W'05 : 4 FN : EC 403 (1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,**
ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (*a, b, etc*) *should be
answered at one place.*

*Answer should be brief and to-the-point and be supple-
mented with neat sketches. Unnecessary long answers
may result in loss of marks.*

*Any missing data or wrong data may be assumed suitably
giving proper justification.*

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) State Helmholtz theorem in words and explain. For
   a given vector
   $$\bar{F} = f_x (3\bar{y} - c_1 \bar{z}) + f_y (c_2 \bar{x} - 2\bar{z}) + f_z (- c_3 \bar{y} - \bar{z})$$

   2

   (*i*) Determine the constants c_1, c_2 and c_3 if $\bar{F}$ is
   irrotational.   3

   (*ii*) Determine the scalar potential function V whose
   negative gradient equals F.   5

   (Turn Over

(b) Define the following :   2 × 5

   (i) Ergodic processes

   (ii) Multiplexing

   (iii) Energy density spectrum

   (iv) Auto covariance

   (v) Quantization noise
      Also illustrate each with a suitable example.

2. (a) Draw a detailed diagram of delta modulator and explain the operation of it. Also discuss the noise performance of delta modulator.   8

  (b) List all the Maxwell's equations (in integral form) and describe in detail the Ampere's circuital law and Faraday's law.   6

  (c) What do you understand by AFC ? Draw and explain the circuit diagram of AFC.   6

3. (a) Discuss the boundary conditions (for $\bar{B}$ & $\bar{H}$) between two lossless media.   6

  (b) Define Amplitude modulation and draw the wave-shapes for following :   8
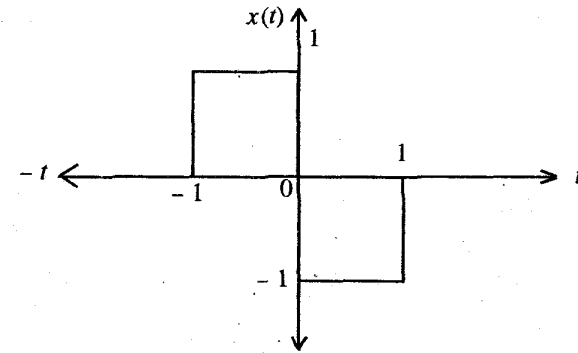
   (i) AM-DSB

   (ii) AM-DSB/SC

   (iii) AM-SSB

     Also establish a comparative study between all the classes of amplitude modulation.

(c) Determine the Fourier transform of   6

4. (a) Describe the following in detail :   8

   (i) Atmospheric noise

   (ii) Thermal noise

   (iii) Shot noise

   (iv) Partition noise.

  (b) Write detailed notes on *any three* of the following :   4 × 3

   (i) Poisson's equation

   (ii) Gauss's laws

   (iii) Magnetic polarization

   (iv) Armstrong modulator

(v) Pulse code modulation

(vi) Square law diode detector.

Group B

5. (a) Define equivalent noise bandwidth (ENBW).   3

(b) Describe, in detail, the MMSC (minimum mean square criteria) criteria for optimum systems (detectors/receivers).   10

(c) What are the performance indices of digital modulation systems.   7

6. (a) What do you understand by account of information ? Also define entropy of the source.   4

(b) Consider that two sources X and Y emit-messages x_1, x_2 and x_3 and y_1, y_2 and y_3 with the joint probability $p(X, Y)$ as shown in the matrix below

$$p(X, Y) \Rightarrow$$

	y_1	y_2	y_3
x_1	3/40	1/40	1/40
x_2	1/20	3/20	1/20
x_3	1/8	1/8	3/8

Calculate $H(X)$, $H(Y)$, $H(X/Y)$ and $H(Y/X)$. Also prove that
$$H(X, Y) = H(X) + H(Y/X)$$
and $\quad = H(Y) + H(X/Y)$ 12

(c) Draw and discuss the Adaptive delta modulator circuit.   4

7. (a) What do you understand by channel coding ? Explain any one error detection and error correction code with suitable diagram of CODEC.   4 + 6

(b) What is a matched filter ? Explain the application of matched filter in coherent detection.   4 + 6

8. Write short notes on *any four* of the following :   5 × 4

(i) Synchronization

(ii) Discrete noisy channel

(iii) Baseband transmission

(iv) Timing recovery

(v) Envelope detectors

(vi) Digital RF modulation.

Group C

9. Choose the *correct* answer :   2 × 10

(i) Companding is used

(a) to overcome quantizing noise

(b) to protect small signals in PCM

(c) to reduce impulse noise

(d) to increase the power content

(ii) Quantizing noise occurs in

(a) TDM

(b) FDM

(c) PWM

(d) PCM

(iii) Balanced modulators are used to

(a) Produce suppressed carrier signal

(b) Produce SSB signal

(c) Produce PCM signal

(d) None of these

(iv) The percentage saving in power in case of a 100% modulated AM signal transmitted as DSB-SC as compared to the one transmitted as DSB is

(a) 50%

(b) 33·33%

(c) 66·66%

(d) 75%

(v) Thermal noise is given by the expression

(a) $n = kTB$

(b) $\Rightarrow n = kT/B$

(c) $n = kT_0 BF_n$

(d) $n = kT_0 B/F_n$

(vi) Major advantage of Armstrong modulator is that

(a) It is capable of producing WBFM signals

(b) The centre frequency (carrier frequency when unmodulated) is extremely stable

(c) A large depth of modulation can be achieved

(d) None of these

(vii) In a ratio detector

(a) Stabilizations against signal strength variations is provided

(b) The output is twice that obtainable from a similar phase discriminator

(c) The circuit is same as in the discriminator except that diodes are reversed

(d) The linearity is worse than in a phase discriminator

(viii) A current is flowing in a circular conductor in a clockwise direction. The coil is in the plane of paper. The direction of the magnetic field is

(a) Away from you

(b) In the plane of paper

(c) Towards you

(d) None of these

4

(*ix*) One of the following cannot be used to demodulate SSB

(*a*) Diode balanced modulator

(*b*) Product detector

(*c*) Bipolar transistor balanced modulator

(*d*) Complete phase shift generator

(*x*) Two metal conductors, one larger than the other, are given the same charge. If both are spherical conductors, the charge density will be

(*a*) same on both

(*b*) more on smaller sphere

(*c*) more on larger sphere

(*d*) none of these

S'06 : 4 FN : EC 403 (1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE questions, taking ANY TWO from **Group A**,
ANY TWO from **Group B** and ALL from **Group C**.

All parts of a question (a, b, etc.) should
be answered at one place.

Answer should be brief and to-the-point and be supplemented
with neat sketches. Unnecessary long answers may
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proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (a) A point charge 5nC is located at (– 3, 4, 0) while line
$y = 1$, $z = 1$ carries uniform charge 2nC/m. If $V = 100$
at A (1, 2, 1) find V at B (– 2, 5, 3).   12

    (b) Find H at the centre C of an equilateral triangular
loop of side 4m carrying 5A of current as shown
below :   8
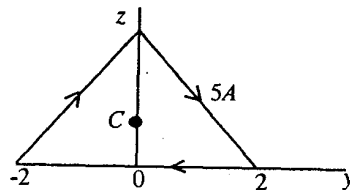
2. (a) Evaluate the Fourier transform of the damped sinusoidal wave

$$g(t) = \exp(-t) \sin(2\pi f_c t) \cdot u(t)$$

where $u(t)$ is the unit step function.   6

(b) Consider the convolution of two signals $g_1(t)$ and $g_2(t)$ show that:

$$\int_{-\infty}^{t} [g_1(\tau) * g_2(\tau)] \, d\tau = \left[\int_{-\infty}^{t} g_1(\tau) \, d\tau \right] * g_2(t).$$

    6

(c) A random process $X(t)$ is defined by

$$X(t) = A \cos(2\pi f_c t)$$

where A is a Gaussian–distributed random variable of zero mean and variance σ_A^2.   8

3. (a) A signal voltage $v_s = 25 \sin 1000t$ and carrier voltage $v_c = 5 \sin(4 \times 10^6 t)$ are applied to the input of a nonlinear resistance whose input–voltage output current relation is $i_o = (10 + 2 v_i - 0.2 v_i^2)$. Determine the frequencies of all components in the output current. Calculate the percentage modulation if the output current is passed through a tuned circuit so that only the components appropriate to AM are produced.   5 + 5

(b) Explain why PCM is more noise resistant than the other forms of pulse modulation. Explain why quantizing noise could affect small-amplitude signals in a PCM system far more than large signals. Show how tapered quantization burls could be used to counteract this effect.   3 + 3 + 4

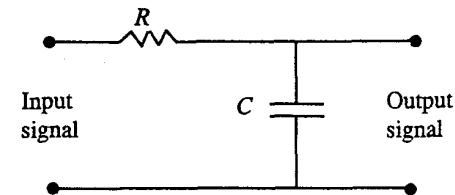4. (a) Using Amperes's law determine an expression for H for an infinite current sheet having uniform current density K Amp/m in the $z = 0$ plane.   6

(b) Explain the principles of time-division multiplex, with a sketch to show how interleaving of channels take place.   6

(c) The sample function

$$x(t) = A_C \cos(2\pi f_c t) + wt$$

is applied to the low–pass RC filter as shown below.

The amplitude A_c and frequency f_c of the sinusoidal component are constants and $w(t)$ is the white Gaussian noise of zero mean and power spectral density $\dfrac{N_0}{2}$. Find an expression for the output signal-to-noise ratio with the sinusoidal component of $x(t)$ regarded as the signal of interest.   8

Group B

5. (a) A Gaussian-distributed random variable X of zero mean and variance σ_x^2 is transformed by a square law device defined by
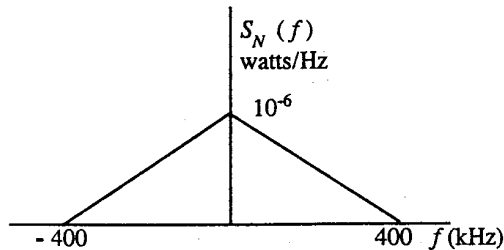
$$Y = X^2$$

Show that the probability density function of the new random variable is given by

$$f_Y(y) = \begin{cases} \dfrac{1}{\sqrt{2\pi y}\ \sigma_x} \ \exp\left(-\dfrac{y}{2\sigma_x{}^2}\right) & y \geq 0 \\[4mm] 0 & y < 0 \end{cases}$$

10

(b) A DSB-SC modulated signal is transmitted over a noisy channel with power spectral density of the noise as shown below:

The message bandwidth is 4 kHz and the carrier frequency is 200 kHz. Assuming that the average power of the modulated wave is 10 watts, determine the output signal to noise ratio of the receiver.   10

6. (a) Define uncertainty and entropy. Show that the entropy $H(\xi)$ of a discrete memory less source is bounded by

$$0 \leq H(\xi) \leq \log_2 k$$

where k is the radix (number of symbols) of the alphabet ξ of the source.   4 + 6

(b) A source emits one of four symbols s_0, s_1, s_2 and s_3, with probabilities $\dfrac{1}{3}, \dfrac{1}{6}, \dfrac{1}{4}$ and $\dfrac{1}{4}$ respectively. The successive symbols emitted by the source are statistically independent. Calculate the entropy of the source. Derive the formula you use.   5 + 5

7. (a) Explain with block diagram the transmission and reception of delta modulation system. What is delta-sigma modulation and what are its advantage over delta modulation.   6 + 4

(b) It is proposed to implement a matched filter in the form of a tapped-delay-line filter with a set of tap-weights $\{w_k, k = 0, 1, ..., k\}$. Given a signal $s(t)$ of duration T seconds to which the filter is matched, find the value of w_k. Assume that the signal is uniformly sampled.   10

8. Write short notes on: 5 x 4

(i) Channel capacity

(ii) DPCM

(iii) TDM

(iv) Synchronization in PCM system.

Group C

9. Answer all questions: 2 x 10

(i) Find the incorrect statement:

(a) $\nabla (A \cdot B) = (A \cdot \nabla) B + (B \cdot \nabla) A + A \times (\nabla \times B) + B \times (\nabla \times A)$

(b) $\nabla \cdot (A \times B) = B \cdot (\nabla \times A) + A \cdot (\nabla \times B)$

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(d) $\nabla \times (VA) = \nabla V \times A + V(\nabla \times A)$.

