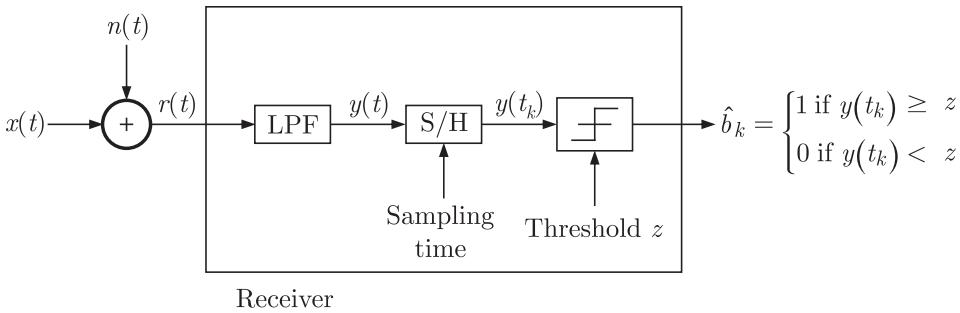


MCQ 8.10

The value of the parameter α (in V^{-1}) is

(A) 10^{10} (B) 10^{7}

(C) 1.414×10^{-10} (D) 2×10^{-20}

MCQ 8.11

The probability of bit error is

(A) $0.5 \times e^{-3.5}$ (B) $0.5 \times e^{-5}$

(C) $0.5 \times e^{-7}$ (D) $0.5 \times e^{-10}$

MCQ 8.12

The Nyquist sampling rate for the signal

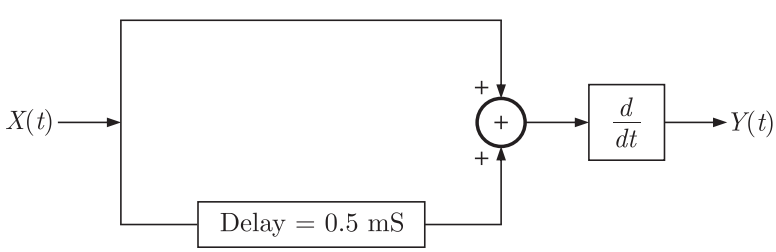
$s(t) = \dfrac{\sin(500\pi t)}{\pi t} \times \dfrac{\sin(700)\pi t}{\pi t}$ is given by

(A) 400 Hz (B) 600 Hz

(C) 1200 Hz (D) 1400 Hz

MCQ 8.13

$X(t)$ is a stationary process with the power spectral density $S_x(f) > 0$, for all f. The process is passed through a system shown below



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Let $S_y(f)$ be the power spectral density of $Y(t)$. Which one of the following statements is correct

(A) $S_y(f) > 0$ for all f

(B) $S_y(f) = 0$ for $|f| > 1$ kHz

(C) $S_y(f) = 0$ for $f = nf_0, f_0 = 2$ kHz kHz, n any integer

(D) $S_y(f) = 0$ for $f = (2n+1) f_0 = 1$ kHz, n any integer

2009 **ONE MARK**

MCQ 8.14

For a message siganl $m(t) = \cos(2\pi f_m t)$ 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) $[1 + \cos(2\pi f_m t)\cos(2\pi f_c t)$

2009 **TWO MARKS**

MCQ 8.15

Consider two independent random variables X and Y with identical distributions. The variables X and Y take values 0, 1 and 2 with probabilities $\frac{1}{2}, \frac{1}{4}$ and $\frac{1}{4}$ respectively. What is the conditional probability $P(X + Y = 2 | X - Y = 0)$?

(A) 0

(B) 1/16

(C) 1/6

(D) 1

MCQ 8.16

A discrete random variable X takes values from 1 to 5 with probabilities as shown in the table. A student calculates the mean X as 3.5 and her teacher calculates the variance of X as 1.5. Which of the following statements is true ?

k	1	2	3	4	5
$P(X = k)$	0.1	0.2	0.3	0.4	0.5

(A) Both the student and the teacher are right

(B) Both the student and the teacher are wrong

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(C) The student is wrong but the teacher is right

(D) The student is right but the teacher is wrong

MCQ 8.17

A message signal given by $m(t) = (\frac{1}{2})\cos\omega_1 t - (\frac{1}{2})\sin\omega_2 t$ amplitude - modulated with a carrier of frequency ω_C to generator $s(t)[1 + m(t)]\cos\omega_c t$. What is the power efficiency achieved by this modulation scheme ?

(A) 8.33% (B) 11.11%

(C) 20% (D) 25%

MCQ 8.18

A communication channel with AWGN operating at a signal to noise ration $SNR >> 1$ and bandwidth B has capacity C_1. If the SNR is doubled keeping constant, the resulting capacity C_2 is given by

(A) $C_2 \approx 2C_1$ (B) $C_2 \approx C_1 + B$

(C) $C_2 \approx C_1 + 2B$ (D) $C_2 \approx C_1 + 0.3B$

Common data for Questions 8.19 & 8.20 :

The amplitude of a random signal is uniformly distributed between -5 V and 5 V.

MCQ 8.19

If the signal to quantization noise ratio required in uniformly quantizing the signal is 43.5 dB, the step of the quantization is approximately

(A) 0.033 V (B) 0.05 V

(C) 0.0667 V (D) 0.10 V

MCQ 8.20

If the positive values of the signal are uniformly quantized with a step size of 0.05 V, and the negative values are uniformly quantized with a step size of 0.1 V, the resulting signal to quantization noise ration is approximately

(A) 46 dB (B) 43.8 dB

(C) 42 dB (D) 40 dB

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2008 **ONE MARK**

MCQ 8.21

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 A_c should be

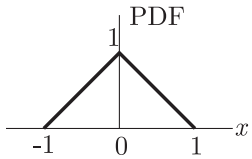
(A) 2 (B) 1

(C) 0.5 (D) 0

2008 **TWO MARKS**

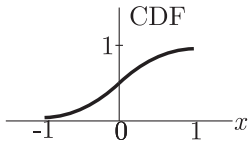
MCQ 8.22

The probability density function (pdf) of random variable is as shown below

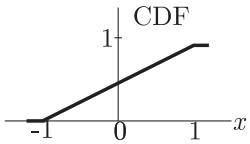


The corresponding commutative distribution function CDF has the form

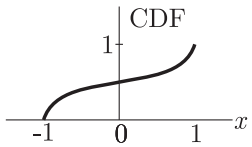
(A)



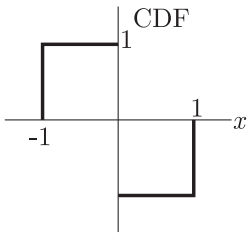
(B)



(C)



(D)



MCQ 8.23

A memory less source emits n symbols each with a probability p. The entropy of the source as a function of n

(A) increases as $\log n$ (B) decreases as $\log\left(\frac{1}{n}\right)$

(C) increases as n (D) increases as $n \log n$

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MCQ 8.24

Noise with double-sided power spectral density on K over all frequencies is passed through a RC low pass filter with 3 dB cut-off frequency of f_c. The noise power at the filter output is

(A) K (B) Kf_c

(C) $k\pi f_c$ (D) ∞

MCQ 8.25

Consider a Binary Symmetric Channel (BSC) with probability of error being p. To transmit a bit, say 1, we transmit a sequence of three 1s. The receiver will interpret the received sequence to represent 1 if at least two bits are 1. The probability that the transmitted bit will be received in error is

(A) $p^3 + 3p^2(1-p)$ (B) p^3

(C) $(1-p^3)$ (D) $p^3 + p^2(1-p)$

MCQ 8.26

Four messages band limited to $W, W, 2W$ and $3W$ respectively are to be multiplexed using Time Division Multiplexing (TDM). The minimum bandwidth required for transmission of this TDM signal is

(A) W (B) $3W$

(C) $6W$ (D) $7W$

MCQ 8.27

Consider the frequency modulated signal

$$10\cos[2\pi \times 10^5 t + 5\sin(2\pi \times 1500t) + 7.5\sin(2\pi \times 1000t)]$$

with carrier frequency of 10^5 Hz. The modulation index is

(A) 12.5 (B) 10

(C) 7.5 (D) 5

MCQ 8.28

The signal $\cos\omega_c t + 0.5\cos\omega_m t \sin\omega_c t$ is

(A) FM only (B) AM only

(C) both AM and FM (D) neither AM nor FM

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Common Data for Question 8.29, 8.30 and 8.31 :

A speed signal, band limited to 4 kHz and peak voltage varying between +5 V and −5 V, is sampled at the Nyquist rate. Each sample is quantized and represented by 8 bits.

MCQ 8.29

If the bits 0 and 1 are transmitted using bipolar pulses, the minimum bandwidth required for distortion free transmission is

(A) 64 kHz (B) 32 kHz

(C) 8 kHz (D) 4 kHz

MCQ 8.30

Assuming the signal to be uniformly distributed between its peak to peak value, the signal to noise ratio at the quantizer output is

(A) 16 dB (B) 32 dB

(C) 48 dB (D) 4 kHz

MCQ 8.31

Assuming the signal to be uniformly distributed between its peak to peak value, the signal to noise ratio at the quantizer output is

(A) 1024 (B) 512

(C) 256 (D) 64

2007 ONE MARK

MCQ 8.32

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) $|R(\tau)| \leq R(0)$

(C) $R(\tau) = -R(-\tau)$

(D) The mean square value of the process is $R(0)$

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MCQ 8.33

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) $S(0) \leq S(f)$ (B) $S(f) \geq 0$

(C) $S(-f) = -S(f)$ (D) $\int_{-\infty}^{\infty} S(f)\, df = 0$

MCQ 8.34

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) $E^2[X]$

2007 TWO MARKS

MCQ 8.35

A Hilbert transformer is a

(A) non-linear system (B) non-causal system

(C) time-varying system (D) low-pass system

MCQ 8.36

In delta modulation, the slope overload distortion can be reduced by

(A) decreasing the step size (B) decreasing the granular noise

(C) decreasing the sampling rate (D) increasing the step size

MCQ 8.37

The raised cosine pulse $p(t)$ is used for zero ISI in digital communications. The expression for $p(t)$ with unity roll-off factor is given by

$$p(t) = \frac{\sin 4\pi Wt}{4\pi Wt(1 - 16W^2t^2)}$$

The value of $p(t)$ at $t = \frac{1}{4W}$ is

(A) -0.5 (B) 0

(C) 0.5 (D) ∞

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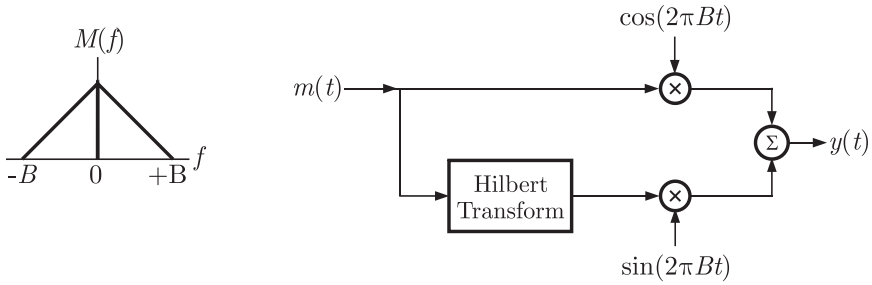
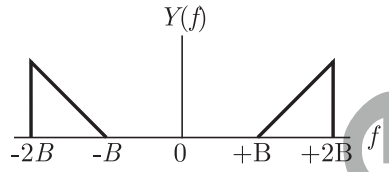
MCQ 8.38

In the following scheme, if the spectrum $M(f)$ of $m(t)$ is as shown, then the spectrum $Y(f)$ of $y(t)$ will be



(A)


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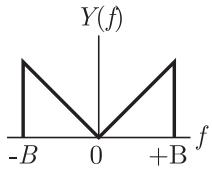

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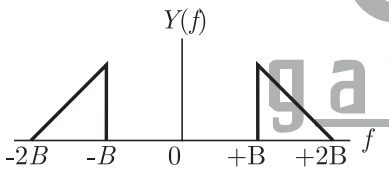

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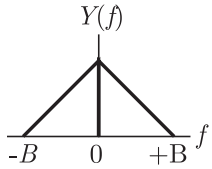

MCQ 8.39

During transmission over a certain binary communication channel, bit errors occur independently with probability p. The probability of *AT MOST* one bit in error in a block of n bits is given by

(A) p^n
(B) $1 - p^n$
(C) $np(1-p)^{n-1} + (1+p)^n$
(D) $1 - (1-p)^n$

MCQ 8.40

In a GSM system, 8 channels can co-exist in 200 kHz bandwidth using TDMA. A GSM based cellular operator is allocated 5 MHz bandwidth. Assuming a frequency reuse factor of $\frac{1}{5}$, i.e. a five-cell repeat pattern, the maximum number of simultaneous channels that can exist in one cell is

(A) 200
(B) 40
(C) 25
(D) 5

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MCQ 8.41

In a Direct Sequence CDMA system the chip rate is 1.2288×10^6 chips per second. If the processing gain is desired to be AT LEAST 100, the data rate

(A) must be less than or equal to 12.288×10^3 bits per sec

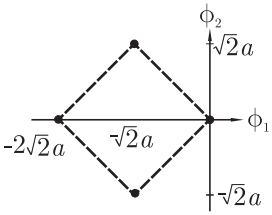
(B) must be greater than 12.288×10^3 bits per sec

(C) must be exactly equal to 12.288×10^3 bits per sec

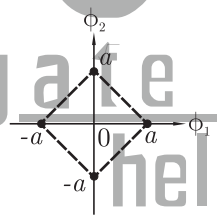
(D) can take any value less than 122.88×10^3 bits per sec

Common Data for Questions 8.41 & 8.42 :

Two 4-array signal constellations are shown. It is given that ϕ_1 and ϕ_2 constitute an orthonormal basis for the two constellation. Assume that the four symbols in both the constellations are equiprobable. Let $\frac{N_0}{2}$ denote the power spectral density of white Gaussian noise.



Constellation 1



Constellation 2

MCQ 8.42

The if ratio or the average energy of Constellation 1 to the average energy of Constellation 2 is

(A) $4a^2$ (B) 4

(C) 2 (D) 8

MCQ 8.43

If these constellations are used for digital communications over an AWGN channel, then which of the following statements is true ?

(A) Probability of symbol error for Constellation 1 is lower

(B) Probability of symbol error for Constellation 1 is higher

(C) Probability of symbol error is equal for both the constellations

(D) The value of N_0 will determine which of the constellations has a lower probability of symbol error

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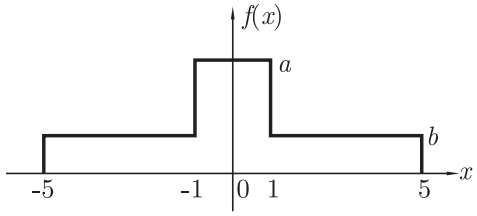
Statement for Linked Answer Question 8.44 & 8.45 :

An input to a 6-level quantizer has the probability density function $f(x)$ as shown in the figure. Decision boundaries of the quantizer are chosen so as to maximize the entropy of the quantizer output. It is given that 3 consecutive decision boundaries are' -1'.'0' and '1'.