(ii) In free space $E = 20\cos(wt - 5x) ay$ v/m. Calculate the displacement current J_d.

(iii) Define power spectral density of a wide-sense stationary random process in terms of the autocorrelation function.

(iv) Pulse width modulation may be generated

    (a) by differentiating pulse position modulation

    (b) with a monostable multivibrator

    (c) by integrating the signal

    (d) with a free running multivibrator.

(v) In order to reduce quantizing noise in receivers one must

    (a) increase the number of standard amplitudes

    (b) send pulses whose sides are more nearly vertical

    (c) Use an RF amplifier in the receiver

    (d) increase the number of samples per sec.

(vi) A receiver connected to an antenna whose resistance is 50 ohms has an equivalent noise resistance of 30 ohms. Calculate the receiver's noise figure in dB.

(vii) Identify the incorrect statement

    (a) The zero frequency value of the power spectral density of a wide-sense stationary random process equals the total area under the graph of the autocorrelation function.

    (b) The mean-square value of a wide-sense stationary random process equals the total area under the graph of the power spectral density.

    (c) The power spectral density of a wide-sense stationary random process is always non negative.

    (d) The power spectral density of a real-valued random process is an odd function of frequency.

(viii) Identify the incorrect statement

    (a) A source in which the symbols emitted during successive signalling intervals are statistically dependent is called descrete memoryless source.

    (b) With the source alphabet ζ e the entropy
$$H(\zeta^n) = n\, H(\zeta)$$

    (c) Limple-Ziv algorithm is intrinsically adaptive.

    (d) Channel capacity is measured in bits per channel use.

(ix) A scheme in ADPCM in which samples of the quantizer output and predication error are used to derive estimates of the predictor coefficients is

(a) AQF

(b) AQB

(c) APF

(d) APB.

(x) Which of the following is not the modulation type for modem specification ?

(a) VSB

(b) FSK

(c) ASK

(d) PSK.

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10

W'06 : 4 FN : EC 403 (1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A** ,
ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

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proper justification.*

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Group A

1. (a) State and explain Poisson's equations and Laplace
        equation.   6

    (b) State the boundary conditions for B and H.   4

    (c) Explain the following :   4 + 4 + 2

        (i) Maxwell's equations in differential form.

        (ii) Magnetic polarization and field intensity.

        (iii) Stokes's theorem.

2. (a) Draw the block diagram of FM detector and explain its operation with necessary waveforms.   8

(b) List the properties of Fourier transforms.   4

(c) Explain the significance of power density spectrum and energy density spectrum.   4

(d) Discuss the importance of probability density functions in communications.   4

3. (a) Explain the principle of multiplexing: FDM and TDM.   8

(b) Give the comparative study between all the classes of amplitude modulation with necessary waveforms.   9

(c) What is the function of AFC?   3

4. (a) Determine the Fourier transform of a unit step function:

$$u(t) = 1 \text{ for } t > 0$$
$$= 0 \text{ for } t < 0.$$ 6

(b) Describe the following in detail: 4 + 4 + 4 + 2

(i) Thermal noise and shot noise.

(ii) Delta modulation

(iii) Pulse code modulation

(iv) Ergodic process.

Group B

5. (a) Describe in detail the maximum signal to noise ratio criterion for optimum systems.   8

(b) Explain the probability density input-output relationships. What is the Gaussian distribution function?   6

(c) Explain the concept of equivalent noise bandwidth.   6

6. (a) Explain the relation between systems capacity and information content of messages.   8

(b) Explain the terms:
Information, entropy, redundancy and rate of communication.   8

(c) What do you understand by channel coding?   4

7. (a) What is optimum terminal filter? Explain its application in signal detection.   8

(b) What is quantization? Explain log-PCM.   6

(c) Explain linear predictive coding used for speech signals.   6

8. Write short notes on any *four* of the following: 5 x 4

(i) Digital RF modulation;

(ii) MMSE

(iii) Discrete noisy channel;

(iv) Matched Filter;

(v) Baseband transmission;

(vi) Modems;

(vii) ISI.

Group C

). Choose the *correct* answer: 2 x 10

(i) Inter symbol interference is a problem in ———— transmission.

(a) PCM

(b) AM

(c) FM

(d) None of the above.

(ii) The bandwidth of a narrow band FM signal generated by a 4 kHz audio signal modulating a 125 MHz carrier

(a) 4 kHz

(b) 8 kHz

(c) 250 kHz

(d) 2 kHHz.

(iii) In an ergodic process ensemble and time averages are

(a) opposite to each other

(b) different

(c) identical

(d) none of the above.

(iv) For a continuous signal the amount of information is

(a) infinite

(b) zero

(c) finite

(d) none of the above.

(v) In AM, the modulation index lies between

(a) -1 and 1

(b) 0 and 1

(c) 1 and $\propto$

(d) $-\propto$ and $\propto$.

(vi) Which filter is commonly used in SSB generation?

(a) RC filter

(b) LC filter

(c) Mechanical filter

(d) LP filter.

(vii) Thermal noise power is proportional to

(a) B

(b) $\sqrt{B}$

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(c) $1/B^2$

(d) B^2.

$(viii)$ Which of the following relations is correct ?

(a) $\nabla \cdot \vec{B} = \varrho$

(b) $\nabla \cdot \vec{D} = -\varrho$

(c) $\nabla \cdot \vec{D} = \varrho$

(d) $\nabla \cdot \vec{B} = \vec{J}$.

(ix) Intrinsic impedance of free space is

(a) $0\,\Omega$

(b) $370\,\Omega$

(c) infinite

(d) $377\,\Omega$.

(x) The magnetic field intensity emanating from a closed surface

(a) is zero

(b) is infinite

(c) depends on dipole moment

(d) depends on volumetric compaction factor.

S'07 : 4 FN : EC 403 (1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**,
ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

*All parts of a question (a, b, etc.) should
be answered at one place.*

*Answer should be brief and to-the-point and be supplemented
with neat sketches. Unnecessary long answers may
result in loss of marks.*

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proper justification.*

Figures on the right-hand side margin indicate full marks .

Group A

1. (a) Define and explain the following :   1 x 3

   (*i*) Gradient

   (*ii*) Divergence

   (*iii*) Curl.

   (b) State and explain the following :   6 + 3

   (*i*) Helmholtz theorem

   (*ii*) Gauss's laws

(Turn Over)

(*iii*) Ampere's circuital law,

with the help of a suitable example. Also, discuss their utility in respective applications.

(*c*) An elementary short dipole is 10 cm long. If the 10 MHz current passing through it is 2 A, what is the field intensity 20 km away from the short dipole in a direction of maximum radiation ?   8

2. (*a*) Derive the mathematical relation for determining the 'Noise-Figure' of a receiver with following parameters :

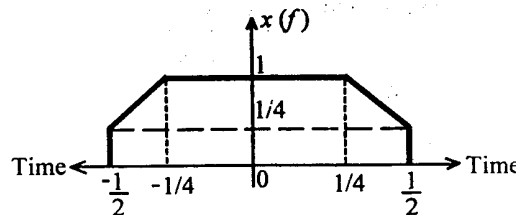(*i*) Receiver has an overall gain A,

(*ii*) An output resistance R_L,

(*iii*) A bandwidth (BW) δ_f,

(*iv*) An absolute operating temperature T, and

(*v*) Input resistance is equal to the antenna resistance R_a.

Also, discuss the method of measuring the same.   5 + 5

(*b*) Determine the Fourier transform of - $x(t)$:   10

3. (*a*) Why are linear amplifiers used in SSB transmitters ? Give a quantitative response.   8

(*b*) Describe the effect of random noise on the output of an FM receiver equipped with an amplitude limiter. Also, discuss the importance of noise triangle.   8

(*c*) Prove that phase discriminator is a FM demodulator.   4

4. (*a*) With the help of a circuit diagram, explain how a balanced modulator is able to demodulate SSB signals.   6

(*b*) Explain the principle of multiplexing and its necessity in communication.   4

(*c*) Define and discuss the pulse-position modulation. Also, explain, with waveforms, how it is derived from PWM ? How is PWM demodulated ?   3 + 4 + 3

Group B

5. (*a*) State and explain the aspect of transmission channel which is defined by the Shannon-Hartley law. How does noise affect channel capacity ?   6

(*b*) Explain how equalization can improve the ability of a transmission channel to carry data.   4

(*c*) State and describe the three types of error detection codes and explain how they detect data errors. What are the merits and demerits of channel coding ? List them.   10

6. (*a*) Explain why quantizing noise could affect small amplitude signals in a PCM system far more than large signals. Also, enumerate how tapered quantizing levels could be used to counter act this effect.   5 + 3

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(b) List the advantages and applications of PCM.   4

(c) What is optimum terminal filter? Explain its application in signal detection.   8

7. (a) A source emits one of six symbols α_0, α_1, α_2, α_3, α_4 and α_5 with probabilities $1/6$, $1/8$, $1/4$, $1/6$, $1/6$, $1/8$, respectively. The symbols emitted by the source are statistically independent. Calculate the entropy of the source and derive the same formula.   4 + 4

(b) State and explain the following: 6 × 2

   (i) maximum SNR criterion; and

   (ii) minimum MSE criterion

   with a comparative study and their applications.

8. Write short notes on the following: 5 × 4

   (i) Synchronization and timing recovery;

   (ii) Baseband transmission;

   (iii) LPC for speech signals;

   (iv) Digital RF modulation.

Group C

9. Write the *correct* answer for the following: 2 × 10

   (i) In an SSB transmitter, one is most likely to find

      (a) class C audio amplifier

   (b) tuned modulator

   (c) class B RF amplifier

   (d) class A RF output amplifier.

(ii) Amplitude modulation is used for broadcasting because

   (a) it is more noise immune than other modulation system

   (b) it consumes less transmitting power

   (c) its use avoids receiver complexity

   (d) no other modulation system can provide the necessary bandwidth for high fidelity.

(iii) When the modulation index of an AM wave is doubled, the antenna current is also doubled. The AM system being used is

   (a) SSB, full carrier

   (b) VSB

   (c) SSB, suppressed carrier

   (d) DSB, full carrier.

(iv) In the stabilized reactance modulator AFC system, the

   (a) discriminator must have a fast line constant to prevent demodulation

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(b) higher the discriminator frequency, the better the oscillator frequency stability

(c) discriminator frequency must not be too low, or the system will fail

(d) phase modulation is converted into FM by the equalizer circuit.

(v) In order to reduce quantizing noise, one must

(a) increase the number of standard amplitudes

(b) send pulses whose sides are more nearly vertical

(c) use an RF amplifier in the receiver

(d) increase the number of samples per second.

(vi) To separate channels in the FDM receiver, it is necessary to use

(a) AND gates

(b) BP filters

(c) differentiators

(d) integrators.

(vii) In a communication system, noise is most likely to affect the signal

(a) at the transmitter

(b) in the channel

(c) in the information source

(d) at the destination.

(viii) A pre-emphasis circuit provides extra noise immunity by

(a) boosting the base frequencies

(b) amplifying the higher audio frequencies

(c) pre-amplifying the whole audio band

(d) converting the phase modulation to FM.

(ix) An FM signal with a modulation index, m_f, is passed through a frequency trippler. The wave in the output of the trippler will have a modulation index of

(a) $m_f/3$

(b) m_f

(c) $3 m_f$

(d) $9 m_f$.

(x) Indicate the false statement in connection with communication receivers

(a) The noise limiter cuts-off the receiver's output during a noise pulse

(b) A product demodulator could be used for the reception of Morse code

(c) Double conversion is used to improve image rejection

(d) Variable sensitivity is used to eliminate selective fading.