MCQ 8.44

The values of a and b are

(A) $a = \frac{1}{6}$ and $b = \frac{1}{12}$

(B) $a = \frac{1}{5}$ and $b = \frac{3}{40}$

(C) $a = \frac{1}{4}$ and $b = \frac{1}{16}$

(D) $a = \frac{1}{3}$ and $b = \frac{1}{24}$

MCQ 8.45

Assuming that the reconstruction levels of the quantizer are the mid-points of the decision boundaries, the ratio of signal power to quantization noise power is

(A) $\frac{152}{9}$

(B) $\frac{64}{3}$

(C) $\frac{76}{3}$

(D) 28

2006 **ONE MARK**

MCQ 8.46

A low-pass filter having a frequency response $H(j\omega) = A(\omega)\, e^{j\phi(\omega)}$ does not produce any phase distortions if

(A) $A(\omega) = C\omega^3, \phi(\omega) = k\omega^3$

(B) $A(\omega) = C\omega^2, \phi(\omega) = k\omega$

(C) $A(\omega) = C\omega, \phi(\omega) = k\omega^2$

(D) $A(\omega) = C, \phi(\omega) = k\omega^{-1}$

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2006 **TWO MARKS**

MCQ 8.47

A signal with bandwidth 500 Hz is first multiplied by a signal $g(t)$ where

$$g(t) = \sum_{R=-\infty}^{\infty}(-1)^k \delta(t - 0.5\times 10^{-4} k)$$

The resulting signal is then passed through an ideal lowpass filter with bandwidth 1 kHz. The output of the lowpass filter would be

(A) $\delta(t)$ (B) $m(t)$

(C) 0 (D) $m(t)\delta(t)$

MCQ 8.48

The minimum sampling frequency (in samples/sec) required to reconstruct the following signal from its samples without distortion

$$x(t) = 5\left(\frac{\sin 2\pi 100t}{\pi t}\right)^3 + 7\left(\frac{\sin 2\pi 100t}{\pi t}\right)^2 \text{ would be}$$

(A) 2×10^3 (B) 4×10^3

(C) 6×10^3 (D) 8×10^3

MCQ 8.49

The minimum step-size required for a Delta-Modulator operating at 32k samples/sec to track the signal (here $u(t)$ is the unit-step function)

$$x(t) = 125[u(t) - u(t-1) + (250t)[u(t-1) - u(t-2)]$$

so that slope-overload is avoided, would be

(A) 2^{-10} (B) 2^{-8}

(C) 2^{-6} (D) 2^{-4}

MCQ 8.50

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

(A) correlated (B) statistically independent

(C) uncorrelated (D) orthogonal

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MCQ 8.51

A source generates three symbols with probabilities 0.25, 0.25, 0.50 at a rate of 3000 symbols per second. Assuming independent generation of symbols, the most efficient source encoder would have average bit rate is

(A) 6000 bits/sec
(B) 4500 bits/sec
(C) 3000 bits/sec
(D) 1500 bits/sec

MCQ 8.52

The diagonal clipping in Amplitude Demodulation (using envelop detector) can be avoided it 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)

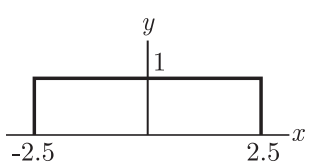
(A) $RC < \frac{1}{W}$
(B) $RC > \frac{1}{W}$
(C) $RC < \frac{1}{\omega}$
(D) $RC > \frac{1}{\omega}$

MCQ 8.53

A uniformly distributed random variable X with probability density function

$$f_x(x) = \frac{1}{10} pu(x+5) - u(x-5)]$$

where $u(.)$ is the unit step function is passed through a transformation given in the figure below. The probability density function of the transformed random variable Y would be



(A) $f_y(y) = \frac{1}{5}[u(y+2.5) - u(y-2.25)]$

(B) $f_y(y) = 0.5\delta(y) + 0.5\delta(y-1)$

(C) $f_y(y) = 0.25\delta(y+2.5) + 0.25\delta(y-2.5) + 5\delta(y)$

(D) $f_y(y) = 0.25\delta(y+2.5) + 0.25\delta(y-2.5) + \frac{1}{10}[u(y+2.5) - u(y-2.5)]$

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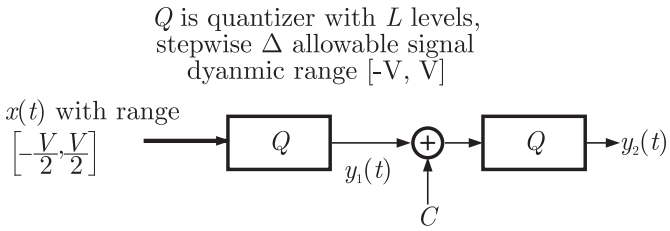
MCQ 8.54

In the following figure the minimum value of the constant "C", which is to be added to $y_1(t)$ such that $y_1(t)$ and $y_2(t)$ are different , is



(A) Δ

(B) $\frac{\Delta}{2}$

(C) $\frac{\Delta^2}{12}$

(D) $\frac{\Delta}{L}$

MCQ 8.55

A message signal with bandwidth 10 kHz is Lower-Side Band SSB modulated with carrier frequency $f_{c1} = 10^6$ Hz. The resulting signal is then passed through a Narrow-Band Frequency Modulator with carrier frequency $f_{c2} = 10^9$ Hz.

The bandwidth of the output would be

(A) 4×10^4 Hz

(B) 2×10^6 Hz

(C) 2×10^9 Hz

(D) 2×10^{10} Hz

Common Data for Questions 8.56 & 8.57 :

Let $g(t) = p(t)*(\ pt)$, where $*$ denotes convolution & $p(t) = u(t) - u(t-1) \lim_{z \to \infty}$ with $u(t)$ being the unit step function

MCQ 8.56

The impulse response of filter matched to the signal $s(t) = g(t) - \delta(1-2)*\ g(t)$ is given as :

(A) $s(1-t)$

(B) $-s(1-t)$

(C) $-s(t)$

(D) $s(t)$

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MCQ 8.57

An Amplitude Modulated signal is given as

$$x_{AM}(t) = 100\,[p(t) + 0.5g(t)]\cos\omega_c t$$

in the interval $0 \le t \le 1$. One set of possible values of modulating signal and modulation index would be

(A) $t, 0.5$ (B) $t, 1.0$

(C) $t, 2.0$ (D) $t^2, 0.5$

Common Data for Question 8.58 & 8.59 :

The following two question refer to wide sense stationary stochastic process

MCQ 8.58

It is desired to generate a stochastic process (as voltage process) with power spectral density $S(\omega) = 16/(16+\omega^2)$ by driving a Linear-Time-Invariant system by zero mean white noise (As voltage process) with power spectral density being constant equal to 1. The system which can perform the desired task could be

(A) first order lowpass R-L filter

(B) first order highpass R-C filter

(C) tuned L-C filter

(D) series R-L-C filter

MCQ 8.59

The parameters of the system obtained in previous Q would be

(A) first order R-L lowpass filter would have $R = 4\Omega$ $L = 1H$

(B) first order R-C highpass filter would have $R = 4\Omega$ $C = 0.25F$

(C) tuned L-C filter would have $L = 4H$ $C = 4F$

(D) series R-L-C lowpass filter would have $R = 1\Omega$, $L = 4H$, $C = 4F$

Common Data for Question 8.60 & 8.61 :

Consider the following Amplitude Modulated (AM) signal, where $f_m < B$

$$X_{AM}(t) = 10\,(1 + 0.5\sin 2\pi f_m t)\cos 2\pi f_c t$$

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MCQ 8.60

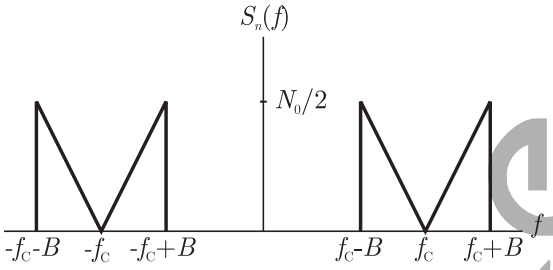
The average side-band power for the AM signal given above is

(A) 25 (B) 12.5

(C) 6.25 (D) 3.125

MCQ 8.61

The AM signal gets added to a noise with Power Spectral Density $S_n(f)$ given in the figure below. The ratio of average sideband power to mean noise power would be :



(A) $\dfrac{25}{8N_0B}$ (B) $\dfrac{25}{4N_0B}$

(C) $\dfrac{25}{2N_0B}$ (D) $\dfrac{25}{N_0B}$

2005 **ONE MARK**

MCQ 8.62

Find the correct match between group 1 and group 2.

Group 1	Group 2
P. $\{1 + km(t)\,A\sin(\omega_c t)\}$	W. Phase modulation
Q. $km(t)\,A\sin(\omega_c t)$	X. Frequency modulation
R. $A\sin\{\omega_c t + km(t)\}$	Y. Amplitude modulation
S. $A\sin\left[\omega_c t + k\int_{-\infty}^{t} m(t)\,dt\right]$	Z. DSB-SC modulation

(A) P – Z, Q – Y, R – X, S – W

(B) P – W, Q – X, R – Y, S – Z

(C) P – X, Q – W, R – Z, S – Y

(D) P – Y, Q – Z, R – W, S – X

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MCQ 8.63

Which of the following analog modulation scheme requires the minimum transmitted power and minimum channel bandwidth ?

(A) VSB (B) DSB-SC

(C) SSB (D) AM

2005 TWO MARKS

MCQ 8.64

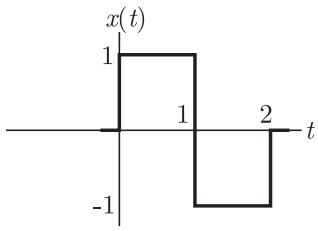
A device with input $X(t)$ and output $y(t)$ is characterized by: $Y(t) = x^2(t)$. An FM signal with frequency deviation of 90 kHz and modulating signal bandwidth of 5 kHz is applied to this device. The bandwidth of the output signal is

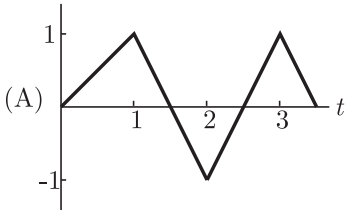
(A) 370 kHz (B) 190 kHz

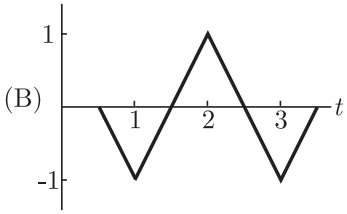
(C) 380 kHz (D) 95 kHz

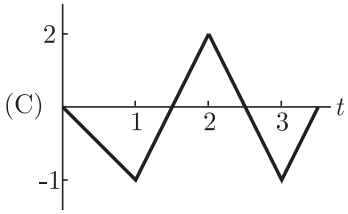
MCQ 8.65

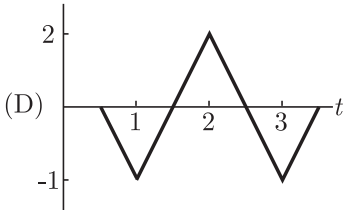
A signal as shown in the figure is applied to a matched filter. Which of the following does represent the output of this matched filter ?











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MCQ 8.66

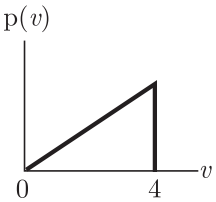
Noise with uniform power spectral density of N_0 W/Hz is passed though a filter $H(\omega) = 2\exp(-j\omega t_d)$ followed by an ideal pass filter of bandwidth B Hz. The output noise power in Watts is

(A) $2N_0B$ (B) $4N_0B$

(C) $8N_0B$ (D) $16N_0B$

MCQ 8.67

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

MCQ 8.68

A carrier is phase modulated (PM) with frequency deviation of 10 kHz by a single tone frequency of 1 kHz. If the single tone frequency is increased to 2 kHz, assuming that phase deviation remains unchanged, the bandwidth of the PM signal is

(A) 21 kHz (B) 22 kHz

(C) 42 kHz (D) 44 kHz

Common Data for Question 8.69 and 8.70 :

Asymmetric three-level midtread quantizer is to be designed assuming equiprobable occurrence of all quantization levels.

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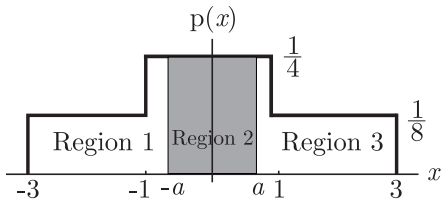

MCQ 8.69

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

(A) $\frac{1}{3}$ (B) $\frac{2}{3}$

(C) $\frac{1}{2}$ (D) $\frac{1}{4}$

MCQ 8.70

The quantization noise power for the quantization region between $-a$ and $+a$ in the figure is

(A) $\frac{4}{81}$ (B) $\frac{1}{9}$

(C) $\frac{5}{81}$ (D) $\frac{2}{81}$

2004 ONE MARK

MCQ 8.71

In a PCM system, if the code word length is increased from 6 to 8 bits, the signal to quantization noise ratio improves by the factor

(A) $\frac{8}{6}$ (B) 12

(C) 16 (D) 8

MCQ 8.72

An AM signal is detected using an envelop detector. The carrier frequency and modulating signal frequency are 1 MHz and 2 kHz respectively. An appropriate value for the time constant of the envelop detector is

(A) 500μsec (B) 20μsec

(C) 0.2μsec (D) 1μsec

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MCQ 8.73

An AM signal and a narrow-band FM signal with identical carriers, modulating signals and modulation indices of 0.1 are added together. The resultant signal can be closely approximated by

(A) broadband FM
(B) SSB with carrier
(C) DSB-SC
(D) SSB without carrier

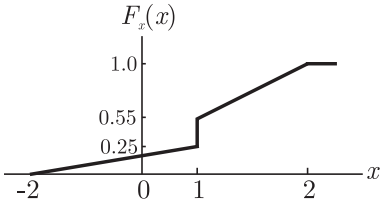
MCQ 8.74

In the output of a DM speech encoder, the consecutive pulses are of opposite polarity during time interval $t_1 \le t \le t_2$. This indicates that during this interval

(A) the input to the modulator is essentially constant
(B) the modulator is going through slope overload
(C) the accumulator is in saturation
(D) the speech signal is being sampled at the Nyquist rate

MCQ 8.75

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

2004 TWO MARKS

MCQ 8.76

A 1 mW video signal having a bandwidth of 100 MHz is transmitted to a receiver through cable that has 40 dB loss. If the effective one-side 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

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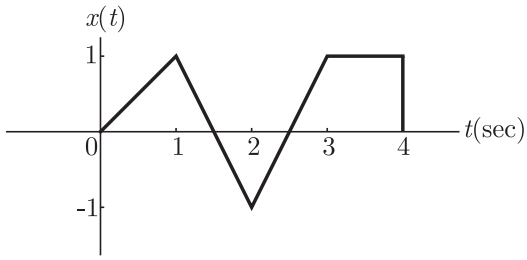
MCQ 8.77

Consider the signal $x(t)$ shown in Fig. Let $h(t)$ denote the impulse response of the filter matched to $x(t)$, with $h(t)$ being non-zero only in the interval 0 to 4 sec. The slope of $h(t)$ in the interval $3 < t < 4$ sec is



(A) $\frac{1}{2}\text{sec}^{-1}$

(B) $-1\,\text{sec}^{-1}$

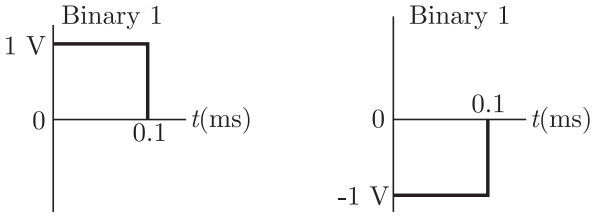
(C) $-\frac{1}{2}\text{sec}^{-1}$

(D) $1\,\text{sec}^{-1}$

MCQ 8.78

A source produces binary data at the rate of 10 kbps. The binary symbols are represented as shown in the figure.

The source output is transmitted using two modulation schemes, namely Binary PSK (BPSK) and Quadrature PSK (QPSK). Let B_1 and B_2 be the bandwidth requirements of the above rectangular pulses is 10 kHz, B_1 and B_2 are



(A) $B_1 = 20$ kHz, $B_2 = 20$ kHz

(B) $B_1 = 10$ kHz, $B_2 = 20$ kHz

(C) $B_1 = 20$ khz, $B_2 = 10$ kHz

(D) $B_1 = 10$ kHz, $B_2 = 10$ kHz

MCQ 8.79

A 100 MHz carrier of 1 V amplitude and a 1 MHz modulating signal of 1 V amplitude are fed to a balanced modulator. The ourput of the modulator is passed through an ideal high-pass filter with cut-

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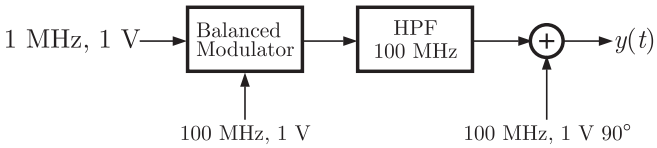
off frequency of 100 MHz. The output of the filter is added with 100 MHz signal of 1 V amplitude and 90° phase shift as shown in the figure. The envelope of the resultant signal is



(A) constant

(B) $\sqrt{1+\sin(2\pi\times10^6 t)}$

(C) $\sqrt{\frac{5}{4}-\sin(2\pi-10^6 t)}$

(D) $\sqrt{\frac{5}{4}+\cos(2\pi\times10^6 t)}$

MCQ 8.80

Two sinusoidal signals of same amplitude and frequencies 10 kHz and 10.1 kHz are added together. The combined signal is given to an ideal frequency detector. The output of the detector is

(A) 0.1 kHz sinusoid

(B) 20.1 kHz sinusoid

(C) a linear function of time

(D) a constant

MCQ 8.81

Consider a binary digital communication system with equally likely 0's and 1's. When binary 0 is transmitted the detector input can lie between the levels -0.25 V and $+0.25$ V with equl probability : when binary 1 is transmitted, the voltage at the detector can have any value between 0 and 1 V with equal probability. If the detector has a threshold of 0.2 V (i.e., if the received signal is greater than 0.2 V, the bit is taken as 1), the average bit error probability is

(A) 0.15

(B) 0.2

(C) 0.05

(D) 0.5

MCQ 8.82

A random variable X with uniform density in the interval 0 to 1 is quantized as follows :

If $0 \le X \le 0.3$, $\quad x_q = 0$

If $0.3 < X \le 1$, $\quad x_q = 0.7$

where x_q is the quantized value of X.

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The root-mean square value of the quantization noise is

(A) 0.573 (B) 0.198

(C) 2.205 (D) 0.266

MCQ 8.83

Choose the current one from among the alternative A, B, C, D after matching an item from Group 1 with the most appropriate item in Group 2.

Group 1	Group 2
1. FM	P. Slope overload
2. DM	Q. μ-law
3. PSK	R. Envelope detector
4. PCM	S. Hilbert transform
	T. Hilbert transform
	U. Matched filter

(A) 1 - T, 2 - P, 3 - U, 4 - S (B) 1 - S, 2 - U, 3 - P, 4 - T

(C) 1 - S, 2 - P, 3 - U, 4 - Q (D) 1 - U, 2 - R, 3 - S, 4 - Q

MCQ 8.84

Three analog signals, having bandwidths 1200 Hz, 600 Hz and 600 Hz, are sampled at their respective Nyquist rates, encoded with 12 bit words, and time division multiplexed. The bit rate for the multiplexed. The bit rate for the multiplexed signal is

(A) 115.2 kbps (B) 28.8 kbps

(C) 57.6 kbps (D) 38.4 kbps

MCQ 8.85

Consider a system shown in the figure. Let $X(f)$ and $Y(f)$ and denote the Fourier transforms of $x(t)$ and $y(t)$ respectively. The ideal HPF has the cutoff frequency 10 kHz.