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**,
ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

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be answered at one place.*

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with neat sketches. Unnecessary long answers may
result in loss of marks.*

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proper justification.*

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Group A

1. (a) Write Poisson's and Laplace's equations. Using Laplace's equation, determine the potential at any point between the two plates of a parallel-plate capacitor and also the surface charge densities on the plates.   12

    (b) What is vector potential ? Derive the wave equation for vector potential.   8

2. (a) Derive Parseval's power theorem relating average power of a periodic signal to its Fourier coefficients.   6

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(b) Explain Gram-Schmidt procedure to obtain orthogonal basis of signals. 10

(c) State and explain Nyquist criterion. 4

3. (a) What is thermal noise? Find out the expression for available signal power in presence of thermal noise. 10

(b) What are shot noise and partition noise? 6

(c) What is noise equivalent bandwidth? 4

4. (a) A frequency-modulated signal which is modulated by a 3 kHz sine wave reaches a maximum frequency of 100·02 MHz and minimum frequency of 99·98 MHz. Determine (i) carrier swing, (ii) carrier frequency, (iii) frequency deviation, of the signal, and (iv) modulation index of the signal. 12

(b) Explain the principle of FDM and TDM? What is TDD? 8

Group B

5. (a) What is entropy of a source? How can you find maximum entropy of several alphabets? Define code efficiency and redundancy of codes. 8

(b) Define channel capacity and channel efficiency for a discrete noisy channel. Describe the properties of binary symmetric channel and binary erase channel. Derive an expression for channel capacity in terms of sampling conditioning. 12

6. (a) What are the differences between DPCM and ADPCM from quantization error point of view? 10

(b) Describe the method of optimum detection of signal using matched filters. Derive an expression for impulse response of a matched filter. 10

7. (a) What is intersymbol interference (ISI)? Describe the principle of a receiver which can be used to compensate or to reduce ISI in the received signal. 10

(b) What is the technique for digital RF modulation? Describe the principle and construction of a Modem. Derive an expression for bit error probability in terms of bit energy. 10

8. (a) Explain Schwarz's inequality for two power signals. Define cross-correlation and auto-correlation of two power signals. Find out spectral density function for a given power signal. 12

(b) What is envelope detector? How can you estimate SNR of an envelope detector? Describe the design constraint for envelope detector. 8

Group C

9. Choose the *correct* answer for the following: 2 x 10

(i) Maxwell's equation

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

is actually

(a) Gauss's law

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(b) Ampere's law

(c) Faraday's law

(d) Lenz's law.

(ii) A source delivers four symbols with probabilities $\left\{\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{8}\right\}$. The entropy of the source is

(a) 1·85 bits

(b) 1·75 bits

(c) 1·65 bits

(d) 1·95 bits.

(iii) The minimum input voltage that produces a specified SNR at the output of the IF section, is known as

(a) selectivity of the receiver

(b) noise figure of the receiver

(c) image rejection of the receiver

(d) sensitivity of the receiver.

(iv) Maxwell's equation $\vec{\nabla} \cdot \vec{B} = 0$ implies that

(a) electric lines of forces are closed

(b) magnetic lines of forces are closed

(c) displacement current is continuous

(d) electric charge density is zero.

(v) A modulation 70% means

(a) unmodulated AM

(b) overmodulated FM

(c) overmodulated AM

(d) unmodulated FM.

(vi) Foster Seeley discriminator is used for

(a) FM detection

(b) AM detection

(c) PCM detection

(d) ADPCM detection.

(vii) Write noise has

(a) non-uniform power spectra density

(b) uniform power spectral density

(c) Gaussian power spectral density

(d) triangular power spectral density.

(viii) On the metallic plane, boundary condition is

(a) normal component of electric field is zero

(b) normal component of magnetic field is zero

(c) tangential component of electric field is zero

(d) tangential component of magnetic field is zero.

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(*ix*) The ring modulator is generally used for

  (*a*) generating SSB/SC signal

  (*b*) generating ISI signal

  (*c*) generating wideband signal

  (*d*) generating DSB/SC signal.

(*x*) Linear predictive coding is

  (*a*) time domain coding

  (*b*) frequency domain coding

  (*c*) space domain coding

  (*d*) None of the above.

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S'08 : 4 FN : EC 403 (1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A** ,
ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

*All parts of a question (a, b, etc.) should
be answered at one place.*

*Answer should be brief and to-the-point and be supplemented
with neat sketches. Unnecessary long answer may
result in loss of marks.*

*Any missing or wrong data may be assumed suitably giving
proper justification.*
Figures on the right-hand side margin indicate full marks.

Group A

1. (a) If $\bar{A} = xz - x^2 y + y^2 z^2$, determine $\text{div}\,(\text{grad}\cdot\bar{A}\,)$.   4

    (b) Find the current distribution producing following field distribution :   8

$$H = \begin{cases} J_0\, r^2\, \hat{a}_\phi & 0 < r < a \\ (J_0\, a^3\, \hat{a}_\phi)\,/\,r & a < r < b \\ 0 & b < r < \infty \end{cases}$$

(c) A parallel plate capacitor, with plate area of $5 cm^2$ and plate operation of 3 mm, has a voltage of $50 \sin 10^3 t$ applied to its plates. Calculate the displacement current assuming $\varepsilon = 2 \varepsilon_0$ 8

2. (a) State and explain the duality property of Fourier transform.   4

(b) Explain the Gram-Schmidt orthogonalization procedure.   8

(c) Find the constant k such that the function

$$f(x) = \begin{cases} kx^2, & 0 < x < 3 \\ 0, & \text{otherwise} \end{cases}$$

is a density function. Find the distribution function for this random variable. Determine $P(1 < x \leq 2)$. 2 + 4 + 2

3. (a) Calculate the shot noise component of current present on a direct current of 1 mA flowing across a semiconductor junction. The effective noise bandwidth is 1 MHz.   4

(b) A mixer stage has a noise figure of 20 dB and this is preceded by an amplifier that has a noise figure of 9 dB and available power gain of 15 dB. Calculate the overall noise figure referred to input.   6

(c) Derive the formula for the instantaneous value of FM voltage and define modulation index. Explain fully the difference between frequency and phase modulation starting with the definition of each type and the meaning of modulation index in each case.   (4 + 1) + 5

4. (a) What is pre-emphasis ? Why is it used in FM system ? Sketch a typical pre-emphasis circuit and explain why de-emphasis must also be used.   6

(b) Explain the principles of time division multiplexing with a sketch to show how the interleaving of channels take place. How does signal-to-noise ratio get affected after multiplexing.   6

(c) A PCM system is to have a signal-to-noise ratio of 40 dB. The signals are speech, and an rms-to-peak ratio of - 10 dB is allowed. Find the number of bits per code word required.   8

Group B

5. (a) Determine the autocorrelation function of the sinusoidal signal with random phase defined by

$$X(t) = A \cos (2\pi f_c t + \Theta)$$

where A and f_c are constants and Θ. a random variable that is uniformly distributed over the interval $(- \pi, \pi)$, i.e.,

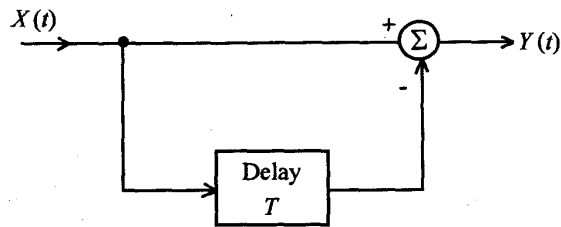$$f_\Theta (\theta) = \begin{cases} 1/2\pi, & - \pi \leq \theta \leq \pi \\ 0, & \text{elsewhere} . \end{cases}$$ 7

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(b) Determine the power spectral density $S_Y(f)$ of the following filter, if the power spectral density of input $X(t)$ is $S_X(f)$:

7

(c) Derive an expression for the channel capacity of PCM system.   6

. (a) Five symbols of a discrete memoryless source and their probabilities are given below :

Symbol	Probability	Code Word
s_0	0·4	00
s_1	0·2	10
s_2	0·2	11
s_3	0·1	010
s_4	0·1	011

Determine the average code word length and the entropy of the memoryless source.   3 + 3

(b) A system has a bandwidth of 4 kHz and a signal-to-noise ratio of 28 dB at the input of the receiver. If the bandwidth of the channel is doubled while transmitted signal power remains same, determine capacity of the channel.   6

(c) State and explain the channel coding theorem. Explain the application of this theorem in binary symmetric channel.   2 + 2 + 4

7. (a) Explain, with a block diagram, the transmission and reception in DPCM system. Explain how will you implement the prediction filter in such a system.   6 + 4

(b) Explain, with a block diagram, the generation and detection of coherent binary PSK signals. Derive an expression for the bit error rate of coherent binary PSK system.   5 + 5

8. Write short notes on the following :   5 x 4

(i) Automatic frequency control

(ii) SNR in envelope detector

(iii) Uncertainty and redundancy

(iv) Inter symbol interference.

Group C

9. Answer the following in brief :   2 x 10

(i) State the Helmholz theorem.

(ii) Define magnetic vector potential.

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(*iii*) Which one of the following statement is *not* correct ?

(*a*) The zero frequency value of the power spectral density of a wide-sense stationary random process equals total area under-the graph of autocorrelation function.

(*b*) The mean-square value of a wide-sense stationary random process equals the total area under the graph of the power spectral density.

(*c*) The power spectral density of a wide-sense stationary random process is always non-negative.

(*d*) The power spectral density of a real-valued random process is an odd function of frequency.

(*iv*) Indicate the *false* statement. The square of the thermal noise voltage generated by a resistor is linearly proportional to

(*a*) its resistance

(*b*) its temperature in degree centigrade

(*c*) Boltzmann constant

(*d*) bandwidth over which it is measured.

(*v*) If the carrier of a 100 percent modulated AM is suppressed, the percentage power saving will be

(*a*) 50

(*b*) 150

(*c*) 100

(*d*) 66·66.

(*vi*) Identify *incorrect* statement from the following :

(*a*) Cross correlation function is an even function.

(*b*) If process $X(t)$ is ergodic in mean, then the variance of time average approaches zero as $t \to \infty$.

(*c*) If a Gaussian process $X(t)$ is applied to a stable filter, then the random process $Y(t)$ developed at the output of filter is also Gaussian.

(*d*) If a Gaussian process is wide sense stationary, then the process is also stationary in the strict sense.

(*vii*) Companding is used mainly

(*a*) to overcome quantizing noise in PCM

(*b*) in PCM transmitters to allow amplitude limiting in receivers

(*c*) to protect small signals in PCM from quantizing distortion

(*d*) in PCM receivers to overcome impulse noise.

(*viii*) The Hartley-Shannon theorem sets a limit on the

(*a*) highest frequency that may be sent over a given channel

(*b*) maximum capacity of a channel with a given noise level

(*c*) maximum number of coding levels in a channel with a given noise level.

(*d*) maximum number of quantizing levels in a channel with a given noise level.

(*ix*) Describe the main property of matched filter.

(*x*) Define the difference between baseband and passband signals.

W'08 : 4 FN : EC 403 (1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A ,**
ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should
be answered at one place.

Answer should be brief and to-the-point and be supplemented
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result in loss of marks.

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proper justification.

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Group A

1. (*a*) State and explain divergence theorem. What do you
    mean by curl of a vector field ?   12

    (*b*) State Stoke's theorem. State and prove Gauss's law
    of electrostatics.   8

2. (*a*) Write Maxwell's equations and explain their physical
    meanings.   8

(b) What is displacement current ? Prove that flux of the sum ($\vec{J} + \vec{D}$) through any closed surface is zero, where $\vec{J}$ and $\vec{D}$ are current density and displacement vector, respectively. 12

3. (a) Explain the following with examples : 3 x 3

   (i) Deterministic and random signals

   (ii) Periodic and aperiodic signals

   (iii) Even and odd signals.

   (b) Explain the frequency translated theorem for Fourier transform. What is convolution theorem ? 11

4. (a) State and explain Parseval's theorem for energy signals. 8

   (b) Explain (i) partition noise, and (ii) transit-time noise. 2 x 3

   (c) A receiver is connected to an antenna whose resistance is $50\,\Omega$ and the equivalent noise resistance is $30\,\Omega$. Determine receiver's noise figure and its equivalent noise temperature. 6

Group B

5. Write notes on the following : 5 x 4

   (i) TDM

   (ii) AM - SSB and its demodulation

   (iii) Channel coding

   (iv) Applications of matched filter.

W' 08 :4 FN : EC 403 (1479)   (2)   (*Continued*)

6. (a) Describe the principle of synchronous detection method for DSB - SC signals. 8

   (b) What is PAM ? Explain delta modulation. 6

   (c) Describe one method of generating FM signal. 6

7. (a) Define entropy of a source. What are the properties of entropy ? Define average mutual information over a joint ensemble and explain with an example. 12

   (b) State Shannon's channel coding theorem and explain the concept of 'channel capacity'. 8

8. (a) What is PCM ? Explain the working principle of PCM generator. 8

   (b) What are the characteristics of speech signals ? Explain the principle of LPC for speech signals. 8

   (c) Explain how ISI can be minimized using the theory of filters. 4

Group C

9. Write the *correct* answer for the following : 2 x 10

   (i) The mathematical form of Gauss's law is

   (a) $\int \vec{D} \times d\vec{a} = \int \varrho\, dV$

   (b) $\int D\, dV = \int \varrho\, da$

   (c) $\int \vec{D} \cdot d\vec{a} = \int \varrho\, dV$

   (d) $\int \vec{D} \times d\vec{V} = \int \varrho\, dV$.

(ii) The equation of continuity is

(a) $\vec{\nabla} \times \vec{J} = \dot{\varrho}$

(b) $\vec{\nabla} J = -\dot{\varrho}$

(c) $\vec{\nabla} \times \vec{J} = -\dot{\varrho}$

(d) $\vec{\nabla} \cdot \vec{J} = -\dot{\varrho}$.

(iii) Static electric fields are irrotational, which can be expressed as

(a) $\vec{\nabla} \times \vec{D} = -\vec{B}$

(b) $\vec{\nabla} \times \vec{E} = 0$

(c) $\vec{\nabla} \cdot \vec{D} = \varrho$

(d) $\vec{E} \times \vec{H} = 0$.

(iv) Power spectral density (S) varies with frequency (f) for flicker noise as

(a) $S \propto 1/f$

(b) $S \propto f$

(c) $S \propto f^2$

(d) $S \propto 1/\sqrt{f}$.

(v) Armstrong method is used for

(a) PCM generation

(b) shot noise minimization

(c) noise-temperature minimization

(d) FM generation.

(vi) Forward error correction codes rely on the controlled use of

(a) bit error rate of signal

(b) redundancy in the transmitted code word

(c) automatic repeat request

(d) digital modulation.

(vii) LPC is

(a) frequency domain coding

(b) time domain coding

(c) space-time coding

(d) time-frequency coding.

(viii) GSM mobile communication uses

(a) FDMA frame

(b) TDMA frame

(c) FDMA-TDMA frame

(d) CDMA frame.

W'08 :4FN :EC403 (1479)   (5)   (Turn O\

(*ix*) Markov source of information is

    (*a*) source with memory

    (*b*) memoryless source

    (*c*) noiseless source

    (*d*) discrete memoryless source.

(*x*) Orthonormal basis functions for representing time-limited energy signals are obtained by

    (*a*) Gaussian signal representation

    (*b*) Gram Schmidt procedure

    (*c*) Ergodic signal representation

    (*d*) Non-coherent signal representation.

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COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,**
ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

*All parts of a question (a,b,etc.) should
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proper justification.*

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Derive the continuity equation.   6

    (*b*) Derive the boundary conditions for conductor-free
    space boundary in electrostatics.   8

    (*c*) Calculate the capacitance of a parallel plate
    capacitor having a mica dielectric with $\epsilon_r = 6$, a plate
    area of 10 in^2 and a separation of 0·01 m.   6

2. (*a*) Derive Poisson's equation.   8

(*Turn Over*)

(b) Derive the following by using Poisson's equation :
4×3

(i) Cartesian co-ordinates for Laplace equation

(ii) Cylindrical co-ordinates for Laplace equation

(iii) Spherical co-ordinates for Laplace equation.

3. (a) Derive Parseval's theorem related to the average power, P, of a periodic signal.   6

(b) What are the types of double side band amplitude modulation ? Explain with examples.   6

(c) Show that the minor theoretical differences between AM and DSB have major repercussions in practical applications.   8

4. (a) Find the power spectrum for randomly phased sinusoidal wave and a random digital wave.   6

(b) Find the noise equivalent bandwidth of a band-pass filter (BPF).   8

(c) Explain a PCM generation scheme with the aid of a neat sketch.   6

Group B

5. (a) Explain the following with their properties :
(i) uncertainty, (ii) information, and (iii) entropy. 4×3

(b) Find the equation for coding efficiency by using source coding theorem.   8

6. Find and sketch the power spectra of the following discrete PAM signals : 5×4

(i) NRZ unipolar format

(ii) NRZ polar format

(iii) NRZ bipolar format

(iv) Manchester format.

7. (a) Briefly explain the eye pattern.   6

(b) Briefly explain quadriphase-shift keying modulation.   6

(c) Explain the principle of DPCM (differential PCM), giving its elementary block diagram.   8

8. (a) Derive the Gaussian channel capacity.   10

(b) How can a tapped-delay-line filter be used as a prediction filter ? Explain with an example.   10

Group C

9. Choose the correct answer for the following : 2×10

(i) The unit of $\overline{V} \times \overline{H}$ is

(a) A

(b) A/m

(c) A/m^2

(d) A - m.

(ii) The depth of penetration of an electromagnetic wave in a medium, having a conductivity σ at a frequency of 1 MHz, is 25 cm. What will be the depth of penetration at a frequency of 4 MHz ?

(a) 6·25 cm

(b) 50·00 cm

(c) 12·50 cm

(d) 100·00 cm.

(iii) If the input is a DSB-SC signal plus noise, what will be output noise at the detector ?

    (a) The in-phase component

    (b) Reduced damping

    (c) Zero

    (d) The envelope.

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

    (a) raised-cosine

    (b) flat (constant)

    (c) parabolic

    (d) Gaussian.

(v) An ideal sawtooth voltage waveform, having a frequency of 500 Hz and an amplitude of 3V, is generated by changing a capacitor of 2 μF in every cycle. The charging requires

    (a) constant voltage source of 3V for 1 ms

    (b) constant voltage source of 3V for 2 ms

    (c) constant current source of 3 μA for 1 ms

    (d) constant current source of 3 mA for 2 ms.

(vi) In a delta modulation system, the granular (idling) noise occurs when the

    (a) modulation signal increases rapidly

    (b) pulse rate decreases

    (c) modulating signal remains constant

    (d) pulse amplitude decreases.

(vii) A rectangular pulse has an amplitude A and duration T. Its energy density spectrum $G(f)$ is

    (a) $AT(\sin \pi ft / \pi ft)$

    (b) $(AT)^2(\sin \pi ft / \pi ft)$

    (c) $AT^2(\sin \pi ft / \pi ft)$

    (d) $A^2(\sin \pi ft / \pi ft)$.

(viii) The impulse response of a system is $h(t)$. What will be the output, $y(t)$, when its input is $x(t)$?

    (a) $h(t) * x(t)$

    (b) $h(t) \otimes x(t)$

    (c) $|H(t)| . x(t)$

    (d) $h(t)$.

(ix) The signal-to-quantization noise ratio in a PCM system depends on

    (a) sampling rate

    (b) number of quantization levels

    (c) message signal bandwidth

    (d) None of the above.

(x) The Fourier transform of a Gaussian time pulse is

    (a) uniform

    (b) pair of impulses

    (c) Gaussian

    (d) Rayleigh.

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

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ANY TWO *from* **Group B** *and* ALL *from* **Group C** .

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proper justification.*

Figures on the right-hand side margin indicate full marks .

Group A

1. (a) State and explain Helmholtz theorem. For any vector
field F, prove the following identity :

$$\nabla^2 F = \nabla \ (\nabla \cdot F) - \nabla \times \nabla \times F.$$ 4 + 6

(b) State and explain the Biot-Savart law for the magnetic
flux density.   4

(c) Given $\varrho_v (r, \phi, z) = 0$ for $0 < r < a$
$= \varrho_0 \, r$ for $a \leqslant r \leqslant b$
$= 0$ for $b \leqslant r \leqslant \infty$.
Find the electric field intensity at all points using Gauss
law in integral form.   6

2. (a) State the point form and integral form of Poynting theorem. Explain the use of this theorem for power flow of electromagnetic waves.   5 + 5

(b) A pulse of amplitude A extends from $t = -T/2$ to $t = +T/2$. Find its energy density spectrum.   10

3. (a) Define autocorrelation $R(\tau)$ of a periodic signal with period between $-T/2$ to $+T/2$. Prove that (i) autocorrelation function exhibits conjugate symmetry, and (ii) maximum value of $R(\tau)$ occurs at origin.   2 + 4 + 4

(b) Define shot noise, transit-fine noise, flicker noise, thermal noise and noise figure. Explain an experimental method for the determination of the noise figure of a radio receiver.   5 + 5

4. (a) What is pre-emphasis? Why is it used? Sketch a typical pre-emphasis circuit and explain why de-emphasis must also be used.   2 + 2 + 2 + 2

(b) Discuss automatic frequency control and metering in communication receivers.   2 + 2

(c) Explain why quantizing noise could affect small amplitude signals in a PCM system for more than large signals. Show how tapered quantizing levels could be used to counteract this effect.   4 + 4

Group B

5. (a) If a Gaussian process, $X(t)$, is applied to a stable linear filter, show that the random process $r(t)$ developed at the output of the filter is also Gaussian.   8

(b) A low pass (within 4000 Hz) signal of strength 0·001 W passes through a distorting channel defined as

$$H(f) = \frac{4000}{j\,4000 + f}$$

and is also corrupted with a additive white Gaussian noise of magnitude 10^{-8} W/Hz. At the receiver side, there is an equalizer which exactly matches the channel within frequency of interest (up to 4000 Hz) and zero elsewhere. Find SNR at the output of the equalizer.   12

6. (a) Define rate of information, joint entropy, conditional entropy, mutual information, and redundancy.   5 x 2

(b) Calculate the bandwidth of the picture (video) signal in a television. The following are the available data :   10
Number of distinguishable brightness levels = 10
Number of elements per picture frame = 3,00,000
Picture frame transmitted per second = 30
S/N required = 30 dB.

7. (a) Describe delta modulation systems. What are its limitations? How can they be overcome?   4 + 2 + 2

(b) What are optimum and matched filters? Find their transfer functions.   4 + 2

(c) The discrete samples of an analog signal is to be uniformly quantized for PCM system. If the maximum value of the analog sample is to be represented within 0·1 % accuracy, find the minimum number of binary digits required.   6

8. Write short notes on the following :   5 x 4

(i) Asynchronous time division multiplexing of PCM signals

(ii) Differential phase shift keying

(iii) Shannon-Hartley theorem

(iv) Linear predictive coder.

Group C

9. Choose the *correct* answer for the following :   2 x 10

(i) Identify the incorrect relation :

(a) $\nabla \times (\bar{A} + \bar{B}) = (\nabla \times \bar{A}) + (\nabla \times \bar{B})$

(b) $\nabla \times (\bar{A} \times \bar{B}) = \bar{B}(\nabla \times \bar{A}) + \bar{A}(\nabla \times \bar{B})$

(c) $\nabla \cdot (\nabla \times \bar{F}) = 0$

(d) $\nabla \times \nabla \bar{F} = 0$.

(ii) Identify the Ampere's law :

(a) $\oint_c E \cdot dl = - \dfrac{d}{dt} \int B \cdot ds$

(b) $\oint_s D \cdot ds = \int_u Pdv$

(c) $\oint_s B \, ds = 0$

(d) $\oint_c H \cdot dl = \int_s Jds + \dfrac{d}{dt} + \int_s D \cdot ds$

(iii) A signal $f(t) = \cos 10\pi t + 2 \cos 5\pi t$ is instantaneously sampled. The maximum allowable value of the sampling interval is

(a) $1/5$ sec

(b) $1/10$ sec

(c) $1/5\pi$

(d) $1/10\pi$.

(iv) Thermal noise is independent of

(a) bandwidth

(b) temperature

(c) centre frequency

(d) Boltzmann's constant.

(v) Image channel rejection in superhetrodyne receiver comes from

(a) IF stage only

(b) RF stage only

(c) Detection and RF stage only

(d) Detection, RF and IF stages.

(vi) A PAM signal can be detected using

(a) a band pass filter

(b) a high pass filter

(c) a differentiator

(d) an integrator.

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(*vii*) Companding is used in PCM to

   (*a*) reduce bandwidth
   (*b*) reduce power
   (*c*) increase S/N ratio
   (*d*) get almost uniform S/N ratio.

(*viii*) Which one of the following gives maximum probability of error ?

   (*a*) ASK
   (*b*) FSK
   (*c*) PSK
   (*d*) DPSK.

(*ix*) Which one of the following is incorrect ?