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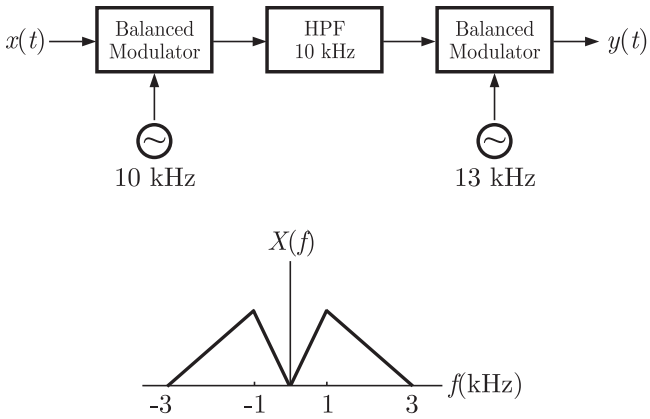

The positive frequencies where $Y(f)$ has spectral peaks are

(A) 1 kHz and 24 kHz
(B) 2 kHz and 244 kHz
(C) 1 kHz and 14 kHz
(D) 2 kHz and 14 kHz

2003 **ONE MARK**

MCQ 8.86

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

MCQ 8.87

The noise at the input to an ideal frequency detector is white. The detector is operating above threshold. The power spectral density of the noise at the output is

(A) raised - cosine
(B) flat
(C) parabolic
(D) Gaussian

MCQ 8.88

At a given probability of error, binary coherent FSK is inferior to binary coherent PSK by.

(A) 6 dB
(B) 3 dB
(C) 2 dB
(D) 0 dB

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2003 **TWO MARKS**

MCQ 8.89

Let X and Y be two statistically independent random variables uniformly distributed in the ranges $(-1,1)$ and $(-2,1)$ respectively. Let $Z = X + Y$. Then the probability that $(z \le -1)$ is

(A) zero (B) $\frac{1}{6}$

(C) $\frac{1}{3}$ (D) $\frac{1}{12}$

Common Data for Questions 8.90 & 8.91 :

$X(t)$ is a random process with a constant mean value of 2 and the auto correlation function $R_{xx}(\tau) = 4(e^{-0.2|\tau|} + 1)$.

MCQ 8.90

Let X be the Gaussian random variable obtained by sampling the process at $t = t_i$ and let

$$Q(\alpha) = \int_{\alpha}^{\infty} -\frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dy$$

The probability that $[x \le 1]$ is

(A) $1 - Q(0.5)$ (B) $Q(0.5)$

(C) $Q\left(\frac{1}{2\sqrt{2}}\right)$ (D) $1 - Q\left(\frac{1}{2\sqrt{2}}\right)$

MCQ 8.91

Let Y and Z be the random variable 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

MCQ 8.92

A sinusoidal signal with peak-to-peak amplitude of 1.536 V is quantized into 128 levels using a mid-rise uniform quantizer. The quantization-noise power is

(A) 0.768 V (B) $48 \times 10^{-6}\ V^2$

(B) $12 \times 10^{-6}\ V^2$ (D) 3.072 V

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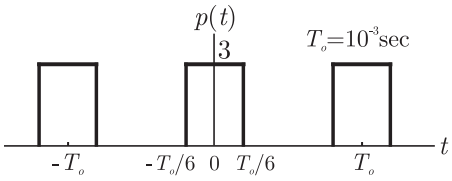
MCQ 8.93

Let $x(t) = 2\cos(800\pi) + \cos(1400\pi t)$. $x(t)$ is sampled with the rectangular pulse train shown in the figure. The only spectral components (in kHz) present in the sampled signal in the frequency range 2.5 kHz to 3.5 kHz are



(A) 2.7, 3.4 (B) 3.3, 3.6

(C) 2.6, 2.7, 3.3, 3.4, 3.6 (D) 2.7, 3.3

MCQ 8.94

A DSB-SC signal is to be generated with a carrier frequency $f_c = 1$ MHz using a non-linear device with the input-output characteristic $V_0 = a_0 v_i + a_1 v_i^3$ where a_0 and a_1 are constants. The output of the non-linear device can be filtered by an appropriate band-pass filter.

Let $V_i = A_c^i \cos(2\pi f^i c^t) + m(t)$ is the message signal. Then the value of f_c^i (in MHz) is

(A) 1.0 (B) 0.333

(B) 0.5 (D) 3.0

Common Data for Question 8.95 & 8.96 :

Let $m(t) = \cos[(4\pi \times 10^3)\, t]$ be the message signal &

$c(t) = 5\cos[(2\pi \times 10^6\, t)]$ be the carrier.

MCQ 8.95

$c(t)$ and $m(t)$ are used to generate an AM signal. The modulation index of the generated AM signal is 0.5. Then the quantity $\dfrac{\text{Total sideband power}}{\text{Carrier power}}$ is

(A) $\frac{1}{2}$ (B) $\frac{1}{4}$

(C) $\frac{1}{3}$ (D) $\frac{1}{8}$

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MCQ 8.96

$c(t)$ and $m(t)$ are used to generated an FM signal. If the peak frequency deviation of the generated FM signal is three times the transmission bandwidth of the AM signal, then the coefficient of the term $\cos[2\pi(1008\times10^3 t)]$ in the FM signal (in terms of the Bessel coefficients) is

(A) $5J_4(3)$

(B) $\frac{5}{2}J_8(3)$

(C) $\frac{5}{2}J_8(4)$

(D) $5J_4(6)$

MCQ 8.97

Choose the correct one from among the alternative A, B, C, D after matching an item in Group 1 with most appropriate item in Group 2.

Group 1	Group 2
P. Ring modulator	1. Clock recovery
Q. VCO	2. Demodulation of FM
R. Foster-Seely discriminator	3. Frequency conversion
S. Mixer	4. Summing the two inputs
	5. Generation of FM
	6. Generation of DSB-Sc

(A) $P-1; Q-3; R-2; S-4$

(B) $P-6; Q=5; R-2; S-3$

(C) $P-6; Q-1; R-3; S-2$

(D) $P-5; Q-6; R-1; S-3$

MCQ 8.98

A superheterodyne receiver is to operate in the frequency range 550 kHz - 1650 kHz, with the intermediate frequency of 450 kHz. Let $R = C_{\max}/C_{\min}$ denote the required capacitance ratio of the local oscillator and I denote the image frequency (in kHz) of the incoming signal. If the receiver is tuned to 700 kHz, then

(A) $R = 4.41, I = 1600$

(B) $R = 2.10, I - 1150$

(C) $R = 3.0, I = 600$

(D) $R = 9.0, I = 1150$

MCQ 8.99

If E_b, the energy per bit of a binary digital signal, is 10^{-5} watt-sec and the one-sided power spectral density of the white noise, $N_0 = 10^{-6}$ W/

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Hz, then the output SNR of the matched filter is

(A) 26 dB (B) 10 dB

(C) 20 dB (D) 13 dB

MCQ 8.100

The input to a linear delta modulator having a step-size $\Delta = 0.628$ is a sine wave with frequency f_m and peak amplitude E_m. If the sampling frequency $f_x = 40$ kHz, the combination of the sine-wave frequency and the peak amplitude, where slope overload will take place is

E_m	f_m
(A) 0.3 V	8 kHz
(B) 1.5 V	4 kHz
(C) 1.5 V	2 kHz
(D) 3.0 V	1 kHz

MCQ 8.101

If S represents the carrier synchronization at the receiver and ρ represents the bandwidth efficiency, then the correct statement for the coherent binary PSK is

(A) $\rho = 0.5, S$ is required (B) $\rho = 1.0, S$ is required

(C) $\rho = 0.5, S$ is not required (D) $\rho = 1.0, S$ is not required

MCQ 8.102

A signal is sampled at 8 kHz and is quantized using 8 - bit uniform quantizer. Assuming SNR_q for a sinusoidal signal, the correct statement for PCM signal with a bit rate of R is

(A) $R = 32$ kbps, $SNR_q = 25.8$ dB

(B) $R = 64$ kbps, $SNR_q = 49.8$ dB

(C) $R = 64$ kbps, $SNR_q = 55.8$ dB

(D) $R = 32$ kbps, $SNR_q = 49.8$ dB

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2002 **ONE MARK**

MCQ 8.103

A 2 MHz sinusoidal carrier amplitude modulated by 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

MCQ 8.104

Consider a sample signal $y(t) = 5 \times 10^{-6} \times (t) \sum_{n=-\infty}^{+\infty} \delta(t - nT_s)$

where $x(t) = 10\cos(8\pi \times 10^3)\, t$ and $T_s = 100\mu$ sec.

When $y(t)$ is passed through an ideal lowpass filter with a cutoff frequency of 5 KHz, the output of the filter is

(A) $5 \times 10^{-6} \cos(8\pi \times 10^3)\, t$ (b) $5 \times 10^{-5} \cos(8\pi \times 10^3)\, t$

(C) $5 \times 10^{-1} \cos(8\pi \times 10^3)\, t$ (D) $10 \cos(8\pi \times 10^3)\, t$

MCQ 8.105

For a bit-rate of 8 Kbps, the best possible values of the transmitted frequencies in a coherent binary FSK system are

(A) 16 kHz and 20 kHz (C) 20 kHz and 32 kHz

(C) 20 kHz and 40 kHz (D) 32 kHz and 40 kHz

MCQ 8.106

The line-of-sight communication requires the transmit and receive antennas to face each other. If the transmit antenna is vertically polarized, for best reception the receiver antenna should be

(A) horizontally polarized

(B) vertically polarized

(C) at 45° with respect to horizontal polarization

(D) at 45° with respect to vertical polarization

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2002 **TWO MARKS**

MCQ 8.107

An angle-modulated signal is given by

$$s(t) = \cos 2\pi (2 \times 10^6 t + 30 \sin 150t + 40 \cos 150t).$$

The maximum frequency and phase deviations of $s(t)$ are

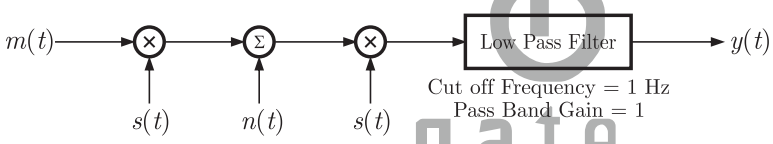
(A) 10.5 kHz, 140π rad (B) 6 kHz, 80π rad

(C) 10.5 kHz, 100π rad (D) 7.5 kHz, 100π rad

MCQ 8.108

In the figure $m(t) = \dfrac{2 \sin 2\pi t}{t}, s(t) = \cos 200\pi t$ and $n(t) = \dfrac{\sin 199\pi t}{t}$.

The output $y(t)$ will be



(A) $\dfrac{\sin 2\pi t}{t}$ (B) $\dfrac{\sin 2\pi t}{t} + \dfrac{\sin \pi t}{t} \cos 3\pi t$

(C) $\dfrac{\sin 2\pi t}{t} + \dfrac{\sin 0.5\pi t}{t} \cos 1.5\pi t$ (D) $\dfrac{\sin 2\pi t}{t} + \dfrac{\sin \pi t}{t} \cos 0.75\pi t$

MCQ 8.109

A signal $x(t) = 100 \cos (24\pi \times 10^3)\, t$ is ideally sampled with a sampling period of 50μsec ana then passed through an ideal lowpass filter with cutoff frequency of 15 kHz. Which of the following frequencies is/are present at the filter output ?

(A) 12 kHz only (B) 8 kHz only

(C) 12 kHz and 9 kHz (D) 12 kHz and 8 kHz

MCQ 8.110

If the variance α_x^2 of $d(n) = x(n) - x(n-1)$ is one-tenth the variance α_x^2 of stationary zero-mean discrete-time signal $x(n)$, then the normalized autocorrelation function $\dfrac{R_{xx}(k)}{\alpha_x^2}$ at $k = 1$ is

(A) 0.95 (B) 0.90

(C) 0.10 (D) 0.05

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2001 **ONE MARK**

MCQ 8.111

A bandlimited signal is sampled at the Nyquist rate. The signal can be recovered by passing the samples through

(A) an RC filter

(B) an envelope detector

(C) a PLL

(D) an ideal low-pass filter with the appropriate bandwidth

MCQ 8.112

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) $\frac{1}{2}$

(B) $\frac{1}{3\sqrt{2\pi}}$

(C) 0

(D) $\frac{1}{4}$

2001 **TWO MARKS**

MCQ 8.113

A video transmission system transmits 625 picture frames per second. Each frame consists of a 400×400 pixel grid with 64 intensity levels per pixel. The data rate of the system is

(A) 16 Mbps

(B) 100 Mbps

(C) 600 Mbps

(D) 6.4 Gbps

MCQ 8.114

The Nyquist sampling interval, for the signal $\sin c(700t) + \sin c(500t)$ is

(A) $\frac{1}{350}$ sec

(B) $\frac{\pi}{350}$ sec

(C) $\frac{1}{700}$ sec

(D) $\frac{\pi}{175}$ sec

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MCQ 8.115

During transmission over a communication channel, bit errors occur independently with probability p. If a block of n bits is transmitted, the probability of at most one bit error is equal to

(A) $1-(1-p)^n$ (B) $p+(n-1)(1-p)$

(C) $np(1-p)^{n-1}$ (D) $(1-p)^n+np(1-p)^{n-1}$

MCQ 8.116

The PSD and the power of a signal $g(t)$ are, respectively, $S_g(\omega)$ and P_g. The PSD and the power of the signal $ag(t)$ are, respectively,

(A) $a^2S_g(\omega)$ and a^2P_g (B) $a^2S_g(\omega)$ and aP_g

(C) $aS_g(\omega)$ and a^2P_g (D) $aS_g(\omega)$ and aP_s

2000 ONE MARK

MCQ 8.117

The amplitude modulated waveform $s(t)=A_c[1+K_am(t)]\cos\omega_ct$ is fed to an ideal envelope detector. The maximum magnitude of $K_0m(t)$ is greater than 1. Which of the following could be the detector output ?

(A) $A_cm(t)$ (B) $A_c^2[1+K_am(t)]^2$

(C) $[A_c(1+K_am(t)]$ (D) $A_c[1+K_am(t)]^2$

MCQ 8.118

The frequency range for satellite communication is

(A) 1 KHz to 100 KHz (B) 100 KHz to 10 KHz

(C) 10 MHz to 30 MHz (D) 1 GHz to 30 GHz

2000 TWO MARKS

MCQ 8.119

In a digital communication system employing Frequency Shift Keying (FSK), the 0 and 1 bit are represented by sine waves of 10 KHz and 25 KHz respectively. These waveforms will be orthogonal for a bit interval of

(A) 45μsec (B) 200μsec

(C) 50μsec (D) 250μsec

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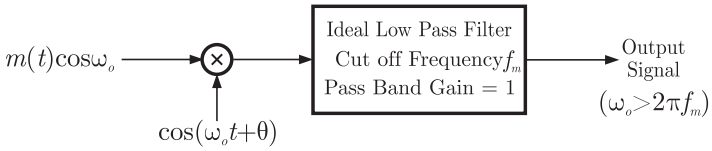
MCQ 8.120

A message $m(t)$ bandlimited to the frequency f_m has a power of P_m. The power of the output signal in the figure is



(A) $\dfrac{P_m \cos\theta}{2}$ (B) $\dfrac{P_m}{4}$

(C) $\dfrac{P_m \sin^2\theta}{4}$ (D) $\dfrac{P_m \cos^2\theta}{4}$

MCQ 8.121

The Hilbert transform of $\cos\omega_1 t + \sin\omega_2 t$ is

(A) $\sin\omega_1 t - \cos\omega_2 t$ (B) $\sin\omega_1 t + \cos\omega_2 t$

(C) $\cos\omega_1 t - \sin\omega_2 t$ (D) $\sin\omega_1 t + \sin\omega_2 t$

MCQ 8.122

In a FM system, a carrier of 100 MHz modulated by a sinusoidal signal of 5 KHz. The bandwidth by Carson's approximation is 1 MHz. If $y(t) =$ (modulated waveform)^3, than by using Carson's approximation, the bandwidth of $y(t)$ around 300 MHz and the and the spacing of spectral components are, respectively.