   (*a*) $H(y/x) = H(x, y) - H(x)$
   (*b*) $H(x, y) = H(x/y) + H(y)$
   (*c*) $I(x, y) = H(x) - H(y/x)$
   (*d*) $I(x, y) = H(y) - H(y/x)$.

(*x*) Distortion, caused by intersymbol interference, can be reduced using

   (*a*) proper equalizer
   (*b*) companding
   (*c*) pulse stuffing
   (*d*) Manchester code.

S'10 : 4 FN : EC 403 (1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**,
ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

All parts of a question (*a, b, etc.*) *should
be answered at one place.*

*Answer should be brief and to-the-point and be supplemented
with neat sketches. Unnecessary long answers may
result in loss of marks.*

*Any missing or wrong data may be assumed suitably giving
proper justification.*

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Show that div curl $A = 0$.   4

   (*b*) Derive the vector statement of Gauss's law.   6

   (*c*) Determine three components of electric field in
      spherical co-ordinates due to an electric dipole.   6

   (*d*) Explain that the 'Ampere's law is not consistent with
      the time varying equation of continuity'.   4

2. (a) What is convection current? Does it obey Ohm's law?   3

(b) Using Maxwell's equations, show that at the surface of a perfect conductor, the tangential component of H is discontinuous by an amount equal to the surface current per unit width.   7

(c) If $f(t)$ is an even function, show that all the sine terms in the trigonometric Fourier series for $f(t)$ vanish.   4

(d) State and prove Parseval's theorem.   6

3. (a) State and prove Schwarz inequality for a pair of real finite energy signals $g_1(t)$ and $g_2(t)$.   5

(b) Show that the random process
$$x(t) = A \cos(\omega t + \theta),$$
where θ is a random variable uniformly distributed in the range $(0, 2\pi)$, is a wide sense stationary process.   5

(c) What is an ergodic process?   3

(d) Calculate the RMS value of the thermal noise voltage across a parallel combination of a resistor R and a capacitor C.   7

4. (a) A receiver, connected to an antenna of resistance 50 ohms, has an equivalent noise resistance of 30 ohms. Find the receiver noise figure in dB.   4

(b) Describe the Armstrong method of producing frequency modulation and state its advantages and disadvantages.   6

(c) A sinusoidal signal of 1 V amplitude and 800 Hz frequency is transmitted by delta modulation. Determine the minimum step size so that overload distortion is avoided. The sampling rate is given to be 40,000 samples/sec.   5

(d) How is the cross-talk in FDM (frequency division multiplexing) reduced?   5

Group B

5. (a) Sketch the magnitude and phase characteristics of a channel for distortionless transmission.   3

(b) Show that an ideal low-pass filter is not physically realisable.   6

(c) Find the power spectral density (PSD) and the power of $g(t) = A \cos(\omega t + \theta)$.   6

(d) Show that modulation causes a shift of the ESD (energy spectral density) of baseband signals.   5

6. (a) Explain how SNR can be maximised using a Wiener-Hopf filter.   6

(b) For a baseband binary digital signal $m(t)$, show that phase modulation is superior to frequency modulation from both bandwidth and power point of view.   6

(c) What is a matched filter? Derive its impulse response in terms of signal components.   3

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(d) The signal-to-noise quantisation ratio of a binary PCM system is required to be at least 1000. Determine the minimum number of bits to represent the quantising level.   5

7. (a) A message source produces five symbols with the probabilities of occurrence as 1/2, 1/6, 1/6, 1/12, and 1/12. Calculate the entropy of the source.   6

(b) A source emits seven symbols with probabilities 1/2, 1/4, 1/8, 1/16, 1/32, 1/64 and 1/64, respectively. Determine a Huffman code for it.   6

(c) Show that the channel capacity of a channel, disturbed by Gaussian white noise, is given by

$$C = B\log_2(1 + S/N) \text{ bits/sec.}$$ 6

(d) What is a binary symmetric channel?   2

8. (a) How are the limits of delta modulation overcome in adaptive delta modulation?   5

(b) Explain FSK and PSK systems of digital modulation with the help of a suitable diagram.   8

(c) What is a modem? Why is it needed at each end of a telephone line for data transmission?   2

(d) Describe necessity of a line code. What is the difference between Manchester code and AMI?   5

Group C

9. Choose the *correct* answer for the following: 2×10

(i) The Fourier transform of $u(t)$ is
(a) 1
(b) $2\pi\delta(\omega)$
(c) $\pi\delta(\omega) + 1/j\omega$
(d) $1/j\omega$.

(ii) div grad V is equal to
(a) zero
(b) infinity
(c) ∇V
(d) $\nabla^2 V$.

(iii) A vector makes angles α, β and γ with the co-ordinate axes. The direction cosines of the vector are
(a) $\cos\alpha, \cos\beta, \cos\gamma$
(b) $\sin\alpha, \sin\beta, \sin\gamma$
(c) $\tan\alpha, \tan\beta, \tan\gamma$
(d) $\sec\alpha, \sec\beta, \sec\gamma$.

(iv) For a uniform plane wave, the electric field is
(a) a function of t only
(b) function of x and t only
(c) function of x, y and t only
(d) function of x, y, z and t only.

(v) Microwave links are generally preferred to coaxial cable for TV transmission because
(a) they have less overall phase distortion
(b) they are cheaper
(c) of their greater bandwidth
(d) of their relative immunity to impulse noise.

(*vi*) The RMS value of the antenna current before modulation is 5 A and it increases to 5·8 A after amplitude modulation. The percentage of modulation index is

(*a*) 88 %

(*b*) 80 %

(*c*) 83·14 %

(*d*) 81·21 %.

(*vii*) In FM demodulation, Foster–Seely discriminator uses a

(*a*) single tuned circuit

(*b*) double tuned circuit in which both the primary and secondary are tuned to different frequencies

(*c*) double tuned circuit in which both the primary and secondary are tuned to the same frequency

(*d*) combination of two transistors in push–pull configuration.

(*viii*) If x and y are independent Gaussian random variables, each with average value zero and with same variance, their joint probability density function is given by

(*a*) $p(x, y) = p(x) \cdot p(y)$

(*b*) $p(x, y) = p(x) + p(y)$

(*c*) $p(x, y) = p(x + y)$

(*d*) $p(x, y) = p(x) \cdot p(y) + p(x)$

(*ix*) Fidelity in a communication receiver is provided by

(*a*) audio stage

(*b*) mixer stage

(*c*) detector stage

(*d*) combination of audio and detector stages.

(*x*) In information theory, the entropy is

(*a*) average mutual information

(*b*) average self–information

(*c*) average noise level

(*d*) average power of interference.

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W'10 : 4 FN : EC 403 (1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**,
ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

*All parts of a question (a, b, etc.) should
be answered at one place.*

*Answer should be brief and to-the-point and be supplemented
with neat sketches. Unnecessary long answers may
result in loss of marks.*

*Any missing or wrong data may be assumed suitably giving
proper justification.*

Figures on the right-hand side margin indicate full marks .

Group A

1. (*a*) Find the Laplacian of $W = 10\ r\sin^2\theta\cos\phi$ in spherical
co-ordinate system.   6

    (*b*) State and explain Gauss's divergence theorem.   6

    (*c*) A parallel plate capacitor, with plate area of
$5\ cm^2$ and plate separation of 3 mm, has a voltage of
$50\ \sin 10^3\ t$ is applied to its plates. Calculate the
displacement current assuming $\epsilon = 2\,\epsilon_0$.   8

2. (a) Find the Fourier transform of the signal

$$x(t) = e^{-at} u(t)$$

where $u(t)$ is unit step function using this relationship. Determine the Fourier transform of the signal $y(t) = e^{-a|t|}$.   4 + 4

(b) Explain Gram Schmidt procedure for orthogonal representation of signals.   6

(c) A voltage, $V(t)$, which is a Gaussian ergodic random process with a mean zero and a variance of 9 volt^2 is measured by (i) d.c. motor, (ii) a true rms meter, and (iii) a meter which first square, $V(t)$, and then reads its d.c. component. Find the output in each meter.   6

3. (a) Determine the frequencies present in upper and lower sidebands of AM–SSB spectrum if the modulating signal is $m(t) = \cos 2\pi \cdot 1000\, t + \cos 2\pi \cdot 2000\, t$ and the carrier is $c(t) = \cos 2\pi \cdot 10000\, t$.   8

(b) Explain, with a circuit diagram, FM generation using Armstrong's method.   6

(c) Explain why quantizing noise could affect small amplitude signals in a PCM system for more than large signals. What is companding? Why is it used?   2 + 2 + 2

4. (a) Derive Ampere's circuit law using the concept of magnetic vector potential.   6

(b) A receiver has an overall gain A, an output resistance R_L, a bandwidth δf and an absolute operating temperature T. If the receiver's input resistance is equal to the antenna resistance R_a, derive a formula for the noise figure of the receiver. One of the terms of this formula will be the noise output power.   8

(c) Explain the principle of time-division multiplexing with a sketch to show how interleaving of channels takes place.   6

Group B

5. (a) Consider a sinusoidal signal with random phase

$$X(t) = A \cos (2\pi f_c t + \Theta)$$

where A and f_c are constants, and Θ, a random variable that is uniformly distributed over the interval $(-\pi, \pi)$, i.e.,

$$f_\Theta(\theta) = \begin{cases} 1/2\pi, & -\pi \le \theta \le \pi \\ 0, & \text{elsewhere.} \end{cases}$$

Determine its autocorrelation function and power spectral density.   10

(b) Deduce an expression for the output signal–to–noise ratio in PCM including both quantization and thermal noise.   10

6. (a) Define channel capacity. Draw the transition probability diagram of a binary symmetric channel and derive an expression for its capacity in terms of probability.   2 + 2 + 4

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(b) Prove that

$$I(X, Y) = H(X) + H(Y) - H(X, Y)$$

where the symbols have their usual meanings.　　6

(c) A Gaussian channel has 1 MHz bandwidth. Calculate the channel capacity if the signal power to noise spectral density ratio (S/n) is 10^5 Hz. Also, find the maximum information rate.　　3 + 3

7. (a) Draw the block diagram of a QPSK transmitter. Explain its working using waveform diagrams for a suitable sequence.　　4 + 4

(b) Explain the principle of differential PCM. Explain the need of a predictor in such systems. Discuss the design of a linear predictor for DPCM.　　4 + 4 + 4

8. Write short notes on the following :　　4 x 5

(i) Balanced modulator

(ii) Shannon's theorem for the rate of information transmission over a communication channel

(iii) Matched filter

(iv) Adaptive delta modulation.

Group C

9. Choose the correct answer for the following :　　10 x 2

(i) In cylindrical co-ordinates, the equation

$$\frac{\partial^2 \psi}{\partial \varrho^2} + \frac{1}{\varrho} \frac{\partial \psi}{\partial \varrho} + \frac{\partial^2 \psi}{\partial z^2} + 10 = 0$$

is called

(a) Lorentz's equation.

(b) Laplace's equation.

(c) Poisson's equation.

(d) Helmholtz equation.

(ii) Which one of the following is not Maxwell's equation for a static electromagnetic field in a linear homogeneous medium

(a) $\oint B \cdot dl = \mu_0 I$

(b) $\nabla \times D = 0$

(c) $\oint D \cdot dS = Q$

(d) $\nabla^2 A = \mu_0 J$

(iii) The distribution function, $F(x)$, of a random variable is $F(x) = P(X \leq x) = P(-\infty < X \leq x)$ and is given by

$$F(x) = \begin{cases} 0, & x < 0 \\ x^3/27, & 0 \leq x < 3 \\ 1, & x \geq 3 \end{cases}$$

The probability $P(1 < x \leq 2)$ is given by

(a) 1/27

(b) 7/27

(c) 1/3

(d) 1

(iv) Identify the false statement from the following :

(a) Transit-time noise is high frequency noise.

(b) Flicker noise is not serious above 500 Hz.

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(c) Shot noise is due to thermal agitations in resistors.

(d) Space noise is observable at frequencies in the range from about 8 MHz to above 1·43 GHz.

(v) When the modulating frequency is doubled, the modulation index is halved and the modulating voltage remains constant. The modulation is

(a) FM

(b) PM

(c) AM

(d) DM

(vi) Which one of the following is not a pulse modulation method ?

(a) ADM

(b) TDM

(c) PPM

(d) DPCM

(vii) A linear system, having impulse response $h(t)$ and input $x(t)$, the integral

$$\int_{-\infty}^{\infty} x(t)\, h(t-\tau)\, d\tau$$

is known as

(a) convolution integral.

(b) auto-correlation of $x(t)$.

(c) cross-correlation of input and output.

(d) None of the above.

(viii) Which one of the following is not the unit of information ?

(a) bit

(b) digit

(c) nat

(d) Hz

(ix) The input to a matched filter is given by

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

The peak amplitude of the filter output is

(a) 10 V

(b) 5 V

(c) 10 mV

(d) 5 mV

(x) The number of bits per sample in a PCM is increased from 8 to 16. The bandwidth of the system will increase

(a) 8 times.

(b) 2 times.

(c) half times.

(d) 2^8 times.

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S'11 : 4 FN : EC 403 (1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**,
ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

*All parts of a question (a, b, etc.) should
be answered at one place.*

*Answer should be brief and to-the-point and be supplemented
with neat sketches. Unnecessary long answers may
result in loss of marks.*

*Any missing or wrong data may be assumed suitably giving
proper justification.*

Figures on the right-hand side margin indicate full marks .

Group A

1. (*a*) State and prove Gauss's law..   6

(*b*) With Maxwell's curl equations, explain their physical interpretations. What is displacement current ?   5

(*c*) Given the potential field $V = 2x^2 y - 5z$ and a point $P(-4, 3, 6)$. At the point P, find out potential V, electric field intensity E, flux density D, and volume change density ϱ in free space.   6

(*d*) What is Biot-Savart law ?   3

2. (a) Obtain the Fourier transform of the Gaussian pulse

   $x(t) = e^{-\pi t^2}$.   10

   (b) State and prove Parseval's theorem for energy signals.   5

   (c) Describe Gram Schmidt procedure for orthogonalised signal representation.   5

3. (a) What is thermal noise? Derive expressions for thermal noise using power spectrum density.   8

   (b) Describe in brief the experimental determination of noise figure.   6

   (c) Show that the power of a single–tone AM signal is

   $$P_t = P_e (1 + m^2/2)$$

   where P_e is the mean square carrier power and m, the percentage modulation.   6

4. (a) What are AM-DSB/SC and AM-SSB? How can AM-SSS signal be generated using phase shifter?   7

   (b) What is QAM for analog signals?   3

   (c) State Carson's rule for FM bandwidth and justify it with proper reasoning.   2

   (d) Explain the working principle of Foster-Seeley detector for FM demodulation.   8

Group B

5. (a) Define entropy of a source. What is conditional entropy?   4

   (b) A binary source emits an independent sequence of '0s' and '1s' with probabilities p and $1-p$, respectively. Evaluate the variation of entropy at $p = 0, 0.5$ and 1.   6

   (c) What is parity check matrix? How parity check matrix for cyclic codes help in channel coding?   8

   (d) What is a prefix condition code?   2

6. (a) What are auto-correlation and cross-correlation functions? Show that auto-correlation function at origin is equal to the average power of the signal.   6

   (b) Draw the block diagram of a PCM transmitted. Explain the working principle of linear quantizer.   4

   (c) Obtain the expressions for mean square value of error introduced by linear quantization process in a PCM system.   10

7. (a) What is vocoder? Explain the principle of LPC for speech signals.   4

   (b) What is TDM? Obtain an expression for TDM guard time.   4

   (c) What is matched filter? Derive the impulse response for a matched filter.   6

   (d) Obtain the expression for signal-to-noise ratio for a matched filter.   6

8. Write short notes on the following: 4 x 5

   (i) Binary erase channel

(*ii*) Shot noise

(*iii*) Delta modulation

(*iv*) Laplace equation and its application.

Group C

9. Choose the *correct* answer for the following :   10 x 2

(*i*) Maximum frequency present in a signal is 2·5 kHz. Then Nyquist rate is

(*a*) 10 kHz

(*b*) 1·5 kHz

(*c*) 2·5 kHz

(*d*) 5 kHz

(*ii*) Actual number of information blocks present in a (7, 5) block code is

(*a*) 2^5

(*b*) 2^7

(*c*) 2^2

(*d*) 2^{12}

(*iii*) The existence of vector magnetic potential is possible because

(*a*) $\vec{\nabla} \cdot \vec{D} = \varrho$

(*b*) $\vec{\nabla} \cdot \vec{B} = 0$

(*c*) $\vec{\nabla} \cdot \vec{J} = -\partial p / \partial t$

(*d*) $\vec{\nabla} \times \vec{H} = \vec{J}$

(*iv*) The power spectral density increases as frequency decreases for

(*a*) shot noise.

(*b*) thermal noise.

(*c*) flicker noise.

(*d*) Partition noise.

(*v*) Kraft inequality is satisfied by

(*a*) block code.

(*b*) prefix code.

(*c*) Hadamard code.

(*d*) Hamming code.

(*vi*) FM signal can be converted into AM signal using

(*a*) frequency discriminator.

(*b*) AFC.

(*c*) slope detector.

(*d*) squaring circuit.

(*vii*) The position of a pulse is varied in accordance with the message signal in

(*a*) PDM

(*b*) PTM

(*c*) PPM

(*d*) PAM

(*viii*) A linear time invariant system is characterized by time invariant output of

(*a*) IFT.

(*b*) convolution.

(*c*) FFT.

(*d*) time scaling.

S'11 : 4 FN : EC 403 (1479)   (4)   (*Continued*)

S'11 : 4 FN : EC 403 (1479)   (5)   (*Turn Over*)

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(*ix*) The d.c. component in a digital data is transformed
to higher frequency location using

(*a*) dedicated line.

(*b*) digital multiplexer.

(*c*) line coder.

(*d*) T –line.

(*x*) VSB modulation, as compared to SSB modulation,
for band occupies

(*a*) more bandwidth.

(*b*) less bandwidth.

(*c*) same bandwidth.

(*d*) signal–dependent bandwidth.

W'11 : 4FN : EC403(1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,**
ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

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be answered at one place.*

*Answer should be brief and to-the-point and be supplemented
with neat sketches. Unnecessary long answers may
result in loss of marks.*

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proper justification.*

Figures on the right-hand side margin indicate full marks.

Group A

1.   (*a*) Show that $\nabla \cdot (\nabla \times A) = 0$.   4

     (*b*) Show that the electric flux through any closed surface surrounding charges is equal to the amount of charge enclosed.   5

     (*c*) Consider a toroidal coil consisting of a large number of closely spaced turns on a tubular core. If 'N' is the number of turns ; 'L', the length of the coil ; and 'I', the current in the coil, derive an expression for the magnetic field strength at any point within the core using Ampere's circuital law.   6

     (*d*) Show that at any surface of discontinuity, the tangential component of 'E' is continuous at the surface.   5

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2. (a) For a unit step function, $u(t)$, find the Fourier transform and compare with its Laplace transform.   4

(b) State and prove sampling theorem for baseband signals.   6

(c) Show that the auto-correlation function is related to power spectral density of a random signal.   5

(d) Show that an ergodic process is always stationary. Give an example of a stationary random process that is not ergodic.   5

3. (a) List various sources of random noise, impulse noise and external noise. How can they be avoided or minimized?   5

(b) Derive an expression for the overall noise figure of two cascaded networks having power gains G_1 and G_2 and noise figures F_1 and F_2, respectively.   5

(c) The equivalent noise temperature of a cooled parametric amplifier is 20°K. Room temperature is 290°K. Find the noise factor.   4

(d) Derive an expression for the mean square thermal noise voltage of a resistor at temperature T for a given bandwidth.   6

4. (a) Show, giving a mathematical proof, how a square law device can be used to generate an AM signal.   5

(b) What is the frequency deviation of a narrowband FM transmitter when its modulation index is 5 in a practical bandwidth of 160 kHz?   5

(c) What is cross-talk in FDM? How is it minimized?   5

(d) A simple diode detector has a load of 500 kΩ in parallel with a capacitance of 100 pF. If the maximum modulation depth of the input signal is 80 percent, find the highest modulation frequency that can be detected.   5

W'11:4FN: EC403 (1479)   (2)   (*Continued*)

Group B

5. (a) Show that in order to achieve distortionless transmission through a system, the transfer function of the system must be of the from   4

$$H(w) = Ae^{jwt_0}$$

(b) Using Paley-Wiener criterion, show that an ideal bandpass filter is not physically realisable.   6

(c) Show that if a narrow band Gaussian noise with mean value σ^2 is applied to a linear envelope detector, the output signal has a Rayleigh density function.   7

(d) Derive an expression for the equivalent noise bandwidth of a network.   3

6. (a) Show that the entropy of a source is maximum when all the symbols are equi-probable.   5

(b) State Shannon-Hartley law and show that bandwidth trades off with signal-to-noise ratio and *vice-versa*.   5

(c) In a picture transmission, there are about 3×10^5 picture elements and eight equiprobable distinguishable levels. Calculate the average information in the picture.   5

(d) Calculate the capacity of a 8 kHz telephone channel having a 32 dB signal-to-noise ratio.   5

7. (a) Using neat sketches, explain how a PWM signal can be converted into a PPM signal.   5

(b) Compare the SNR characteristics of PAM and PDM.   5

(c) With the help of a block diagram, explain the working of a PCM system.   5

(d) The number of quantisation levels in a certain binary PCM system is 64. Determine the signal-to-noise ratio for a voltage range ± 10 V.   5

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8. (a) Draw and explain the block diagram of adaptive delta modulation system.   5

(b) Explain, with suitable examples, working and design of a matched filter used in communication systems.   8

(c) What are the advantages of PSK over FSK ?   3

(d) A speech signal is transmitted using delta modulaton. The pulse repetition frequency is 56 Kbps and the step size is 100 mV. Determine the permissible amplitude of the speech signal that can be transmitted by the DM system avoiding overload distortion.   4

Group C

9. Choose the *correct* answer for the following :   10 × 2

(i)   In electromagnetic waves, polarisation

(a) is caused by reflection.

(b) is due to the transverse nature of the waves.

(c) results from the longitudinal nature of waves.

(d) is always vertical in an isotropic medium.

(ii)   An electromagnetic wave is reflected by the ionosphere due to its interaction with

(a) electrons.

(b) protons.

(c) water vapour.

(d) ultraviolet rays.

(iii)   The spectral density of white noise

(a) varies with frequencies.

(b) is constant.

(c) varies with bandwidth.

(d) is infinite.

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

(a) unchanged.

(b) halved.

(c) doubled.

(d) increased by 50 percent.

(v)   In an SSB transmitter, one is most likely to find a

(a) class C audio amplifier.

(b) tuned modulator.

(c) class B RF amplifier.

(d) class A RF output amplifier.

(vi)   Quadrature multiplexing is a form of

(a) TDM

(b) FDM

(c) combined TDM and FDM

(d) None of the above.

(vii)   Redundancy in information theory is given by

(a) $E = H(y/x)/H(x)$

(b) $E = 1 + H(y/x)/H(x)$

(c) $E = 1 - H(y/x)/H(x)$

(d) $E = H(x)/H(y/x)$

(viii) A pulse communication system that is inherently highly immune to noise is

(a) PAM

(b) PWM

(c) PPM

(d) PCM

(*ix*) A PWM signal can be generated by

    (*a*) a monostable multivibrator.

    (*b*) an astable multivibrator.

    (*c*) integrating the PPM signal.

    (*d*) differentiating the PPM signal.

(*x*) In a DM system, the granular (idling) noise occurs when the modulating signal

    (*a*) increases rapidly.

    (*b*) remains constant.

    (*c*) decreases rapidly.

    (*d*) ceases to exist.