(A) 3 MHz, 5 KHz (B) 1 MHz, 15 KHz

(C) 3 MHz, 15 KHz (D) 1 MHz, 5 KHz

1999 ONE MARK

MCQ 8.123

The input to a channel is a bandpass signal. It is obtained by linearly modulating a sinusoidal carrier with a single-tone signal. The output of the channel due to this input is given by

$$y(t) = (1/100)\cos(100t - 10^{-6})\cos(10^6 t - 1.56)$$

The group delay (t_g) and the phase delay (t_p) in seconds, of the channel are

(A) $t_g = 10^{-6}, t_p = 1.56$ (B) $t_g = 1.56, t_p = 10^{-6}$

(C) $t_g = 10^8, t_p = 1.56 \times 10^{-6}$ (D) $t_g = 10^8, t_p = 1.56$

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MCQ 8.124

A modulated signal is given by $s(t) = m_1(t)\cos(2\pi f_c t) + m_2(t)\sin(2\pi f_c t)$ where the baseband signal $m_1(t)$ and $m_2(t)$ have bandwidths of 10 kHz , and 15 kHz, respectively. The bandwidth of the modulated signal, in kHz, is

(A) 10 (B) 15

(C) 25 (D) 30

MCQ 8.125

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

(A) $\exp(-at)\exp[j(\omega_c + \Delta\omega)t]\,u(t)$

(B) $\exp(-at)\exp(j\Delta\omega t)\,u(t)$

(C) $\exp(j\Delta\omega t)\,u(t)$

(D) $\exp[j\omega_c + \Delta\omega)t]$

1999 TWO MARKS

MCQ 8.126

The Nyquist sampling frequency (in Hz) of a signal given by

$6 \times 10^4 \sin c^2(400t) * 10^6 \sin c^3(100t)$ is

(A) 200 (B) 300

(C) 500 (D) 1000

MCQ 8.127

The peak-to-peak input to an 8-bit PCM coder is 2 volts. The signal power-to-quantization noise power ratio (in dB) for an input of $0.5\cos(\omega_m t)$ is

(A) 47.8 (B) 49.8

(C) 95.6 (D) 99.6

MCQ 8.128

The input to a matched filter is given by

$$s(t) = \begin{cases} 10\sin(2\pi \times 10^6 t) & 0 < 1 < 10^{-4}\,\text{sec} \\ 0 & \text{otherwise} \end{cases}$$

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The peak amplitude of the filter output is

(A) 10 volts (B) 5 volts

(C) 10 millivolts (D) 5 millivolts

MCQ 8.129

Four independent messages have bandwidths of 100 Hz, 200 Hz and 400 Hz, respectively. Each is sampled at the Nyquist rate, and the samples are time division multiplexed (TDM) and transmitted. The transmitted sample rate (in Hz) is

(A) 1600 (B) 800

(C) 400 (D) 200

1998 ONE MARK

MCQ 8.130

The amplitude spectrum of a Gaussian pulse is

(A) uniform (B) a sine function

(C) Gaussian (D) an impulse function

MCQ 8.131

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 $2T$

MCQ 8.132

The image channel selectivity of superheterodyne receiver depends upon

(A) IF amplifiers only

(B) RF and IF amplifiers only

(C) Preselector, RF and IF amplifiers

(D) Preselector, and RF amplifiers only

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MCQ 8.133

In a PCM system with uniform quantisation, increasing the number of bits from 8 to 9 will reduce the quantisation noise power by a factor of

(A) 9 (B) 8

(C) 4 (D) 2

MCQ 8.134

Flat top sampling of low pass signals

(A) gives rise to aperture effect (B) implies oversampling

(C) leads to aliasing (D) introduces delay distortion

MCQ 8.135

A DSB-SC signal is generated using the carrier $\cos(\omega_c t + \theta)$ and modulating signal $x(t)$. The envelope of the DSB-SC signal is

(A) $x(t)$ (B) $|x(t)|$

(C) only positive portion of $x(t)$ (D) $x(t)\cos\theta$

MCQ 8.136

Quadrature multiplexing is

(A) the same as FDM

(B) the same as TDM

(C) a combination of FDM and TDM

(D) quite different from FDM and TDM

MCQ 8.137

The Fourier transform of a voltage signal $x(t)$ is $X(f)$. The unit of $|X(f)|$ is

(A) volt (B) volt-sec

(C) volt/sec (D) volt^2

MCQ 8.138

Compression in PCM refers to relative compression of

(A) higher signal amplitudes (B) lower signal amplitudes

(C) lower signal frequencies (D) higher signal frequencies

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MCQ 8.139

For a give data rate, the bandwidth B_p of a BPSK signal and the bandwidth B_0 of the OOK signal are related as

(A) $B_p = \frac{B_0}{4}$ (B) $B_p = \frac{B_0}{2}$

(C) $B_p = B_0$ (D) $B_p = 2B_0$

MCQ 8.140

The spectral density of a real valued random process has

(A) an even symmetry (B) an odd symmetry

(C) a conjugate symmetry (D) no symmetry

MCQ 8.141

The probability density function of the envelope of narrow band Gaussian noise is

(A) Poisson (B) Gaussian

(C) Rayleigh (D) Rician

1997 ONE MARK

MCQ 8.142

The line code that has zero dc component for pulse transmission of random binary data is

(A) Non-return to zero (NRZ)

(B) Return to zero (RZ)

(C) Alternate Mark Inversion (AM)

(D) None of the above

MCQ 8.143

A probability density function is given by $p(x) = Ke^{-x^2/2} - \infty < x < \infty$. The value of K should be

(A) $\frac{1}{\sqrt{2\pi}}$ (B) $\sqrt{\frac{2}{\pi}}$

(C) $\frac{1}{2\sqrt{\pi}}$ (D) $\frac{1}{\pi\sqrt{2}}$

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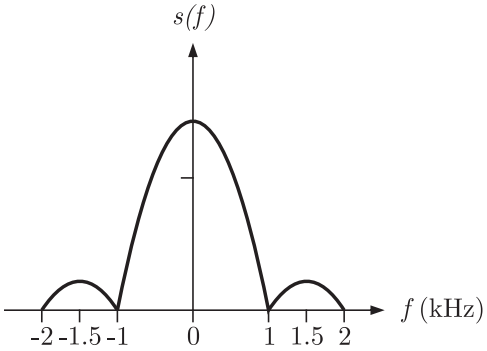
MCQ 8.144

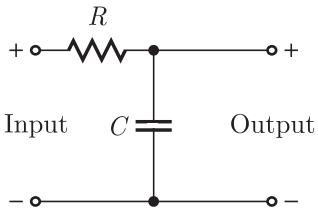
A deterministic signal has the power spectrum given in the figure is, The minimum sampling rate needed to completely represent this signal is

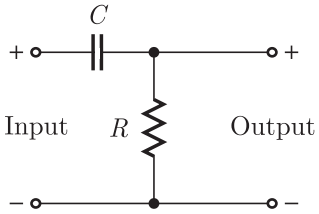


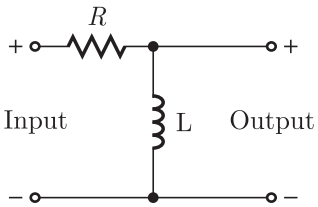
(A) 1 kHz
(B) 2 kHz
(C) 3 kHz
(D) None of these

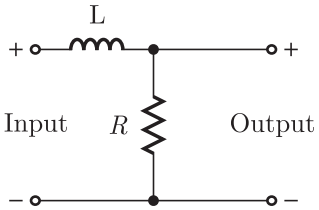
MCQ 8.145

A communication channel has first order low pass transfer function. The channel is used to transmit pulses at a symbol rate greater than the half-power frequency of the low pass function. Which of the network shown in the figure is can be used to equalise the received pulses?

(A)


(B)


(C)


(D)


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MCQ 8.146

The power spectral density of a deterministic signal is given by $[\sin(f)/f^2]$ where f is frequency. The auto correlation 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

1996 ONE MARK

MCQ 8.147

A rectangular pulse of duration T is applied to a filter matched to this input. The out put of the filter is a

(A) rectangular pulse of duration T
(B) rectangular pulse of duration $2T$
(C) triangular pulse
(D) sine function

MCQ 8.148

The image channel rejection in a superheterodyne receiver comes from

(A) IF stages only
(B) RF stages only
(C) detector and RF stages only
(D) detector RF and IF stages

1996 TWO MARKS

MCQ 8.149

The number of bits in a binary PCM system is increased from n to $n+1$. As a result, the signal to quantization noise ratio will improve by a factor

(A) $\frac{n+1}{n}$
(B) $2^{(n+1)/n}$
(C) $2^{2(n+1)/n}$
(D) which is independent of n

MCQ 8.150

The auto correlation function of an energy signal has

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(A) no symmetry (B) conjugate symmetry

(C) odd symmetry (D) even symmetry

MCQ 8.151

An FM signal with a modulation index 9 is applied to a frequency tripler. The modulation index in the output signal will be

(A) 0 (B) 3

(C) 9 (D) 27

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SOLUTIONS

SOL 8.1

Quantized 4 level require 2 bit representation i.e. for one sample 2 bit are required. Since 2 sample per second are transmitted we require 4 bit to be transmitted per second.
Hence (D) is correct option.

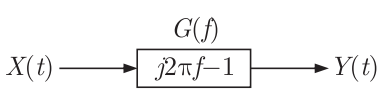
SOL 8.2

In FM the amplitude is constant and power is efficient transmitted. No variation in power.
There is most bandwidth efficient transmission in SSB- SC. because we transmit only one side band.
Simple Diode in Non linear region (Square law) is used in conventional AM that is simplest receiver structure.
In VSB dc. component exists.
Hence (B) is correct option.

SOL 8.3

We have
$$S_x(f) = F\{R_x(\tau)\} = F\{\exp(-\pi\tau^2)\}$$
$$= e^{-\pi f^2}$$

The given circuit can be simplified as



Power spectral density of output is
$$S_y(f) = |G(f)|^2 S_x(f)$$
$$= |j2\pi f - 1|^2 e^{-\pi f^2}$$
$$= (\sqrt{(2\pi f)^2 + 1})^2 e^{-\pi f^2}$$

or $$S_y(f) = (4\pi^2 f^2 + 1)\, e^{-\pi f^2}$$
Hence (A) is correct option.

SOL 8.4

Highest frequency component in $m(t)$ is $f_m = 4000\pi/2\pi = 2000$ Hz
Carrier frequency $f_C = 1$ MHz

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For Envelope detector condition

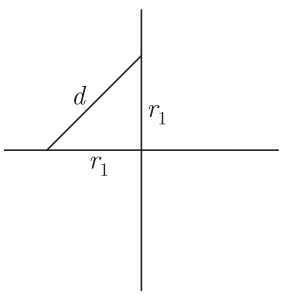
$$1/f_C << RC << 1/f_m$$

$$1\ \mu s << RC << 0.5\ ms$$

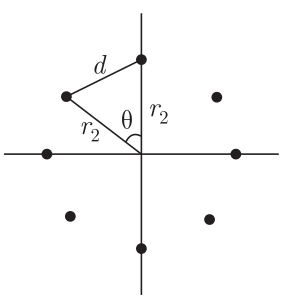
Hence (B) is correct option.

SOL 8.5

Four phase signal constellation is shown below



Now
$$d^2 = r_1^2 + r_1^2$$
$$d^2 = 2r_1^2$$
$$r_1 = d/\sqrt{2} = 0.707d$$



$$\theta = \frac{2\pi}{M} = \frac{2\pi}{8} = \frac{\pi}{4}$$

Applying Cooine law we have

$$d^2 = r_2^2 + r_2^2 - 2r_2^2 \cos\frac{\pi}{4}$$

$$= 2r_2^2 - 2r_2^2\ 1/\sqrt{2}\ = (2-\sqrt{2})\, r_2^2$$

or
$$r_2 = \frac{d}{\sqrt{2-\sqrt{2}}} = 1.3065d$$

Hence (D) is correct option.

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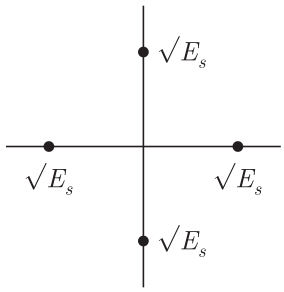
SOL 8.6

Here P_e for 4 PSK and 8 PSK is same because P_e depends on d. Since P_e is same, d is same for 4 PSK and 8 PSK.



Additional Power SNR

$$= (SNR)_2 - (SNR)_1$$

$$= 10\log\left(\frac{E_{S2}}{No}\right) - 10\log\left(\frac{E_{S1}}{No}\right)$$

$$= 10\log\left(\frac{E_{S2}}{E_{S1}}\right)$$

$$= 10\log\left(\frac{r_2}{r_1}\right)^2 \Rightarrow 20\log\left(\frac{r_2}{r_1}\right) = 20\log\frac{1.3065\text{d}}{0.707\text{d}}$$

Additional SNR $= 5.33$ dB

Hence (D) is correct option.

SOL 8.7

Conventional AM signal is given by

$$x(t) = A_C[1 + \mu m(t)]\cos(2\pi f_C t)$$

Where $\mu < 1$, for no over modulation.

In option (C)

$$x(t) = A_C\left[1 + \frac{1}{4}m(t)\right]\cos(2\pi f_C t)$$

Thus $\mu = \frac{1}{4} < 1$ and this is a conventional AM-signal without over-modulation

Hence (C) is correct option.

SOL 8.8

Power $$P = \frac{(6)^2}{2} = 18 \text{ W}$$

Hence (B) is correct option.

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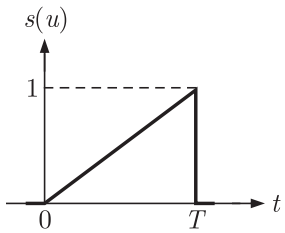
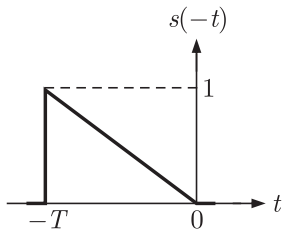
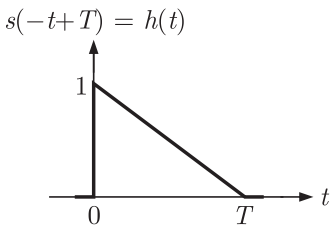
SOL 8.9

Impulse response of the matched filter is given by

$$h(t) = S(T - t)$$







Hence (C) is correct option.

SOL 8.10

Let response of LPF filters

$$H(f) = \begin{cases} 1, & |f| < 1\,\text{MHz} \\ 0, & \text{elsewhere} \end{cases}$$

Noise variance (power) is given as

$$P = \sigma^2 = \int_0^{f_o} |H(f)|^2 N_o\, df = \frac{2}{\alpha^2} \text{ (given)}$$

$$\int_0^{1\times 10^6} 2 \times 10^{-20}\, df = \frac{2}{\alpha^2}$$

$$2 \times 10^{-20} \times 10^6 = \frac{2}{\alpha^2}$$

$$\alpha^2 = 10^{14}$$

or $$\alpha = 10^7$$

Hence (B) is correct option.

SOL 8.11

Probability of error is given by

$$P_e = \frac{1}{2}[P(0/1) + P(1/0)]$$

$$P(0/1) = \int_{-\infty}^{\alpha/2} 0.5 e^{-\alpha|n-a|} dn = 0.5 e^{-10}$$

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where $a = 2 \times 10^{-6}$ V and $\alpha = 10^7 V^{-1}$

$$P(1/0) = \int_{a/2}^{\infty} 0.5 e^{-\alpha|n|} dn = 0.5 e^{-10}$$

$$P_e = 0.5 e^{-10}$$

Hence (D) is correct option.

SOL 8.12

$$S(t) = \sin c(500t) \sin c(700t)$$

$S(f)$ is convolution of two signals whose spectrum covers $f_1 = 250$ Hz and $f_2 = 350$ Hz. So convolution extends

$$f = 25 + 350 = 600 \text{ Hz}$$

Nyquist sampling rate

$$N = 2f = 2 \times 600 = 1200 \text{ Hz}$$

Hence(C) is correct option.

SOL 8.13

For the given system, output is written as

$$y(t) = \frac{d}{dt}[x(t) + x(t-0.5)]$$

$$y(t) = \frac{dx(t)}{dt} + \frac{dx(t-0.5)}{dt}$$

Taking laplace on both sides of above equation

$$Y(s) = sX(s) + se^{-0.5s} X(s)$$

$$H(s) = \frac{Y(s)}{X(s)} = s(1 + e^{-0.5s})$$

$$H(f) = jf(1 + e^{-0.5 \times 2\pi f}) = jf(1 + e^{-\pi f})$$

Power spectral density of output

$$S_Y(f) = |H(f)|^2 S_X(f) = f^2 (1 + e^{-\pi f})^2 S_X(f)$$

For $S_Y(f) = 0$, $\quad 1 + e^{-\pi f} = 0$

$$f = (2n+1) f_0$$

or $\quad f_0 = 1 \text{ KHz}$

Hence (D) is correct option.

SOL 8.14

$$\cos(2\pi f_m t) \cos(2\pi f_c t) \longrightarrow \text{DSB suppressed carrier}$$

$$\cos(2\pi f_c t) \longrightarrow \text{Carrier Only}$$

$$\cos[2\pi(f_c + f_m) t] \longrightarrow \text{USB Only}$$

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$[1+\cos(2\pi f_m t)\cos(2\pi f_c t)] \longrightarrow$ USB with carrier

Hence (C) is correct option.

SOL 8.15

We have

$$p(X=0)=p(Y=0)=\frac{1}{2}$$

$$p(X=1)=p(Y=1)=\frac{1}{4}$$

$$p(X=2)=p(Y=2)=\frac{1}{4}$$

Let $\quad X+Y=2 \longrightarrow A$

and $\quad X-Y=0 \longrightarrow B$

Now

$$P(X+Y=2|X-Y=0)=\frac{P(A\cap B)}{P(B)}$$

Event $P(A\cap B)$ happen when $X+Y=2$ and $X-Y=0$. It is only the case when $X=1$ and $Y=1$.

Thus $\quad P(A\cap B)=\frac{1}{4}\times\frac{1}{4}=\frac{1}{16}$

Now event $P(B)$ happen when

$X-Y=0$ It occurs when $X=Y$, i.e.

$X=0$ and $Y=0$ or

$X=1$ and $Y=1$ or

$X=2$ and $Y=2$

Thus $\quad P(B)=\frac{1}{2}\times\frac{1}{2}+\frac{1}{4}\times\frac{1}{4}+\frac{1}{4}\times\frac{1}{4}=\frac{6}{16}$

Now $\quad \frac{P(A\cap B)}{P(B)}=\frac{1/16}{6/16}=\frac{1}{6}$

Hence (C) is correct option.