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S'12:4FN:EC 403 (1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**, ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

All parts of a question (a,b,etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

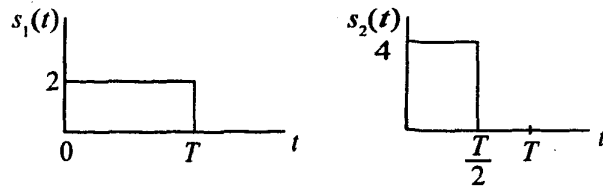*Figures on the right-hand side margin indicate full marks.*

Group A

1.   (*a*) State and prove stoke's theorem.   6

     (*b*) A square loop of *N* turns and size length, *a*, carrying current *i* A. Show that the value of flux density at the centre is

$$\bar{B} = \mu_l N_2 \sqrt{2} / \pi a \text{ Tesla} \qquad 8$$

     (*c*) Explain Biot-Savart's law and Ampere's circuital law.   6

2.   (*a*) Define auto-correlation, convolution and power spectral density. 3×2

     (*b*) State and explain Parseval's theorem.   4

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(c) Two functions, $s_1(t)$ and $s_2(t)$, are shown below :

Here the interval of interest extends from $t = 0$ to $t = T$. Use the Gram-Schmidt procedure to express these functions in terms of orthonormal components.   10

3. (a) The parallel tuned circuit at the input of a radio receiver is tuned to resonate at 120 MHz by a capacitance of 25 pF. The Q factor of the circuit is 30. The channel bandwidth of the receiver is limited to 10 kHz by the audio sections. Calculate the effective noise voltage appearing at the input at room temperature (290°K). $k = 1.38 \times 10^{-23}$ J/K.   6

    (b) Describe a method for noise figure measurement of avalanche diode.   6

    (c) Explain a method of obtaining SSBSC signal. How will you demodulate such signals ?   4 + 4

4. (a) Define and describe pulse position modulation and explain with waveforms how it is derived from PWM.   6

    (b) Show diagrammatically, and with explanation, how channels are combined into groups and groups into supergroups and so on when FDM is generated in a system.   6

    (c) Show that PWM demodulation can be achieved by sample time averaging of PWM pulses by an averaging low-pass filter.   8

Group B

5. (a) Consider a random process

    $$X(t) = A \cos (2\pi f_c t + \Theta)$$

    where Θ is a uniformly distributed random variable over the interval $(-\pi, \pi)$. Find the power spectral density of $X(t)$.   8

    (b) Define noise equivalent bandwidth of a network. How will you determine the noise equivalent bandwidth of a low-pass filter ?   6

    (c) Explain the synchronous and asynchronous time division multiplexing of PCM signals.   6

6. (a) Define the terms 'entropy', 'rate of information', 'joint entropy', 'conditional entropy' and 'channel capacity'. 5 × 1

    (b) An event has six possible outcomes with probabilities $p_1 = 1/2$, $p_2 = 1/4$, $p_3 = 1/8$, $p_4 = 1/16$, $p_5 = 1/32$ and $p_6 = 1/32$. Find the rate of information, if there are 16 outcomes per sec.   5

    (c) State and explain Shannon-Hartley theorem.   5

    (d) For the binary symmetric channel, find the channel capacity for $p = 0.9$.   5
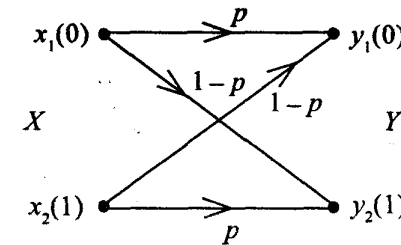
7. (a) Describe delta modulation system. What are its limitations ? How can they be overcome in adaptive delta modulation ?   6

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(b) Explain synchronous and asynchronous time division multiplexing of PCM signals. **6**

(c) Derive an expression for the signal to quantization noise ratio in DM. **8**

8. (a) What is a matched filter ? Derive an expression for its transfer function. **6**

(b) Explain the working of an integrate and dump baseband signal receiver. Derive an expression for its output signal-to-noise ratio. **8**

(c) How does the phase of carrier vary for message

$m(n) = \{1, 0, 1, 1, 0, 1, ...\}$ in DPSK ? **6**

Group C

9. Choose the *correct* answer for the following : **10 × 2**

(i) A charge is uniformly distributed throughout a sphere of radius a. Taking the potential at infinity as zero, the potential at $r = b < a$ is

(a) $-\int_{\infty}^{b} Qr / 4\pi \, \epsilon_0 \, a^3$

(b) $-\int_{-\infty}^{b} \left(Q / 4\pi \, \epsilon_0 \, r^2 \right) dr$

(c) $-\int_{-\infty}^{a} \left(Q / 4\pi \, \epsilon_0 \, r^2 \right) dr - \int_{a}^{b} \dfrac{Qr}{4\pi \, \epsilon_0 \, a^3} \, dr$

(d) $-\int_{\infty}^{a} \left(Q / 4\pi \, \epsilon_0 \, r^3 \right) dr$

(ii) An electromagnetic field is said to be non-existent if it fails to satisfy Maxwell's equation and wave equations derived from them. Which one of the following fields in free space is not Maxwellen ?

(a) $E = 100 \cos \omega t \, a_x$

(b) $D = e^{-10y} \sin (10^3 - 10y) \, a_z$

(c) $H = 10 \cos (10^5 t - z/10) \, a_x$

(d) $B = (1 - p^2) \sin \omega t \, a_z$

(iii) Identify the incorrect statement :

(a) Sine function is frequently encountered in spectral analysis.

(b) If for two signals $v_1(t)$ and $v_2(t)$ the cross-correlation $R_{12}(\gamma) = 0$, then the signals are coherent.

(c) For any arbitrary signal, $v(t)$, $v_e(t) = [v(t) + v(-t)]/2$ is an even signal.

(d) A causal signal is one for which $v(t) = 0$ for $t < 0$.

(iv) (I) Gallium arsenide FET is used for low noise MW amplification.

(II) Mean square value of shot noise is proportional to d.c. value of the current.

(III) Flicker noise is also known as $1/f$ noise.

Here (a) (I) and (II) are true

(b) only (II) is true.

(c) (I) and (III) are true.

(d) (I), (II), (III) are true.

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(v) An FM signal with modulation index, mf, is passed through frequency tripler. The wave in the output of the tripler will have a modulation index

    (a) $mf/3$

    (b) mf

    (c) $3\,mf$

    (d) $9\,mf$

(vi) If the random variables X and Y are statistically independent, then

    (I)   conditional probability density $f_Y(y/x) = f_Y(y)$.

    (II) joint probability density $f_{XY}(x, y) = f_X(x) \cdot f_Y(y)$.

    (III) joint distribution function $F_{XY}(x, y) = F_X(x) \cdot F_Y(y)$.

    Here (a) only (I) is true.

            (b) (I) and (II) are true.

            (c) (I) and (III) are true.

            (d) (II) and (III) are true.

(vii) A random process $X(t)$ has mean $E[X(t)] = $ constant and auto-correlation $E[X(t)\, X(t+Y)]$ depends only on Y. The random process is

    (a) Gaussian.

    (b) Ergodic.

    (c) in strict sense stationary.

    (d) in wide sense stationary.

($viii$) If the events $S = s_k, S = s_l$ and $S = s_i$ occur with probabilities p_k, p_l and p_i, respectively, then determine the *incorrect* statement for the information I :

    (a) $I(s_k) = 1$ for $p_k = 1$

    (b) $I(s_k) \geq 0$ for $0 \leq p_k \leq 1$

    (c) $I(s_k) > I(s_i)$ for $p_k < p_i$

    (d) $I(s_k\, s_l) = I(s_k) + I(s_l)$

(ix) Identify the *incorrect* statement :

    (a) In PCM system, a reduction in amplitude of input signal by a factor 2 reduces signal quantization noise ratio by a factor 6 dB in μ-law companding.

    (b) In DPCM coding, the variance of the signal to be encoded is reduced.

    (c) The slope overload error in DM can be reduced by increasing sampling frequency.

    (d) The step size in ADM is variable.

(x) For QPSK,

    (a) error rate is lower than 16 MPSK.

    (b) error rate is higher than QASK.

    (c) signals are in time quadrature.

    (d) more inter-symbol interference compared to MSK.

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W'12:4FN : EC403 (1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

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Group A

1. (*a*) State and explain Gauss's law. Apply Gauss's law to obtain the field of a point charge which is symmetric about a point.   10

   (*b*) Derive Poisson's equation and obtain the Laplace's equation.   4

   (*c*) Obtain capacitance between two concentric conducting spheres.   6

2. (*a*) What is Biot-Savart law ?   4

   (*b*) Write Maxwell's equations in integral form and explain their physical significance.   7

   (*c*) Define (*i*) magnetic potential and flux density; (*ii*) displacement current, (*iii*) equipotential surfaces.
   3×3

3. (a) Obtain the Fourier transform of the function x at (i) $a > 0$, (ii) $a < 0$, where

$$x(t) = 1, \text{ for } -\tau/2 < t < \tau/2$$
$$= 0, \text{ otherwise.} \qquad 6$$

(b) Explain frequency shifting properties of Fourier transform and find Fourier transform of $u(t)\, e^{jwt}$.   7

(c) What is convolution? State and explain time convolution theorem and find Fourier transform output for $\sin(t) * \cos 2\pi f_c t$.   7

4. (a) Define (i) shot noise, and (ii) flicker noise.   2 + 2

(b) For AM and FM signals, define the popular modulation parameter.   4

(c) Explain Armstrong method of FM generation.   6

(d) What is PCM? Derive an expression for uniform quantization noise variance in PCM system.   6

Group B

5. (a) What is power spectral density? What are the properties of power spectral density function?   12

(b) State and prove Parseval's theorem. Show that auto-correlation function for energy signals exhibits conjugate symmetry.   6

(c) What are orthogonal signals? Give an example of a pair of periodic signals that are orthogonal.   2

6. (a) Define (i) mutual information, (ii) joint entropy, (iii) prefix code, and (iv) Markov source.   4 × 2

(b) What is channel capacity theorem? Describe the properties of binary erase channel.   8

(c) Obtain maximum possible entropy for an 8 symbol source.   4

7. (a) What is linear-time invariant system? Give an example to explain it.   4

(b) What are DPSK and QPSK? For DPSK, find the probability of error.   8

(c) Prove that binary symbols '1' and '0' modulate the phase of the carrier in BPSK. How can BPSK signal suffer with residual AM in the modulated output?   8

8. Write notes on *any two* of the following: 2 × 10

(a) Matched filter

(b) LPC for speech signals

(c) Comparison of PCM and log-PCM

(d) TDM.

Group C

9. Choose the *correct* answer for the following: 10 × 2

(i) Charge density is a source (or sink) of electric flux lines and is expressed by the equation

(a) $\vec{\nabla} \cdot \vec{B} = 0$

(b) $\vec{\nabla} \cdot \vec{D} = \rho$

(c) $\vec{\nabla} \times \vec{E} = -\partial \vec{B}/\partial t$

(d) $\vec{\nabla} \times \vec{H} = \partial \vec{D}/\partial t$

(ii) Vector magnetic potential $\vec{A}$ is related with flux density $\vec{B}$ as

(a) $\vec{A} = \vec{\nabla} \times \vec{B}$

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(b) $\vec{B} = \vec{\nabla} \cdot \vec{A}$

(c) $\vec{A} = \vec{\nabla} \times (\vec{\nabla} \times \vec{B})$

(d) $\vec{B} = \vec{\nabla} \times \vec{A}$

(iii) Square-law detector is used for

(a) FM detection.

(b) BPSK detection.

(c) AM detection.

(d) FSK detection.

(iv) Maximum bandwidth will be required by

(a) FM

(b) QAM

(c) PAM

(d) QPSK

(v) Slope detector is a

(a) discriminator.

(b) regulator.

(c) high pass filter

(d) low pass filter.

(vi) When, in a circuit, current is divided into two or more paths, the type of noise generated is

(a) flicker noise.

(b) partition noise.

(c) transit-time noise.

(d) white noise.

(vii) For a line-code, the transmission bandwidth must be

(a) infinity.

(b) very small.

(c) zero.

(d) of some high value.

(viii) Idle noise may occur in

(a) delta modulation.

(b) phase modulation.

(c) AM.

(d) FM.

(ix) In a (5, 4) block code, number of information generated is

(a) 2

(b) 8

(c) 16

(d) 64

(x) Four equally probable symbols transmit 16 symbols/sec on an average. The average information rate is

(a) 8 b/sec

(b) 16 b/sec

(c) 4 b/sec

(d) 32 b/sec

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S'13:4FN : EC 403(1479)

COMMUNICATION ENGINEERING

Time : Three hours

Maximum Marks : 100

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Group A

1. (a) Given $\overline{H} = x^2 \hat{a}_x + y^2 \hat{a}_y$. Evaluate

$$\int \overline{H} \cdot \overline{dl},$$

where L is along the curve $y = x^2$ from $(0, 0)$ to $(1, 1)$.   6

   (b) State Helmholtz theorem and Stoke's theorem.   2 + 2

   (c) Derive Ampere's law using the concept of magnetic
vector potential.   10

2. (a) Explain the concept of displacement current. A parallel
plate capacitor with plate area 5 cm² and separation
3 mm has a voltage $50 \sin 10^3 t$ V applied to its
plates. Calculate the displacement current assuming
$\varepsilon = 2\varepsilon_0$.   4 + 6

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(b) Prove the relation

$$f(t-b) * \delta(t-c) = f(t-b-c)$$

where * signifies convolution.   5

(c) The spectral range of a function extends from 10·0 MHz to 10·2 MHz. Find the minimum sampling rate and maximum sampling time.   5

3. (a) Define strict-sense stationary, wide-sense stationary, multiple, ergodic and Gaussian random process.   5 × 1

(b) Show that $(E[XY])^2 \leq E(X^2) E(Y^2)$, where X and Y are real random variables with finite second moments.   10

(c) Describe a method for experimental determination of noise figure of an amplifier.   5

4. (a) An amplitude modulated signal has a radio frequency output of 50W at 100 % modulation. The internal loss in the modulator is 10 W. What is the unmodulated carrier power ? If the percentage modulation is reduced to 75 %, how much output is needed from the modulator ?   4 + 4

(b) Explain, with circuit diagrams, the generation of PPM signals and its demodulation.   6

(c) Explain the principle of time division multiplexing. How is this concept used for multiplexing several PAM signals in TDM-PAM systems.   6

Group B

5. (a) Show that the mean-square value of the output of a stable linear time-invariant filter in response to a wide-sense stationary process is equal to the integral over all frequencies of the power spectral density of the input random process multiplied by the required magnitude of the transfer function of the filter.   10

(b) A white Gaussian noise $\omega(t)$ of zero mean and power spectral density $N_0/2$ is applied to the following RC filter. Find the auto-correlation function of the filtered noise.   10
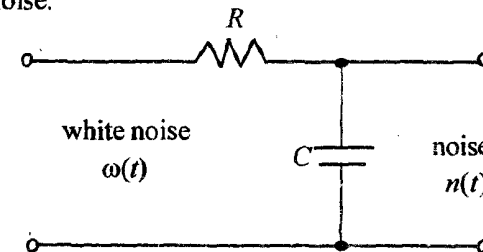
6. (a) Prove that $H(Y) + H(X/Y) = H(X) + H(Y/X)$.   6

(b) Deduce the expression

$$C = B\log_2\left(1 + \frac{12}{\lambda^2}\frac{S}{N}\right)$$

for channel capacity of a PCM equalizer.   6

(c) A transmitter has an alphabet of four letters $\{x_1, x_2, x_3, x_4\}$ and receiver has an alphabet of three letters $\{y_1, y_2, y_3\}$. The joint probability matrix is

$$P(Y/X) = \begin{array}{c} \\ x_1 \\ x_2 \\ x_3 \\ x_4 \end{array} \begin{bmatrix} y_1 & y_2 & y_3 \\ 0\cdot3 & 0\cdot05 & 0 \\ 0 & 0\cdot25 & 0 \\ 0 & 0\cdot15 & 0\cdot05 \\ 0 & 0\cdot05 & 0\cdot15 \end{bmatrix}.$$

Calculate the entropy $H(Y/X)$.   8

7. (a) Compare bandwidths of BFSK, QPSK, BPSK, M-ary FSK, MSK and MPSK.   6 × 1

(b) Explain the basic principle of differential PCM. Why do you need a predictor in DPCM system ?   8

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(c) 24 telephone channels, each band limited of 3·4 kHz, are to be time division multiplexed by using 8-bit PCM. Calculate the bandwidth required for 8 kHz sampling frequency.   6

8. Write short notes on the following :   6 + 6 + 8

   (a) Gram Schmidt procedure for orthogonal representation of signals

   (b) Ratio of SNR gains of AM-DSB, AM-DSB/SC and AM-SSB system.

   (c) Baseband transmission.

Group C

9. Choose the *correct* answer for the following :   10 × 2

   (i) Which one of the following is zero ?

   (a) grad div
   (b) div grad
   (c) curl grad
   (d) curl curl.

   (ii) Which one of the following expressions are not Maxwell's equations for time-varying fields ?

   (a) $\nabla \cdot E = -\dfrac{\partial B}{\partial t}$

   (b) $\nabla \cdot J + \dfrac{\partial P_v}{\partial t} = 0$

   (c) $\oint H \cdot dl = \int \left(\sigma E + \in \dfrac{\partial E}{\partial t} \right) \cdot ds$

   (d) $\oint B \cdot ds = 0.$

(iii) If the signal $v(t)$ and its Fourier transform $V(f)$ is represented by the notation $v(t) \leftrightarrow V(f)$, the property $V(t) \leftrightarrow v(-f)$ is known as

   (a) duality property.
   (b) inversion property.
   (c) shift property.
   (d) scaling property.

(iv) The noise generated in electronic devices from a phenomenon associated with flow of current across semiconductor junctions is known as

   (a) thermal noise.
   (b) shot noise.
   (c) partition noise.
   (d) transit time noise.

(v) Indicate which of the following pulse modulation system is analog ?

   (a) PCM
   (b) Differential PCM
   (c) Delta
   (d) PWM

(vi) In a communication system, the phase of the system is allowed to vary by 90° at the most, thus giving rise to four signals with phase angles 0°, 90°, 180° and 270°. The system is known as

   (a) FSK
   (b) PSK
   (c) QPSK
   (d) OQPSK

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(*vii*) The auto-correlation of a rectangular pulse of duration *T* is a

(*a*) triangular pulse of duration *T*.

(*b*) triangular pulse of duration 2*T*.

(*c*) rectangular pulse of duration *T*.

(*d*) rectangular pulse of duration 2*T*.

(*viii*) Channel capacity of a noise-free channel, having *M* symbols, is given by

(*a*) $\log M$

(*b*) M

(*c*) 2^M

(*d*) $M \log M$

(*ix*) In a DM system, the granular noise occurs when the modulating signal

(*a*) increases rapidly.

(*b*) decreases rapidly.

(*c*) change within the step size.

(*d*) has high frequency component.

(*x*) The input to a matched filter is given by

$$S(t) = \begin{cases} 10\sin(2\pi 10^6 t) & \text{for} \quad 0 < t < 10^{-4} \text{ sec} \\ 0 & \text{otherwise} \end{cases}$$

The peak amplitude of the filter output is

(*a*) 10 V

(*b*) 5 V

(*c*) 10 mV

(*d*) 5 mV

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Group A

1. (a) State Stroke's theorem. Use divergence theorem to
        find the flux coming out of a box bounded by surfaces,
        described by $x = 1, y = 1$ and $z = 1$. The flux density in
        the region is given by $D = 4xz\ i_x + y^2\ i_y + yx\ i_z$, where
        i_x, i_y and i_z are unit vectors. 6

    (b) Derive Ampere's law using the concept of magnetic
        vector potential. 6

    (c) What are the physical significance of Maxwell's equation ?
        Write Maxwell's equation in differential and integral
        forms for free space and for harmonically varying fields. 8

2. (a) Find the auto-correlation of a rectangular pulse of
        duration T. 5

(b) Explain stationary and non-stationary random process.   5

(c) If $X(w)$ is the Fourier transform of a continuous-time signal $x(t)$, i.e., $x(t) \longleftrightarrow X(\omega)$, then prove the following properties of the Fourier transform :

(i) Time-shifting property, i.e.,

$$x(t - t_0) \longleftrightarrow e^{-j\omega t_0} X(\omega).$$ 5

(ii) Duality property, i.e., $X(t) \longleftrightarrow 2\pi x(-\omega)$.   5

3. (a) What is noise in communication system ? Explain different types of noise in communication system.   6

(b) What is the importance of noise figure ? Describe a method for the determination of noise figure.   6

(c) The noise output of a resistor is amplified by a noiseless amplifier having a gain of 60 and a bandwidth of 20 kHz. A meter, connected to the output of the amplifier, reads 1 mV rms. If the bandwidth of the amplifier is reduced to 5 kHz, its gain remaining constant, what does the meter read now ? Also, if the resistor is operated at 80 °C, what is its resistance ?   8

4. (a) Give the block diagram of frequency demodulation and calculate figure of merit for it. Discuss in brief about pre-emphasis and de-emphasis.   8

(b) What is meant by pulse width modulation ? Explain the generation of pulse width modulation.   6

(c) What is multiplexing ? Compare FDM and TDM.   6

Group B

5. (a) Find the constant k for the density function $f(x) = kx^2$ for $(0 < x < 2)$ and zero elsewhere. Also, compute $P(1 < x < 2)$.   7

(b) Two random variables, X and Y, have joint density function $f(x, y) = 6(1 - x - y)$, where $0 \leq x \leq 1$ and $0 \leq y \leq 1 - x$. Find $E(X)$ and $E(Y)$.   7

(c) Explain variance and standard deviation of a random variable.   6

6. (a) Prove the following :   5 + 5

(i) Power of the energy signal is zero over infinite time.

(ii) Energy of the power signal is infinite over infinite time.

(b) A source is generating four possible symbols with probabilities of 1/8, 1/8, 1/4, 1/2, respectively. Find entropy and information rate, if the source is generating 1 symbol/ms.   5

(c) Prove that $H(Y) + H(X/Y) = H(X) + H(Y/X)$.   5

7. (a) Compare bandwidths of BFSK, QPSK, BPSK, M-ary FSK, MSK and MPSK.   10

(b) Derive and explain the Nyquist first criterion to minimize ISI.   10

8. Write short notes on the following :   4 × 5

(a) Baseband transmission
(b) SNR in envelope detector
(c) Matched filter
(d) Quantization noise of a PCM system with uniform quantizer.

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Group C

9. Choose the *correct* answer for the following :　　　10×2

(i) If $x_e(t)$ and $x_0(t)$ are even and odd parts of the signal $x(t)$, then signal $x(t)$ can be represented as

(a) $x_e(t) + x_0(t)$

(b) $x_e(t) - x_0(t)$

(c) $x_e(t)/x_0(t)$

(d) $x_e(t) \times x_0(t)$

(ii) If E and P are average energy and power of the signal, then power signals are the signals with

(a) $0 < E < \infty, P = 0$

(b) $0 < E < \infty, P = \infty$

(c) $0 < P < \infty, E = \infty$

(d) $0 < P < \infty, E = 0$

(iii) Biot Savart's law is equivalent to

(a) Coulombs law.

(b) theory of relativity.

(c) Both of them are correct.

(d) None of the three above.

(iv) Given vector

$V = i(x + 2y + az) + j(bx - 3y - z) + k(4x + cy + 2z)$

is irrotational, the values of a, b, c are given as

(a) $a = 4, b = 1, c = 2$

(b) $a = -4, b = -1, c = 2$

(c) $a = 4, b = 2, c = -1$

(d) $a = 4, b = -2, c = 2$

(v) A charge particle is moving with velocity v and magnetic field B experiences force F_m. Which one of the following statement is false ?

(a) B and F_m are normal to each other.

(b) F_m can perform work.

(c) F_m depends upon v.

(d) F_m is a deflecting force.

(vi) If a random process $X(t)$ is ergodic, then

(a) statistical averages and time averages are different.

(b) statistical averages and time averages are same.

(c) statistical averages is greater than time averages.

(d) both are zero.

(vii) For scalar field V and vector field A, the div (VA) will be

(a) $V \operatorname{div} A$

(b) $V \operatorname{div} A + A.\operatorname{div} V$

(c) $V \operatorname{div} A + A.\operatorname{grade} V$

(d) zero.

(viii) If random variables x and y are independent, then

(a) $f(x, y) = f_1(x)f_2(y)$

(b) $F(x, y) = F_1(x) F_2(y)$

(c) $E(XY) = \mu_x \mu_y$

(d) All the three above.

(ix) Fourier transform of a d.c. signal with unity strength is

(a) xero

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(*b*) 1

(*c*) $2\pi\delta(\omega)$

(*d*) 2π

(*x*) Random variable is

   (*a*) a function of time *t*.

   (*b*) a variable that can be described by differential equation.

   (*c*) functional mapping of outcomes in an experiment to real numbers.

   (*d*) any variable.

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