SOL 8.16

The mean is

$$\overline{X}=\Sigma x_i p_i(x)$$
$$=1\times0.1+2\times0.2+3\times0.4+4\times0.2+5\times0.1$$
$$=0.1+0.4+1.2+0.8+0.5=3.0$$
$$\overline{X^2}=\Sigma x_i^2 p_i(x)$$
$$=1\times0.1+4\times0.2+9\times0.4+16\times0.2+25\times0.1$$
$$=0.1+0.8+3.6+3.2+2.5=10.2$$

Variance $\quad \sigma_x^2=\overline{X^2}-(\overline{X})^2$

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$$= 10.2 - (3)^2 = 1.2$$

Hence (B) is correct option.

SOL 8.17

$$m(t) = \frac{1}{2}\cos\omega_1 t - \frac{1}{2}\sin\omega_2 t$$

$$s_{AM}(t) = [1 + m(t)]\cos\omega_c t$$

Modulation index $= \dfrac{|m(t)|_{\max}}{V_c}$

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

$$\eta = \frac{m^2}{m^2+2} \times 100\% = \frac{\left(\frac{1}{\sqrt{2}}\right)^2}{\left(\frac{1}{\sqrt{2}}\right)^2 + 2} \times 100\% = 20\%$$

Hence (C) is correct option.

SOL 8.18

We have $C_1 = B\log_2\left(1 + \dfrac{S}{N}\right)$

$$\approx B\log_2\left(\frac{S}{N}\right) \qquad \text{As } \frac{S}{N} >> 1$$

If we double the $\dfrac{S}{N}$ ratio then

$$C_2 \approx B\log_2\left(\frac{2S}{N}\right)$$

$$\approx B\log_2 2 + B\log_2\frac{S}{N}$$

$$\approx B + C_1$$

Hence (B) is correct option.

SOL 8.19

We have $SNR = 1.76 + 6n$

or $43.5 = 1.76 + 6n$

$$6n = 43.5 + 1.76$$

$$6n = 41.74 \longrightarrow n \approx 7$$

No. of quantization level is

$$2^7 = 128$$

Step size required is

$$= \frac{V_H - V_L}{128} = \frac{5-(-5)}{128} = \frac{10}{128}$$

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$$= .078125$$
$$\approx .0667$$

Hence (C) is correct option.

SOL 8.20

For positive values step size

$$s_+ = 0.05 \text{ V}$$

For negative value step size

$$s_- = 0.1 \text{ V}$$

No. of quantization in $+ive$ is

$$= \frac{5}{s_+} = \frac{5}{0.05} = 100$$

Thus $\quad 2^{n+} = 100 \longrightarrow n^+ = 7$

No. of quantization in $-ve$

$$Q_1 = \frac{5}{s_-} = \frac{5}{0.1} = 50$$

Thus $\quad 2^{n^-} = 50 \longrightarrow n^- = 6$

$$\left(\frac{S}{N}\right)_+ = 1.76 + 6n^+ = 1.76 + 42 = 43.76 \text{ dB}$$

$$\left(\frac{S}{N}\right)_- = 1.76 + 6n^- = 1.76 + 36 = 37.76 \text{ dB}$$

Best $\quad \left(\frac{S}{N}\right)_0 = 43.76 \text{ dB}$

Hence (B) is correct option.

SOL 8.21

We have $\quad x_{AM}(t) = A_c \cos\omega_c + 2\cos\omega_m t \cos\omega_c t$

$$= A_C\left(1 + \frac{2}{A_c}\cos\omega_m t\right)\cos\omega_c t$$

For demodulation by envelope demodulator modulation index must be less than or equal to 1.

Thus $\quad \frac{2}{A_c} \le 1$

$$A_c \ge 2$$

Hence minimum value of $A_c = 2$

Hence (A) is correct option.

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SOL 8.22

CDF is the integration of PDF. Plot in option (A) is the integration of plot given in question.
Hence (A) is correct option.

SOL 8.23

The entropy is

$$H = \sum_{i=1}^{m} p_i \log_2 \frac{1}{p_i} \text{ bits}$$

Since $$p_1 = p_2 = ... = p_n = \frac{1}{n}$$

$$H = \sum_{i=1}^{n} \frac{1}{n} \log n = \log n$$

Hence (A) is correct option.

SOL 8.24

PSD of noise is $\frac{N_0}{2} = K$ ...(1)

The 3-dB cut off frequency is

$$f_c = \frac{1}{2\pi RC} \quad ...(2)$$

Output noise power is

$$= \frac{N_0}{4RC} = \left(\frac{N_0}{2}\right)\frac{1}{2RC} = K\pi f_c$$

Hence (C) is correct option.

SOL 8.25

At receiving end if we get two zero or three zero then its error.
Let p be the probability of 1 bit error, the probability that transmitted bit error is

$$= \text{Three zero + two zero and single one}$$
$$= {}^3C_3 p^3 + 3C_2 p^2 (1-p)$$
$$= p^3 + p^2(1-p)$$

Hence (D) is correct option.

SOL 8.26

Bandwidth of TDM is

$$= \frac{1}{2} \text{ (sum of Nyquist Rate)}$$

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$$= \frac{1}{2}[2\,W + 2\,W + 4\,W + 6\,W] = 7\,W$$

Hence (D) is correct option.

SOL 8.27

We have $\theta_i = 2\pi 10^5 t + 5\sin(2\pi 1500t) + 7.5\sin(2\pi 1000t)$

$$\omega_i = \frac{d\theta_i}{dt} = 2\pi 10^5 + 10\pi 1500\cos(2\pi 1500t) + 15\pi 1000\cos(2\pi 1000t)$$

Maximum frequency deviation is

$$\Delta\omega_{\max} = 2\pi(5\times 1500 + 7.5\times 1000)$$

$$\Delta f_{\max} = 15000$$

Modulation index is $= \dfrac{\Delta f_{\max}}{f_m} = \dfrac{15000}{1500} = 10$

Hence (B) is correct option.

SOL 8.28

Hence (C) is correct option.

SOL 8.29

$$f_m = 4 \text{ KHz}$$

$$f_s = 2f_m = 8 \text{ kHz}$$

Bit Rate $R_b = nf_s = 8\times 8 = 64$ kbps

The minimum transmission bandwidth is

$$BW = \frac{R_b}{2} = 32 \text{ kHz}$$

Hence (B) is correct option.

SOL 8.30

$$\left(\frac{S_0}{N_0}\right) = 1.76 + 6n \text{ dB}$$

$$= 1.76 + 6\times 8 = 49.76 \text{ dB} \qquad \text{We have } n = 8$$

Hence (C) is correct option.

SOL 8.31

As $\text{Noise} \propto \dfrac{1}{L^2}$

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To reduce quantization noise by factor 4, quantization level must be two times i.e. $2L$.

Now $\quad L = 2^n = 2^8 = 256$

Thus $\quad 2L = 512$

Hence (B) is correct option.

SOL 8.32

Autocorrelation is even function.

Hence (C) is correct option.

SOL 8.33

Power spectral density is non negative. Thus it is always zero or greater than zero.

Hence (B) is correct option.

SOL 8.34

The variance of a random variable x is given by

$$E[X^2] - E^2[X]$$

Hence (A) is correct option.

SOL 8.35

A Hilbert transformer is a non-linear system.

Hence (A) is correct option.

SOL 8.36

Slope overload distortion can be reduced by increasing the step size

$$\frac{\Delta}{T_s} \geq \text{slope of } x(t)$$

Hence (D) is correct option.

SOL 8.37

We have $\quad p(t) = \dfrac{\sin(4\pi Wt)}{4\pi Wt(1 - 16W^2t^2)}$

at $t = \dfrac{1}{4W}$ it is $\dfrac{0}{0}$ form. Thus applying L' Hospital rule

$$p^{\left(\frac{1}{4W}\right)} = \frac{4\pi W\cos(4\pi Wt)}{4\pi W[1 - 48W^2t^2]}$$

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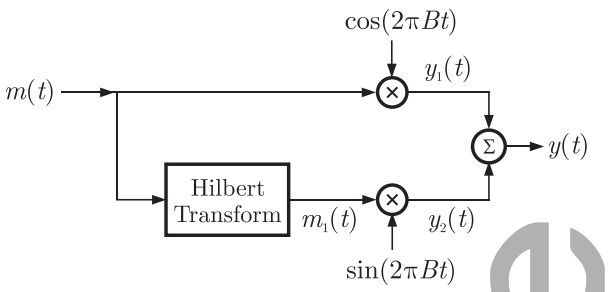
$$= \frac{\cos(4\pi Wt)}{1 - 48\,W^2 t^2} = \frac{\cos\pi}{1-3} = 0.5$$

Hence (C) is correct option.

SOL 8.38

The block diagram is as shown below



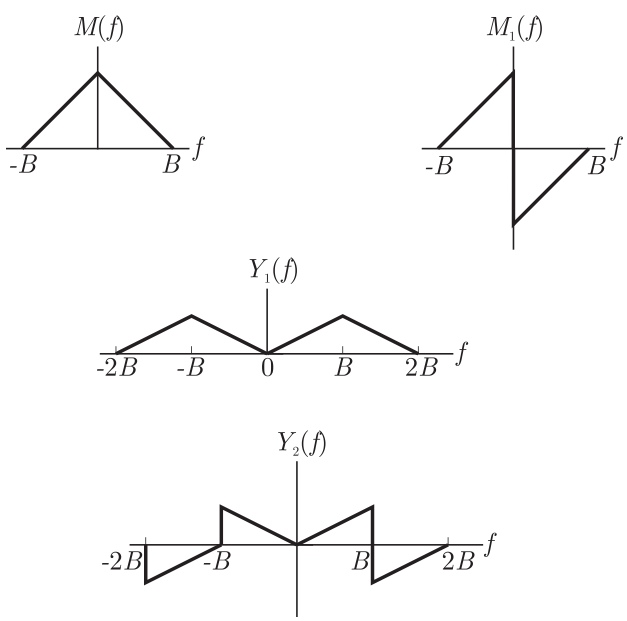
Here $$M_1(f) = \hat{M}(f)$$

$$Y_1(f) = M(f)\left(\frac{e^{j2\pi B} + e^{-j2\pi B}}{2}\right)$$

$$Y_2(f) = M_1(f)\left(\frac{e^{j2\pi B} - e^{-j2\pi B}}{2}\right)$$

$$Y(f) = Y_1(f) + Y_2(f)$$

All waveform is shown below



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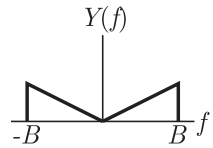

Hence (B) is correct option.

SOL 8.39

By Binomial distribution the probability of error is

$$p_e = {}^nC_r p^r (1-p)^{n-r}$$

Probability of at most one error

$$= \text{Probability of no error} + \text{Probability of one error}$$
$$= {}^nC_0 p^0 (1-p)^{n-0} + {}^nC_1 p^1 (1-p)^{n-1}$$
$$= (1-p)^n + np(1-p)^{n-1}$$

Hence (C) is correct option.

SOL 8.40

Bandwidth allocated for 1 Channel = 5 M Hz

Average bandwidth for 1 Channel $\frac{5}{5} = 1$ MHz

Total Number of Simultaneously Channel $= \frac{1\text{M} \times 8}{200k} = 40$ Channel

Hence (B) is correct option.

SOL 8.41

Chip Rate $\quad R_C = 1.2288 \times 10^6$ chips/sec

Data Rate $\quad R_b = \frac{R_C}{G}$

Since the processing gain G must be at least 100, thus for $G_{\min}$ we get

$$R_{b\max} = \frac{R_C}{G_{\min}} = \frac{1.2288 \times 10^6}{100} = 12.288 \times 10^3 \text{ bps}$$

Hence (A) is correct option.

SOL 8.42

Energy of constellation 1 is

$$E_{g1} = (0)^2 + (-\sqrt{2}\,a)^2 + (-\sqrt{2}\,a)^2 + (\sqrt{2}\,a)^2 + (-2\sqrt{2}\,a)^2$$
$$= 2a^2 + 2a^2 + 2a^2 + 8a^2 = 16a^2$$

Energy of constellation 2 is

$$E_{g2} = a^2 + a^2 + a^2 + a^2 = 4a^2$$

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$$\text{Ratio} = \frac{E_{g1}}{E_{g2}} = \frac{16a^2}{4a^2} = 4$$

Hence (B) is correct option.

SOL 8.43

Noise Power is same for both which is $\frac{N_0}{2}$.
Thus probability of error will be lower for the constellation 1 as it has higher signal energy.
Hence (A) is correct option.

SOL 8.44

Area under the pdf curve must be unity

Thus $\quad 2a + 4a + 4b = 1$

$$2a + 8b = 1 \qquad ...(1)$$

For maximum entropy three region must by equivaprobable thus

$$2a = 4b = 4b \qquad ...(2)$$

From (1) and (2) we get

$$b = \frac{1}{12} \text{ and } a = \frac{1}{6}$$

Hence (A) is correct option.

SOL 8.45

Hence (*) is correct option.

SOL 8.46

A LPF will not produce phase distortion if phase varies linearly with frequency.

$$\phi(\omega) \propto \omega$$

i.e. $\quad \phi(\omega) = k\omega$

Hence (B) is correct option.

SOL 8.47

Let $m(t)$ is a low pass signal, whose frequency spectra is shown below

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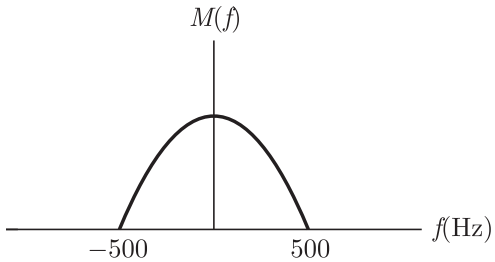
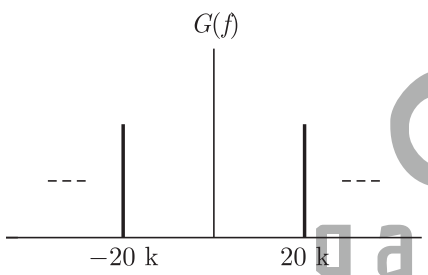


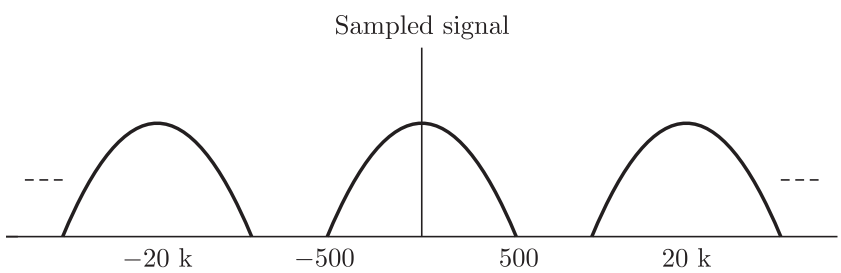
Fourier transform of $g(t)$

$$G(t) = \frac{1}{0.5 \times 10^{-4}} \sum_{k=-\infty}^{\infty} \delta(f - 20 \times 10^3 k)$$

Spectrum of $G(f)$ is shown below



Now when $m(t)$ is sampled with above signal the spectrum of sampled signal will look like.



When sampled signal is passed through a LP filter of BW 1 kHz, only $m(t)$ will remain.
Hence (B) is correct option.

SOL 8.48

The highest frequency signal in $x(t)$ is $1000 \times 3 = 3$ kHz if expression is expanded. Thus minimum frequency requirement is

$$f = 2 \times 3 \times 10^3 = 6 \times 10^3 \text{ Hz}$$

Hence (C) is correct option.

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SOL 8.49

We have

$$x(t) = 125t[u(t) - u(t-1)] + (250 - 125t)[u(t-1) - u(t-2)]$$

The slope of expression $x(t)$ is 125 and sampling frequency f_s is 32×1000 samples/sec.

Let Δ be the step size, then to avoid slope overload

$$\frac{\Delta}{T_s} \geq \text{slope } x(t)$$

$$\Delta f_c \geq \text{slope } x(t)$$

$$\Delta \times 32000 \geq 125$$

$$\Delta \geq \frac{125}{32000}$$

$$\Delta = 2^{-8}$$

Hence (B) is correct option.

SOL 8.50

The sampling frequency is

$$f_s = \frac{1}{0.03\text{m}} = 33 \text{ kHz}$$

Since $f_s \geq 2f_m$, the signal can be recovered and are correlated.

Hence (A) is correct option.

SOL 8.51

We have $p_1 = 0.25,\ p_2 = 0.25$ and $p_3 = 0.5$

$$H = \sum_{i=1}^{3} p_1 \log_2 \frac{1}{p_1} \text{ bits/symbol}$$

$$= p_1 \log_2 \frac{1}{p_1} + p_2 \log_2 \frac{1}{p_2} + p_3 \log_2 \frac{1}{p_3}$$

$$= 0.25 \log_2 \frac{1}{0.25} + 0.25 \log_2 \frac{1}{0.25} + 0.5 \log_2 \frac{1}{0.5}$$

$$= 0.25 \log_2 4 + 0.25 \log_2 4 + 0.5 \log_2 2$$

$$= 0.5 + 0.5 + \frac{1}{2} = \frac{3}{2} \text{ bits/symbol}$$

$$R_b = 3000 \text{ symbol/sec}$$

Average bit rate $= R_b H$

$$= \frac{3}{2} \times 3000 = 4500 \text{ bits/sec}$$

Hence (B) is correct option.

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SOL 8.52

The diagonal clipping in AM using envelop detector can be avoided if

$$\frac{1}{\omega_c} << RC < \frac{1}{W}$$

But from $$\frac{1}{RC} \geq \frac{W\mu \sin Wt}{1+\mu \cos Wt}$$

We can say that RC depends on W, thus

$$RC < \frac{1}{W}$$

Hence (A) is correct option.

SOL 8.53

Hence (B) is correct option.

SOL 8.54

When $\triangle/2$ is added to $y(t)$ then signal will move to next quantization level. Otherwise if they have step size less than $\frac{\triangle}{2}$ then they will be on the same quantization level.
Hence (B) is correct option.

SOL 8.55

After the SSB modulation the frequency of signal will be $f_c - f_m$ i.e.

$$1000 - 10 \text{ kHz} \approx 1000 \text{ kHz}$$

The bandwidth of FM is

$$BW = 2(\beta+1)\triangle f$$

For $NBFM \beta << 1$, thus

$$BW_{NBFM} \approx 2\triangle f = 2(10^9 - 10^6) \approx 2\times 10^9$$

Hence (C) is correct option.

SOL 8.56

We have
$$p(t) = u(t) - u(t-1)$$
$$g(t) = p(t)^* \; p(t)$$
$$s(t) = g(t) - \delta(t-2)^* \; g(t) = g(t) - g(t-2)$$

All signal are shown in figure below :

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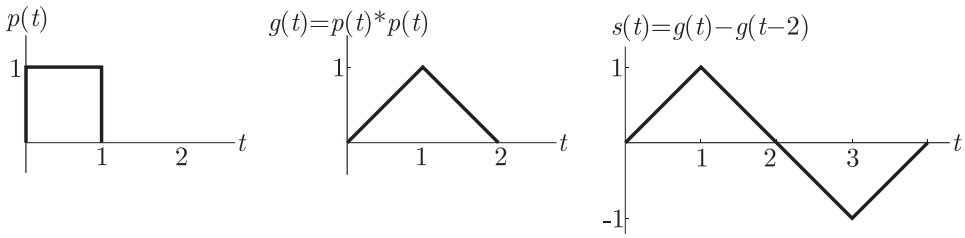

The impulse response of matched filter is

$$h(t) = s(T-t) = s(1-t)$$

Here T is the time where output SNR is maximum.
Hence (A) is correct option.

SOL 8.57

We have $\quad x_{AM}(t) = 10[P(t) + 0.5g(t)]\cos\omega_c t$

where $\quad p(t) = u(t) - u(t-1)$

and $\quad g(t) = r(t) - 2r(t-1) + r(t-2)$

For desired interval $0 \le t \le 1$, $p(t) = 1$ and $g(t) = t$, Thus we have,

$$x_{AM}(t) = 100(1 - 0.5t)\cos\omega_c t$$

Hence modulation index is 0.5
Hence (A) is correct option.

SOL 8.58

We know that $\quad S_{YY}(\omega) = |H(\omega)|^2 . S_{XX}(\omega)$

Now $S_{YY}(\omega) = \dfrac{16}{16+\omega^2}$ and $S_{XX}(\omega) = 1$ white noise

Thus $\quad \dfrac{16}{16+\omega^2} = |H(\omega)|^2$

or $\quad |H(\omega)| = \dfrac{4}{\sqrt{16+\omega^2}}$

or $\quad H(s) = \dfrac{4}{4+s}$

which is a first order low pass RL filter.
Hence (A) is correct option.

SOL 8.59

We have $\quad \dfrac{R}{R+sL} = \dfrac{4}{4+s}$

or $\quad \dfrac{\frac{R}{L}}{\frac{R}{L}+s} = \dfrac{4}{4+s}$

Comparing we get $L = 1$ H and $R = 4\Omega$
Hence (A) is correct option.

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SOL 8.60

We have $\quad x_{AM}(t) = 10(1 + 0.5\sin 2\pi f_m t)\cos 2\pi f_c t$

The modulation index is 0.5

Carrier power $\quad P_c = \dfrac{(10)^2}{2} = 50$

Side band power $\quad P_s = \dfrac{(10)^2}{2} = 50$

Side band power $\quad P_s = \dfrac{m^2 P_c}{2} = \dfrac{(0.5)^2(50)}{2} = 6.25$

Hence (C) is correct option.

SOL 8.61

$$\text{Mean noise power} = \text{Area under the PSD curve}$$
$$= 4\left[\frac{1}{2}\times B\times\frac{N_o}{2}\right] = BN_o$$

The ratio of average sideband power to mean noise power is

$$\frac{\text{Side Band Power}}{\text{Noise Power}} = \frac{6.25}{N_0 B} = \frac{25}{4N_o B}$$

Hence (B) is correct option.

SOL 8.62

$$\{1 + km(t)\}\,A\sin(\omega_c t) \longrightarrow \text{Amplitude modulation}$$
$$dm(t)\,A_{\sin}(\omega_c t) \longrightarrow \text{DSB-SC modulation}$$
$$A\sin\{\cos t + km(t)\} \longrightarrow \text{Phase Modulation}$$
$$A\sin[\omega_c^t + k]_{-\infty}^{t} m(t)\,dt \longrightarrow \text{Frequency Modulation}$$

Hence (D) is correct option.

SOL 8.63

$$\text{VSB} \longrightarrow f_m + f_c$$
$$\text{DSB - SC} \longrightarrow 2f_m$$
$$\text{SSB} \longrightarrow f_m$$
$$\text{AM} \longrightarrow 2f_m$$

Thus SSB has minimum bandwidth and it require minimum power.

Hence (C) is correct option.

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SOL 8.64

Let $x(t)$ be the input signal where

$$x(t) = \cos(\cos t + \beta_1 \cos \omega_m t)$$

$$y(t) = x^2(t) = \frac{1}{2} + \frac{\cos(2\omega_c t + 2\beta_1 \cos \omega_m t)}{2}$$

Here $\beta = 2\beta_1$ and $\beta_1 = \dfrac{\Delta f}{f_m} = \dfrac{90}{5} = 18$

$$BW = 2(\beta + 1) f_m = 2(2 \times 18 + 1) \times 5 = 370 \text{ kHz}$$

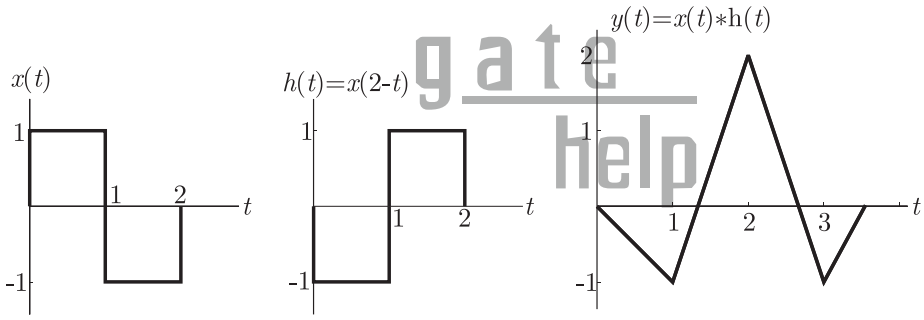
Hence (A) is correct option.

SOL 8.65

The transfer function of matched filter is

$$h(t) = x(t - t) = x(2 - t)$$

The output of matched filter is the convolution of $x(t)$ and $h(t)$ as shown below



Hence (C) is correct option.

SOL 8.66

We have

$$H(f) = 2e^{-j\omega t_d}$$

$$|H(f)| = 2$$

$$G_0(f) = |H(f)|^2 G_i(f)$$

$$= 4N_o \text{ W/Hz}$$

The noise power is $= 4N_o \times B$

Hence (B) is correct option.

SOL 8.67

As the area under pdf curve must be unity

$$\frac{1}{2}(4 \times k) = 1 \longrightarrow k = \frac{1}{2}$$

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Now mean square value is

$$\sigma_v^2 = \int_{-\infty}^{+\infty} v^2 p(v)\, dv$$

$$= \int_0^4 v^2 \left(\frac{v}{8}\right) dv \qquad \text{as } p(v) = \frac{1}{8} v$$

$$= \int_0^4 \left(\frac{v^3}{8}\right) dv = 8$$

Hence (C) is correct option.

SOL 8.68

The phase deviation is

$$\beta = \frac{\Delta f}{f_m} = \frac{10}{1} = 10$$

If phase deviation remain same and modulating frequency is changed

$$BW = 2(\beta + 1) f_m' = 2(10 + 1)2 = 44 \text{ kHz}$$

Hence (D) is correct option.

SOL 8.69

As the area under pdf curve must be unity and all three region are equivaprobable. Thus are under each region must be $\frac{1}{3}$.

$$2a \times \frac{1}{4} = \frac{1}{3} \longrightarrow a = \frac{2}{3}$$

Hence (B) is correct option.

SOL 8.70

$$N_q = \int_{-a}^{+a} x^2 p(x)\, dx = 2\int_0^a x^2 \cdot \frac{1}{4}\, dx = \frac{1}{2}\left[\frac{x^3}{3}\right]_0^a = \frac{a^3}{6}$$

Substituting $a = \frac{2}{3}$ we have

$$N_q = \frac{4}{81}$$

Hence (A) is correct option.

SOL 8.71

When word length is 6

$$\left(\frac{S}{N}\right)_{N=6} = 2^{2\times 6} = 2^{12}$$

When word length is 8

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$$\left(\frac{S}{N}\right)_{N=8} = 2^{2\times 8} = 2^{16}$$

Now $$\frac{\left(\frac{S}{N}\right)_{N=8}}{\left(\frac{S}{N}\right)_{N=6}} = \frac{2^{16}}{2^{12}} = 2^4 = 16$$

Thus it improves by a factor of 16.
Hence (C) is correct option.

SOL 8.72

Carrier frequency $f_c = 1\times 10^6$ Hz
Modulating frequency
$$f_m = 2\times 10^3 \text{ Hz}$$
For an envelope detector
$$2\pi f_c > \frac{1}{Rc} > 2\pi f_m$$
$$\frac{1}{2\pi f_c} < RC < \frac{1}{2\pi f_m}$$
$$\frac{1}{2\pi f_c} < RC < \frac{1}{2\pi f_m}$$
$$\frac{1}{2\pi 10^6} < RC < \frac{1}{2\times 10^3}$$
$$1.59\times 10^{-7} < RC < 7.96\times 10^{-5}$$
so, 20 μsec sec best lies in this interval.
Hence (B) is correct option.

SOL 8.73

$$\begin{aligned}
S_{AM}(t) &= A_c[1+0.1\cos\omega_m t]\cos\omega_m t \\
s_{NBFM}(t) &= A_c\cos[\omega_c t + 0.1\sin\omega_m t] \\
s(t) &= S_{AM}(t) + S_{NB}f_m(t) \\
&= A_c[1+0.1\cos\omega_m t]\cos\omega_c t + A_c\cos(\omega_c t + 0.1\sin\omega_m t) \\
&= A_c\cos\omega_c t + A_c 0.1\cos\omega_m t\cos\omega_c t \\
&\quad + A_c\cos\omega_c t\cos(0.1\sin\omega_m t) - A_c\sin\omega_c t.\sin(0.1\sin\omega_m t)
\end{aligned}$$

As $0.1\sin\omega_m t \cong +0.1$ to -0.1
so, $\cos(0.1\sin\omega_m t) \approx 1$
As when θ is small $\cos\theta \approx 1$ and $\sin\theta \cong \theta$, thus
$$\begin{aligned}
\sin(0.1\sin\omega_m t) &= 0.1\,\text{sincos}\,\omega_c t\cos\omega_m t + A_c\cos\omega_c t \\
&\qquad - A_c 0.1\sin\omega_m t\sin\omega_c t \\
&= \underbrace{2A_c\cos\omega_c t}_{\text{cosec}} + \underbrace{0.1A_c\cos(\omega_c+\omega_m)t}_{USB}
\end{aligned}$$

Thus it is SSB with carrier.
Hence (B) is correct option.

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SOL 8.74

Consecutive pulses are of same polarity when modulator is in slope overload.

Consecutive pulses are of opposite polarity when the input is constant.

Hence (A) is correct option.

SOL 8.75

$$F(x_1 \le X < x_2) = p(X = x_2) - P(X = x_1)$$

or $$P(X = 1) = P(X = 1^+) - P(X = 1^-)$$
$$= 0.55 - 0.25 = 0.30$$

Hence (D) is correct option.

SOL 8.76

The SNR at transmitter is

$$SNR_{tr} = \frac{P_{tr}}{\mathbb{N}B}$$

$$\frac{10^{-3}}{10^{-20} \times 100 \times 10^6} = 10^9$$

In dB $$SNR_{tr} = 10 \log 10^9 = 90 \text{ dB}$$

Cable Loss $= 40$ db

At receiver after cable loss we have

$$SNR_{Rc} = 90 - 40 = 50 \text{ dB}$$

Hence (A) is correct option.

SOL 8.77

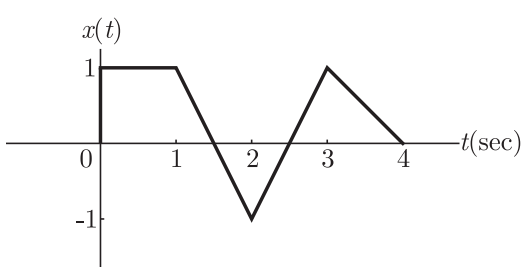
The impulse response of matched filter is

$$h(t) = x(T - t)$$

Since here $T = 4$, thus

$$h(t) = x(4 - t)$$

The graph of $h(t)$ is as shown below.



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From graph it may be easily seen that slope between $3 < t < 4$ is -1. Hence (B) is correct option.

SOL 8.78

The required bandwidth of M array PSK is

$$BW = \frac{2R_b}{n}$$

where $2^n = M$ and R_b is bit rate

For BPSK, $\quad M = 2 = 2^n \longrightarrow n = 1$

Thus $\quad B_1 = \dfrac{2R_b}{1} = 2 \times 10 = 20 \text{ kHz}$

For QPSK, $M = 4 = 2^n \longrightarrow n = 2$

Thus $\quad B_2 = \dfrac{2R_b}{2} = 10 \text{ kHz}$

Hence (C) is correct option.

SOL 8.79

We have $\quad f_c = 100 \text{ MHz} = 100 \times 10^6$ and $f_m = 1 \text{ MHz}$
$\quad = 1 \times 10^6$

The output of balanced modulator is

$$V_{BM}(t) = [\cos \omega_c t][\cos \omega_c t]$$
$$= \frac{1}{2}[\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t]$$

If $V_{BM}(t)$ is passed through HPF of cut off frequency $f_H = 100 \times 10^6$, then only $(\omega_c + \omega_m)$ passes and output of HPF is

$$V_{HP}(t) = \frac{1}{2}\cos(\omega_c + \omega_m)t$$

Now $\quad V_0(t) = V_{HP}(t) + \sin(2\pi \times 100 \times 10^6)t$

$$= \frac{1}{2}\cos[2\pi 100 \times 10^6 + 2\pi \times 1 \times 10^6 t] + \sin(2\pi \times 100 \times 10^6)t$$

$$= \frac{1}{2}\cos[2\pi 10^8 + 2\pi 10^6 t] + \sin(2\pi 10^8)t$$

$$= \frac{1}{2}[\cos(2\pi 10^8 t)t\cos(2\pi 10^6 t)] - \sin[2\pi 10^8 t \sin(2\pi 10^6 t) + \sin 2\pi 10^8 t]$$

$$= \frac{1}{2}\cos(2\pi 10^6 t)\cos 2\pi 10^8 t + \left(1 - \frac{1}{2}\sin 2\pi 10^6 t\right)\sin 2\pi 10^8 t$$

This signal is in form

$$= A\cos 2\pi 10^8 t + B\sin 2\pi 10^8 t$$

The envelope of this signal is

$$= \sqrt{A^2 + B^2}$$

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$$= \sqrt{\left(\frac{1}{2}\cos(2\pi 10^6 t)\right)^2 + \left(1 - \frac{1}{2}\sin(2\pi 10^6 t\right)^2}$$

$$= \sqrt{\frac{1}{4}\cos^2(2\pi 10^6 t) + 1 + \frac{1}{4}\sin^2(2\pi 10^6 t) - \sin(2\pi 10^6 t)}$$

$$= \sqrt{\frac{1}{4} + 1 - \sin(2\pi 10^6 t)}$$

$$= \sqrt{\frac{5}{4} - \sin(2\pi 10^6 t)}$$

Hence (C) is correct option.

SOL 8.80

$$s(t) = A\cos[2\pi 10 \times 10^3 t] + A\cos[2\pi 10.1 \times 10^3 t]$$

Here $T_1 = \dfrac{1}{10 \times 10^3} = 100\mu\,\text{sec}$

and $T_2 = \dfrac{1}{10.1 \times 10^3} = 99\mu\,\text{sec}$

Period of added signal will be LCM $[T_1, T_2]$

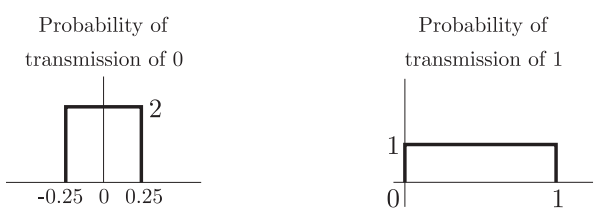
Thus $T = LCM[100, 99] = 9900\mu\,\text{sec}$

Thus frequency $f = \dfrac{1}{9900\mu} = 0.1\ \text{kHz}$

Hence (A) is correct option.

SOL 8.81

The pdf of transmission of 0 and 1 will be as shown below :



Probability of error of 1

$$P(0 \le X \le 0.2) = 0.2$$

Probability of error of 0 :

$$P(0.2 \le X \le 0.25) = 0.05 \times 2 = 0.1$$

$$\text{Average error} = \frac{P(0 \le X \le 0.2) + P(0.2 \le X \le 0.25)}{2}$$

$$= \frac{0.2 + 0.1}{0} = 0.15$$

Hence (A) is correct option.

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SOL 8.82

The square mean value is

$$\sigma^2 = \int_{-\infty}^{\infty} (x - x_q)^2 f(x)\, dx$$

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

$$= \int_0^{0.3} (x - 0)^2 f(x)\, dx + \int_{0.3}^{0.1} (x - 0.7)^2 f(x)\, dx$$

$$= \left[\frac{x^3}{3}\right]_0^{0.3} + \left[\frac{x^3}{3} + 0.49x - 14\frac{x^2}{2}\right]_{0.3}^{1}$$

or $\sigma^2 = 0.039$

$$\text{RMS} = \sqrt{\sigma^2} = \sqrt{0.039} = 0.198$$

Hence (B) is correct option.

SOL 8.83

FM $\longrightarrow$ Capture effect
DM $\longrightarrow$ Slope over load
PSK $\longrightarrow$ Matched filter
PCM $\longrightarrow$ $\mu -$ law

Hence (C) is correct option.

SOL 8.84

Since $f_s = 2f_m$, the signal frequency and sampling frequency are as follows

$f_{m1} = 1200$ Hz $\longrightarrow$ 2400 samples per sec
$f_{m2} = 600$ Hz $\longrightarrow$ 1200 samples per sec
$f_{m3} = 600$ Hz $\longrightarrow$ 1200 samples per sec

Thus by time division multiplexing total 4800 samples per second will be sent. Since each sample require 12 bit, total 4800×12 bits per second will be sent

Thus bit rate $R_b = 4800 \times 12 = 57.6$ kbps

Hence (C) is correct option.

SOL 8.85

The input signal $X(f)$ has the peak at 1 kHz and -1 kHz. After balanced modulator the output will have peak at $f_c \pm 1$ kHz i.e. :

$10 \pm 1 \longrightarrow 11$ and 9 kHz
$10 \pm (-1) \longrightarrow 9$ and 11 kHz

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9 kHz will be filtered out by HPF of 10 kHz. Thus 11 kHz will remain. After passing through 13 kHz balanced modulator signal will have 13 ± 11 kHz signal i.e. 2 and 24 kHz.
Thus peak of $Y(f)$ are at 2 kHz and 24 kHz.
Hence (B) is correct option.

SOL 8.86

The input is a coherent detector is DSB - SC signal plus noise. The noise at the detector output is the in-phase component as the quadrature component $n_q(t)$ of the noise $n(t)$ is completely rejected by the detector.
Hence (A) is correct option.

SOL 8.87

The noise at the input to an ideal frequency detector is white. The PSD of noise at the output is parabolic
Hence (C) is correct option.

SOL 8.88

We have $$P_e = \frac{1}{2}\text{erfc}\left(\sqrt{\frac{E_d}{2\eta}}\right)$$

Since P_e of Binary FSK is 3 dB inferior to binary PSK
Hence (B) is correct option.

SOL 8.89

The pdf of Z will be convolution of pdf of X and pdf of Y as shown below.

Now $$p[Z \le z] = \int_{-\infty}^{z} f_Z(z)\, dz$$

$$p[Z \le -2] = \int_{-\infty}^{-2} f_Z(z)\, dz$$

$$= \text{Area } [z \le -2]$$

$$= \frac{1}{2} \times \frac{1}{6} \times 1 = \frac{1}{12}$$

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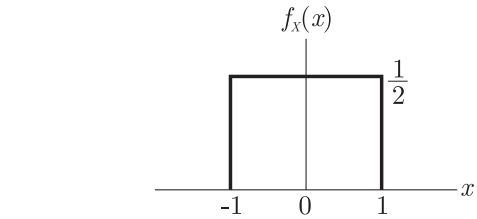

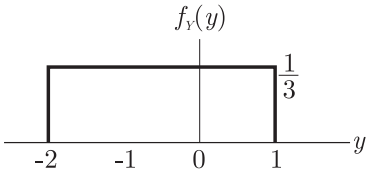

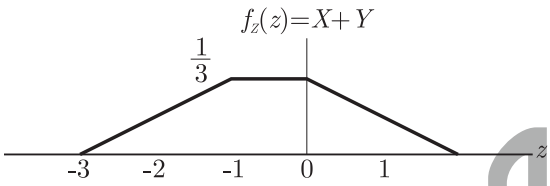

Hence (D) is correct option.

SOL 8.90

We have $R_{XX}(\tau) = 4(e^{-0.2|\tau|}+1)$

$R_{XX}(0) = 4(e^{-0.2|0|}+1) = 8 = \sigma^2$

or $\sigma = 2\sqrt{2}$ Given

mean $\mu = 0$

Now $P(x \le 1) = F_x(1)$

$= 1 - Q\left(\frac{X-\mu}{\sigma}\right)$ at $x = 1$

$= 1 - Q\left(\frac{1-0}{2\sqrt{2}}\right) = 1 - Q\left(\frac{1}{2\sqrt{2}}\right)$

Hence (D) is correct option.

SOL 8.91

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

We have $E[X^2(t)] = R_x(10)$

$= 4[e^{-0.2|0|}+1] = 4[1+1] = 8$

$E[Y^2] = E[X^2(2)] = 8$

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$$E[Z^2] = E[X^2(4)] = 8$$
$$E[YZ] = R_{XX}(2) = 4[e^{-0.2(4-2)} + 1] = 6.68$$
$$E[W^2] = \sigma_w^2 = 8 + 8 - 2 \times 6.68 = 2.64$$

Hence (C) is correct option.

SOL 8.92

$$\text{Step size } \delta = \frac{2m_p}{L} = \frac{1.536}{128} = 0.012 \text{ V}$$

$$\text{Quantization Noise power} = \frac{\delta^2}{12} = \frac{(0.012)^2}{12}$$
$$= 12 \times 10^{-6} \ V^2$$

Hence (C) is correct option.

SOL 8.93

The frequency of pulse train is

$$f\frac{1}{10^{-3}} = 1 \text{ k Hz}$$

The Fourier Series coefficient of given pulse train is

$$C_n = \frac{1}{T_o}\int_{-T_o/2}^{-T_o/2} A e^{-jn\omega_o t}\, dt$$
$$= \frac{1}{T_o}\int_{-T_o/6}^{-T_o/6} A e^{-jn\omega_o t}\, dt$$
$$= \frac{A}{T_o(-jn\omega_o)}\left[e^{-j\omega_o t}\right]_{-T_o/6}^{-T_o/6}$$
$$= \frac{A}{(-j2\pi n)}(e^{-j\omega_o t} - e^{jn\omega_o T_o/6})$$
$$= \frac{A}{j2\pi n}(e^{jn\pi/3} - e^{-jn\pi/3})$$

or
$$C_n = \frac{A}{\pi n}\sin\left(\frac{n\pi}{3}\right)$$

From C_n it may be easily seen that 1,2,4,5,7, harmonics are present and 0,3,6,9,.. are absent. Thus $p(t)$ has 1 kHz, 2 kHz, 4 kHz, 5 kHz, 7 kHz,... frequency component and 3 kHz, 6 kHz.. are absent.

The signal $x(t)$ has the frequency components 0.4 kHz and 0.7 kHz. The sampled signal of $x(t)$ i.e. $x(t)^*\ p(t)$ will have

1 ± 0.4 and 1 ± 0.7 kHz
2 ± 0.4 and 2 ± 0.7 kHz
4 ± 0.4 and 4 ± 0.7 kHz

Thus in range of 2.5 kHz to 3.5 kHz the frequency present is

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$$2 + 0.7 = 2.7 \text{ kHz}$$
$$4 - 0.7 = 3.3 \text{ kHz}$$

Hence (D) is correct option.

SOL 8.94

$$v_i = A_c^1 \cos(2\pi f_c t) + m(t)$$
$$v_0 = a_o v_i + a v_i^3$$
$$v_0 = a_0[A_c^{'} \cos(2\pi f_c^{'} t) + m(t)] + a_1[A_c^{'} \cos(2\pi f_c^{'} t) + m(t)]^3$$
$$= a_0 A_c^{'} \cos(2\pi f_c^{'} t) + a_0 m(t) + a_1[(A_c^{'} \cos 2\pi f_c^{'} t)^3 + (A_c^{'} \cos(2\pi f_c^{'}) t)^2 m(t) + 3A_c^{'} \cos(2\pi f_c^{'} t) m^2(t) + m^3(t)]$$
$$= a_0 A_c^{'} \cos(2\pi f_c^{'} t) + a_0 m(t) + a_1 (A_c^{'} \cos 2 f_c^{'} t)^3 + 3a_1 A_c^{'2}\left[\frac{1 + \cos(4\pi f_c^{'} t)}{2}\right] m(t)$$
$$= 3a_1 A_c^{'} \cos(2\pi f_c^{'} t) m^2(t) + m^3(t)$$

The term $3a_1 A_c^{'}(\frac{\cos 4\pi f_c^{'} t}{2}) m(t)$ is a DSB-SC signal having carrier frequency 1. MHz. Thus $2f_c^{'} = 1$ MHz or $f_c^{'} = 0.5$ MHz

Hence (C) is correct option.

SOL 8.95

$$P_T = P_c\left(1 + \frac{\alpha^2}{2}\right)$$
$$P_{sb} = \frac{P_c \alpha^2}{2} = \frac{P_c (0.5)^2}{2}$$

or $$\frac{P_{sb}}{P_c} = \frac{1}{8}$$

Hence (D) is correct option.

SOL 8.96

AM Band width $= 2f_m$

Peak frequency deviation $= 3(2f_m) = 6f_m$

Modulation index $\beta = \dfrac{6f_m}{f_m} = 6$

The FM signal is represented in terms of Bessel function as

$$x_{FM}(t) = A_c \sum_{n=-\infty}^{\infty} J_n(\beta) \cos(\omega_c - n\omega_n) t$$
$$\omega_c + n\omega_m = 2\pi(1008 \times 10^3)$$
$$2\pi 10^6 + n4\pi \times 10^3 = 2\pi(1008 \times 10^3), n = 4$$

Thus coefficient $= 5J_4(6)$

Hence (D) is correct option.

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SOL 8.97

$$\text{Ring modulation} \longrightarrow \text{Generation of DSB - SC}$$
$$VCO \longrightarrow \text{Generation of FM}$$
$$\text{Foster seely discriminator} \longrightarrow \text{Demodulation of fm}$$
$$\text{mixer} \longrightarrow \text{frequency conversion}$$

Hence (B) is correct option.

SOL 8.98

$$f_{\max} = 1650 + 450 = 2100 \text{ kHz}$$
$$f_{\min} = 550 + 450 = 1000 \text{ kHz}$$

or
$$f = \frac{1}{2\pi\sqrt{LC}}$$

frequency is minimum, capacitance will be maximum

$$R = \frac{C_{\max}}{C_{\min}} = \frac{f_{\max}^2}{f_{\min}^2} = (2.1)^2$$

or
$$R = 4.41$$
$$f_i = f_c + 2f_{IF} = 700 + 2(455) = 1600 \text{ kHz}$$

Hence (A) is correct option.

SOL 8.99

$$E_b = 10^{-6} \text{ watt-sec}$$
$$N_o = 10^{-5} \text{ W/Hz}$$
$$(\text{SNR}) \text{ matched filler} = \frac{E_o}{\frac{N_o}{2}} = \frac{10^6}{2 \times 10^{-5}} = .05$$
$$(\text{SNR})dB = 10\log 10(0.05) = 13 \text{ dB}$$

Hence (D) is correct option.

SOL 8.100

For slopeoverload to take place $E_m \geq \dfrac{\Delta f_s}{2\pi f_m}$

This is satisfied with $E_m = 1.5$ V and $f_m = 4$ kHz

Hence (B) is correct option.

SOL 8.101

If $s \rightarrow$ carrier synchronization at receiver

$\rho \rightarrow$ represents bandwidth efficiency

then for coherent binary PSK $\rho = 0.5$ and s is required.

Hence (A) is correct option.

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SOL 8.102

$$\text{Bit Rate} = 8k \times 8 = 64 \text{ kbps}$$
$$(\text{SNR})_q = 1.76 + 6.02n \text{ dB}$$
$$= 1.76 + 6.02 \times 8 = 49.8 \text{ dB}$$

Hence (B) is correct option.

SOL 8.103

The frequency of message signal is

$$f_c = 1000 \text{ kHz}$$

1 The frequency of message signal is

$$f_m = \frac{1}{100 \times 10^{-6}} = 10 \text{ kHz}$$

Here message signal is symmetrical square wave whose FS has only odd harmonics i.e. 10 kHz, 30 kHz 50 kHz. Modulated signal contain $f_c \pm f_m$ frequency component. Thus modulated signal has

$$f_c \pm f_m = (1000 \pm 10) \text{ kH} = 1010 \text{ kHz}, 990 \text{ kHz}$$
$$f_c \pm 3f_m = (1000 \pm 10) \text{ kH} = 1030 \text{ kHz}, 970 \text{ kHz}$$

Thus, there is no 1020 kHz component in modulated signal.
Hence (C) is correct option.

SOL 8.104

We have
$$y(t) = 5 \times 10^{-6} x(t) \sum_{n=-\infty}^{+\infty} \delta(t - nT_s)$$
$$x(t) = 10 \cos(8\pi \times 10^3) t$$
$$T_s = 100 \mu \text{sec}$$

The cut off f_c of LPF is 5 kHz
We know that for the output of filter

$$= \frac{x(t)\, y(t)}{T_s}$$
$$= \frac{10 \cos(8\pi \times 10^3) t \times 5 \times 10^{-6}}{100 \times 10^{-6}}$$
$$= 5 \times 10^{-1} \cos(8\pi \times 10^3) t$$

Hence (C) is correct option.

SOL 8.105

Transmitted frequencies in coherent BFSK should be integral of bit rate 8 kHz.
Hence (C) is correct option.

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SOL 8.106

For best reception, if transmitting waves are vertically polarized, then receiver should also be vertically polarized i.e. transmitter and receiver must be in same polarization.
Hence (B) is correct option.

SOL 8.107

$$s(t) = \cos 2\pi(2\times 10^6 t + 30\sin 150t + 40\cos 150t)$$
$$= \cos\{4\pi 10^6 t + 100\pi \sin(150t+\theta)\}$$

Angle modulated signal is

$$s(t) = A\cos\{\omega_c t + \beta\sin(\omega_m t+\theta)\}$$

Comparing with angle modulated signal we get
Phase deviations $\beta = 100\pi$
Frequency deviations

$$\Delta f = \beta f_m = 100\pi \times \frac{150}{2\pi} = 7.5 \text{ kHz}$$

Hence (D) is correct option.

SOL 8.108

We have $m(t)\,s(t) = y_1(t)$

$$= \frac{2\sin(2\pi t)\cos(200\pi t)}{t}$$

$$= \frac{\sin(202\pi t) - \sin(198\pi t)}{t}$$

$$y_1(t) + n(t) = y_2(t) = \frac{\sin 202\pi t - \sin 198\pi t}{t} + \frac{\sin 199\pi t}{t}$$

$$y_2(t)\,s(t) = u(t)$$

$$= \frac{[\sin 202\pi t - \sin 198\pi t + \sin 199\pi t]\cos 200\pi t}{t}$$

$$= \frac{1}{2}[\sin(402\pi t) + \sin(2\pi t) - \{\sin(398\pi t) - \sin(2\pi t)\}$$
$$+ \sin(399\pi t) - \sin(\pi t)]$$

After filtering

$$y(t) = \frac{\sin(2\pi t) + \sin(2\pi t) - \sin(\pi t)}{2t}$$

$$= \frac{\sin(2\pi t) + 2\sin(0.5t)\cos(1.5\pi t)}{2t}$$

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$$= \frac{\sin 2\pi t}{2t} + \frac{\sin 0.5\pi t}{t}\cos 1.5\pi t$$

Hence (*) is correct option.

SOL 8.109

The signal frequency is

$$f_m = \frac{24\pi 10^3}{2\pi} = 12 \text{ kHz}$$

$$T_s = 50\mu\sec \rightarrow f_s = \frac{1}{T_s} = \frac{1}{50}\times 10^6 = 20 \text{ kHz}$$

After sampling signal will have $f_s \pm f_m$ frequency component i.e. 32 and 12 kHz

At filter output only 8 kHz will be present as cutoff frequency is 15 kHz.

Hence (B) is correct option.

SOL 8.110

$$d(n) = x(n) - x(n-1)$$

$$E[d(n)]^2 = E[x(n) - x(n-1)]^2$$

or $$E[d(n)]^2 = E[x(n)]^2 + E[x(n-1)]^2 - 2E[x(n)\,x(n-1)]$$

or $$\sigma_d^2 = \sigma_x^2 + \sigma_x^2 - 2R_{xx}(1) \qquad \text{as } k = 1$$

As we have been given $\sigma_d^2 = \frac{\sigma_x^2}{10}$, therefore

$$\frac{\sigma_x^2}{10} = \sigma_x^2 + \sigma_x^2 - 2R_{xx}(1)$$

or $$2R_{xx}(1) = \frac{19}{10}\sigma_x^2$$

or $$\frac{R_{xx}}{\sigma_x^2} = \frac{19}{20} = 0.95$$

Hence (A) is correct option.

SOL 8.111

An ideal low - pass filter with appropriate bandwidth f_m is used to recover the signal which is sampled at nyquist rate $2f_m$.

Hence (A) is correct option.

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SOL 8.112

For any PDF the probability at mean is $\frac{1}{2}$. Here given PDF is Gaussian random variable and $X = 4$ is mean.
Hence (A) is correct option.

SOL 8.113

We require 6 bit for 64 intensity levels because $64 = 2^6$
Data Rate = Frames per second × pixels per frame × bits per pixel
$= 625 \times 400 \times 400 \times 6 = 600$ Mbps sec
Hence (C) is correct option.

SOL 8.114

We have

$$\sin c(700t) + \sin c(500t) = \frac{\sin(700\pi t)}{700\pi t} + \frac{\sin(500\pi t)}{500\pi t}$$

Here the maximum frequency component is $2\pi f_m = 700\pi$ i.e. $f_m = 350$ Hz

Thus Nyquist rate $\quad f_s = 2f_m$
$= 2(350) = 700$ Hz

Thus sampling interval $\quad = \frac{1}{700}$ sec

Hence (C) is correct option.

SOL 8.115

Probability of error $= p$
Probability of no error $= q = (1 - p)$
Probability for at most one bit error
= Probability of no bit error
+ probability of 1 bit error
$= (1-p)^n + np(1-p)^{n-1}$
Hence (D) is correct option.

SOL 8.116

If $\quad g(t) \xleftrightarrow{FT} G(\omega)$
then PSD of $g(t)$ is

$$S_g(\omega) = |G(\omega)|^2$$

and power is

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$$P_g = \frac{1}{2\pi}\int_{-\infty}^{\infty} S_g(\omega)\, d\omega$$

Now $\quad ag(t) \xleftrightarrow{FT} aG(\omega)$

PSD of $ag(t)$ is

$$S_{ag}(\omega) = |a(G(\omega))|^2$$
$$= a^2|G(\omega)|^2$$

or $\quad S_{ag}(\omega) = a^2 S_g(\omega)$

Similarly $\quad P_{ag} = a^2 P_g$

Hence (A) is correct option.

SOL 8.117

The envelope of the input signal is $[1 + k_a m(t)]$ that will be output of envelope detector.

Hence (C) is correct option.

SOL 8.118

Frequency Range for satellite communication is 1 GHz to 30 GHz,

Hence (D) is correct option.

SOL 8.119

Waveform will be orthogonal when each bit contains integer number of cycles of carrier.

Bit rate $\quad R_b = HCF(f_1, f_2)$

$$= HCF(10k, 25k)$$
$$= 5 \text{ kHz}$$

Thus bit interval is $\quad T_b = \frac{1}{R_b} = \frac{1}{5k} = 0.2 \text{ msec} = 200\ \mu\text{sec}$

Hence (B) is correct option.

SOL 8.120

We have $\quad P_m = \overline{m^2(t)}$

The input to LPF is

$$x(t) = m(t)\cos\omega_o t \cos(\omega_o t + \theta)$$

$$= \frac{m(t)}{2}[\cos(2\omega_o t + \theta) + \cos\theta]$$

$$= \frac{m(t)\cos(2\omega_o t + \theta)}{2} + \frac{m(t)\cos\theta}{2}$$

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The output of filter will be

$$y(t) = \frac{m(t)\cos\theta}{2}$$

Power of output signal is

$$P_y = \overline{y^2(t)} = \frac{1}{4}\overline{m^2(t)}\cos^2\theta = \frac{P_m\cos^2\theta}{4}$$

Hence (D) is correct option.

SOL 8.121

Hilbert transformer always adds $-90°$ to the positive frequency component and $90°$ to the negative frequency component.

Hilbert Trans form

$$\cos\omega t \rightarrow \sin\omega t$$
$$\sin\omega t \rightarrow \cos\omega t$$

Thus $\cos\omega_1 t + \sin\omega_2 t \rightarrow \sin\omega_1 t - \cos\omega_2 t$

Hence (A) is correct option.

SOL 8.122

We have $x(t) = A_c\cos\{\omega_c t + \beta\sin\omega_m t\}$

$$y(t) = \{x(t)\}^3$$
$$= A_c^2\cos(3\omega_c t + 3\beta\sin\omega_m t) + 3\cos(\omega_c t + \beta\sin\omega_m t)$$

Thus the fundamental frequency doesn't change but BW is three times.

$$BW = 2(\Delta f) = 2(\Delta f \times 3) = 3 \text{ MHz}$$

Hence (A) is correct option.

SOL 8.123

Hence (C) is correct option.

SOL 8.124

This is Quadrature modulated signal. In QAM, two signals having bandwidth. B_1 & B_2 can be transmitted simultaneous over a bandwidth of $(B_1 + B_2)$ Hz

so $B.W. = (15 + 10) = 25$ kHz

Hence (C) is correct option.

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SOL 8.125

A modulated signal can be expressed in terms of its in-phase and quadrature component as

$$S(t) = S_1(t)\cos(2\pi f_c t) - S_Q(t)\sin(2\pi f_c t)$$

Here $$S(t) = [e^{-at} cps\Delta\omega t \cos\omega_c t - e^{at}\sin\Delta\omega t \sin\omega_c t]\,\mu(t)$$

$$= [e^{-at}\cos\Delta\omega t]\cos 2\pi f_c t - [e^{-at}\sin\Delta\omega t]\sin 2\pi f_c t$$

$$= S_1(t)\cos 2\pi f_c t - S_Q(t)\sin 2\pi f_c t$$

Complex envelope of $s(t)$ is

$$\overline{S}(t) = S_1(t) + jS_Q(t)$$

$$= e^{-at}\cos\Delta\omega t + je^{-at}\sin\Delta\omega t$$

$$= e^{-at}[\cos\Delta\omega t + j\sin\Delta\omega t]$$

$$= \exp(-at)\exp(j\Delta\omega t)\,\mu(t)$$

Hence (B) is correct option.

SOL 8.126

Given function

$$g(t) = 6\times 10^4 \sin c^2(400t) * 10^6 \sin c^3(100t)$$

Let $$g_1(t) = 6\times 10^4 \sin c^2(400t)$$

$$g_2(t) = (10^6)\sin c^3(100t)$$

We know that $g_1(t) * g_2(t) \rightleftharpoons G_1(\omega)\,G_2(\omega)$ occupies minimum of Bandwidth of $G_1(\omega)$ or $G_2(\omega)$

Band width of $G_1(\omega) = 2\times 400 = 800$ rad/sec or $= 400$ Hz

Band width of $G_2(\omega) = 3\times 100 = 300$ rad/sec or 150 Hz

Sampling frequency $= 2\times 150 = 300$ Hz

Hence (B) is correct option.

SOL 8.127

For a sinusoidal input SNR(dB) is PCM is obtained by following formulae.

$$SNR(\text{dB}) = 1.8 + 6n \qquad n \text{ is no. of bits}$$

Here $n = 8$

So, $$SNR(\text{dB}) = 1.8 + 6\times 8 = 49.8$$

Hence (B) is correct option.

SOL 8.128

We know that matched filter output is given by

$$g_0(t) = \int_{-\infty}^{\infty} g(\lambda)\, g(T_0 - t + \lambda)\, d\lambda \text{ at } t = T_0$$

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$$[g_0(t)]_{\max} = \int_{-\infty}^{\infty} g(\lambda)\, g(\lambda)\, d\lambda = \int_{-\infty}^{\infty} g^2(t)\, dt$$

$$= \int_0^{1\times 10^{-4}} [10 \sin(2\pi \times 10^6)^2]\, dt$$

$$[g_0(t)]_{\max} = \frac{1}{2} \times 100 \times 10^{-4} = 5 \text{ mV}$$

Hence (D) is correct option.

SOL 8.129

Sampling rate must be equal to twice of maximum frequency.

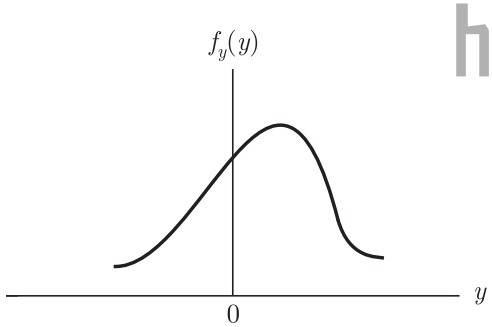
$$f_s = 2 \times 400 = 800 \text{ Hz}$$

Hence (B) is correct option.

SOL 8.130

The amplitude spectrum of a gaussian pulse is also gaussian as shown in the fig.

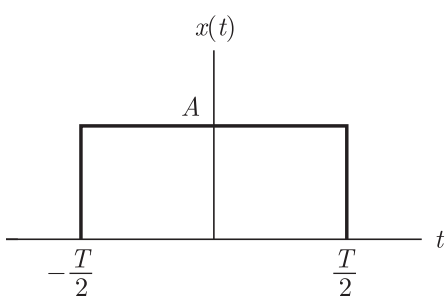
$$f_Y(y) = \frac{1}{\sqrt{2\pi}} \exp\left(\frac{-y^2}{2}\right)$$



Hence (C) is correct option.

SOL 8.131

Let the rectangular pulse is given as



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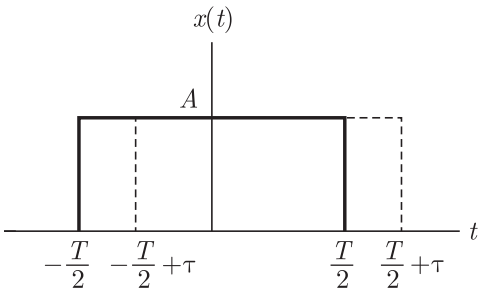
Auto correlation function is given by

$$R_{xx}(\tau) = \frac{1}{T}\int_{-T/2}^{T/2} x(t)\, x(t-\tau)\, dt$$

When $x(t)$ is shifted to right $(\tau > 0), x(t-\tau)$ will be shown as dotted line.



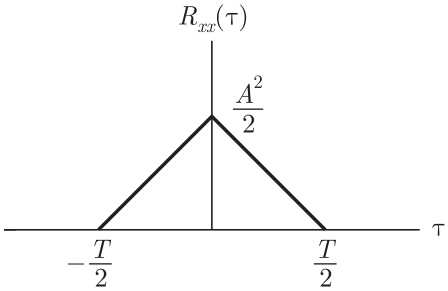
$$R_{xx}(\tau) = \frac{1}{T}\int_{-\frac{T}{2}+\tau}^{\frac{T}{2}+\tau} A^2\, dt$$

$$= \frac{A^2}{T}\left[\frac{T}{2} + \frac{T}{2} - \tau\right] = \frac{A^2}{T}\left[\frac{T}{2} - \tau\right]$$

(τ) can be negative or positive, so generalizing above equations

$$R_{xx}(\tau) = \frac{A^2}{T}\left[\frac{T}{2} - |\tau|\right]$$

$R_{xx}(\tau)$ is a regular pulse of duration T.



Hence (C) is correct option.

SOL 8.132

Selectivity refers to select a desired frequency while rejecting all others. In super heterodyne receiver selective is obtained partially by RF amplifier and mainly by IF amplifier.

Hence (B) is correct option.

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SOL 8.133

In PCM, SNR α 2^{2n}
so if bit increased from 8 to 9

$$\frac{(SNR)_1}{(SNR)_2} = \frac{2^{2\times 8}}{2^{2\times 9}} = 2^2 = \frac{1}{4}$$

so SNR will increased by a factor of 4
Hence (C) is correct option.

SOL 8.134

In flat top sampling an amplitude distortion is produced while reconstructing original signal $x(t)$ from sampled signal $s(t)$. High frequency of $x(t)$ are mostly attenuated. This effect is known as aperture effect.
Hence (A) is correct option.

SOL 8.135

$$\text{Carrier } C(t) = \cos(\omega_e t + \theta)$$
$$\text{Modulating signal} = x(t)$$
$$\text{DSB - SC modulated signal} = x(t)\,c(t) = x(t)\cos(\omega_e t + \theta)$$
$$\text{envelope} = |x(t)|$$

Hence (A) is correct option.

SOL 8.136

In Quadrature multiplexing two baseband signals can transmitted or modulated using I_4 phase & Quadrature carriers and its quite different form FDM & TDM.
Hence (D) is correct option.

SOL 8.137

Fourier transform perform a conversion from time domain to frequency domain for analysis purposes. Units remain same.
Hence (A) is correct option.

SOL 8.138

In PCM, SNR is depends an step size (i.e. signal amplitude) *SNR* can be improved by using smaller steps for smaller amplitude. This is obtained by compressing the signal.
Hence (A) is correct option.

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SOL 8.139

Band width is same for BPSK and APSK(OOK) which is equal to twice of signal Bandwidth.
Hence (C) is correct option.

SOL 8.140

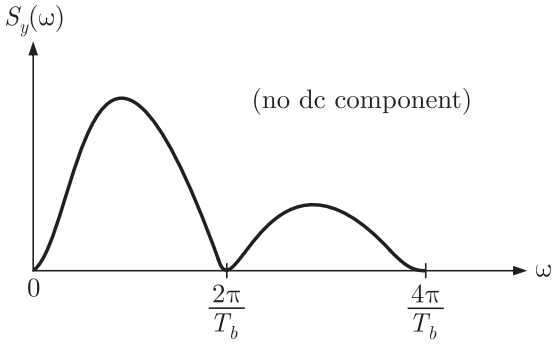
The spectral density of a real value random process symmetric about vertical axis so it has an even symmetry.
Hence (A) is correct option.

SOL 8.141

Hence (A) is correct option.

SOL 8.142

It is one of the advantage of bipolar signalling (AMI) that its spectrum has a dc null for binary data transmission PSD of bipolar signalling is



Hence (C) is correct option.

SOL 8.143

Probability Density function (PDF) of a random variable x defined as

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

so here $$K = \frac{1}{\sqrt{2\pi}}$$

Hence (A) is correct option.

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SOL 8.144

Here the highest frequency component in the spectrum is 1.5 kHz [at 2 kHz is not included in the spectrum]

Minimum sampling freq. $= 1.5 \times 2 = 3\,\text{kHz}$

Hence (C) is correct option.

SOL 8.145

We need a high pass filter for receiving the pulses.

Hence (B) is correct option.

SOL 8.146

Power spectral density function of a signal $g(t)$ is fourier transform of its auto correlation function

$$R_g(\tau) \xleftrightarrow{\mathcal{F}} S_g(\omega)$$

$$\text{here} \quad S_g(\omega) = \sin c^2(f)$$

so $R_g(t)$ is a triangular pulse.

$$f[\text{triang.}] = \sin c^2(f)$$

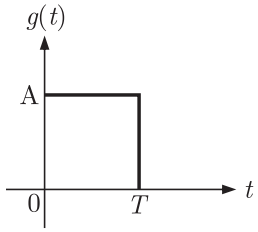
Hence (D) is correct option.

SOL 8.147

For a signal $g(t)$, its matched filter response given as

$$h(t) = g(T - t)$$

so here $g(t)$ is a rectangular pulse of duration T.



output of matched filter

$$y(t) = g(t) * h(t)$$

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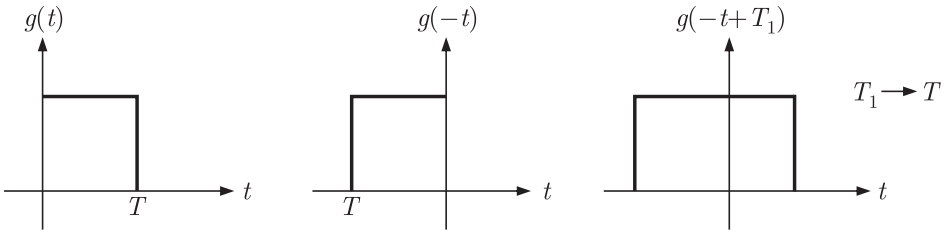
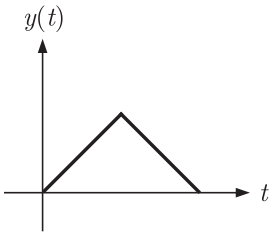


if we shift $g(-t)$ for convolution $y(t)$ increases first linearly then decreases to zero.



Hence (C) is correct option.

SOL 8.148

The difference between incoming signal frequency (f_c) and its image frequency (f_c) is $2I_f$ (which is large enough). The RF filter may provide poor selectivity against adjacent channels separated by a small frequency differences but it can provide reasonable selectivity against a station separated by $2I_f$. So it provides adequate suppression of image channel.
Hence (C) is correct option.

SOL 8.149

In PCM SNR is given by

$$SNR = \frac{3}{2}2^{2n}$$

if no. of bits is increased from n to $(n+1)$ SNR will increase by a factor of $2^{2(n+1)/n}$
Hence (C) is correct option.

SOL 8.150

The auto correlation of energy signal is an even function.
auto correlation function is gives as

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$$R(\tau) = \int_{-\infty}^{\infty} x(t)\,x(t+\tau)\,dt$$

put $$R(-\tau) = \int_{-\infty}^{\infty} x(t)\,x(t-\tau)\,dt$$

Let $$t-\tau = \alpha$$

$$dt = d\alpha$$

$$R(-\tau) = \int_{-\infty}^{\infty} x(\alpha+\tau)\,x(\alpha)\,d\alpha$$

change variable $\alpha \rightarrow t$

$$R(-\tau) = \int_{-\infty}^{\infty} x(t)\,x(t+\tau)\,dt = R(\tau)$$

$$R(-\tau) = R(\tau) \text{ even function}$$

Hence (D) is correct option.

SOL 8.151

Hence (D) is correct option.

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