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Amrita School of Engineering, Coimbatore

B.Tech Degree Examinations – November 2024

Fifth Semester

Cybersecurity

20CYS301 Digital Communications

Duration: Three hours | Maximum: 100 Marks

CO	Course Outcomes
CO01	Understand the fundamental principles of digital modulation and demodulation methods
CO02	Identify and list various issues present in the design of a communication system
CO03	Apply the time domain and frequency domain concepts of signals in data communication
CO04	Design suitable error detection and error correction algorithms to achieve error free data communication

Answer all the questions

1. Convolution codes act on individual message bits or on groups of bits?

   Is Cyclic Redundancy Code (CRC) a convolution code or a block code? – Justify

   [5.0] [C04] [BTL2]

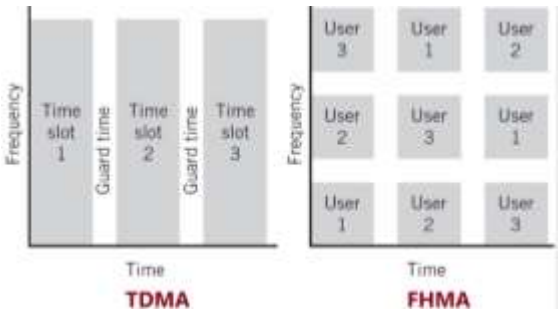
2. The figure shows usage of spectrum across time and frequency for TDMA and FHMA.

   Spatial division multiple access (SDMA) is common in satellite-ground communications.

   Does SDMA have guard bands across time axis?

   Does SDMA have guard bands across frequency axis?

   Which of the three, TDMA, FHMA or SDMA supports the max number of users? Justify.



   [5.0] [C02] [BTL2]

3. The availability of channel characteristics is a pre-requisite for the use of error correction codes (ECCs) or for automatic repeat request (ARQ). Justify.

   224 bit of message is sent in packet size of 2 words (4 bytes) using Hamming(8,4).

   - What is the code rate which is *data transmitted*/*sum of data and code bits transmitted*.
   - How many packets are sent?

   [5.0] [C04] [BTL3]

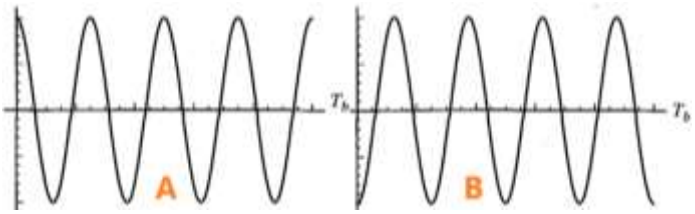
4. Hamming Codes (HCs) meet the following definition: $(2)^p \geq d + p + 1$ where d and p are the number of data and parity bits respectively

   Find min # of parity bits needed for 16 bits of data to be sent.

   Write your answer in the standard format for Hamming Codes.

   [5.0] [C04] [BTL3]

5. A and B are two sine functions. Are A and B antipodal or orthogonal signals? Justify.

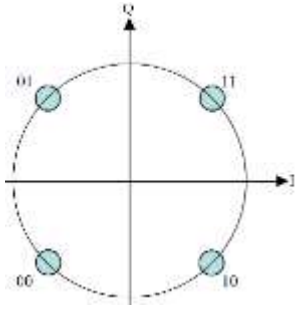
   If B is antipodal to A then redraw B as B' for 2 periods such that B' is orthogonal.

   If B is orthogonal to A then redraw B as B' for 2 periods such that B' is antipodal.

   If the two signals are used to form the carriers for a binary pulse shift keying (BPSK) then will reception error be smaller if the two were antipodal or if the two were orthogonal? Justify.

   [5.0] [C03] [BTL3]

6. The figure shows Quadrature Amplitude Modulation (QAM).

   In QAM, which parameter of the carrier – amplitude, phase or frequency – is modulated?

   The dots on the circle denote 4 carriers. On each carrier, one message value can be transmitted. E.g., 11 at 45°, 01 at 135°, and so on.

   Redraw if 8 carriers are used.

   Redraw if 8 carriers are used if the minimum distance between the carries is 60°. Hint: modulate using two of three parameters.

   [5.0] [C03] [BTL3]

7. Derive the expression for power of DSB-SC AM message signal $A_c \cdot m(t) \cdot cos(2 \cdot \pi \cdot f_c \cdot t)$. Signal power is $P[u(t)] = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} u^2(t) dt$

   [10.0] [C01] [BTL3]

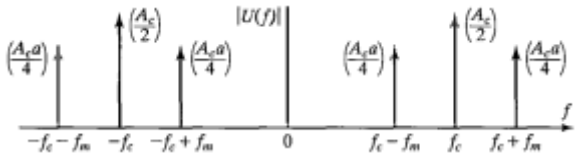
8. CRC-16-CCIT is a cyclic redundancy code (CRC) which is used as an encoder in Bluetooth communications. It is given by the polynomial $x^{16} + x^{12} + x^5 + 1$.

   Write the polynomial in binary form.

   Write the encoded data if the data to be transmitted is 10000000 11111111 1. What is the code rate?

   [10.0] [C04] [BTL3]

9. The figure shows double sideband AM (DSB-AM).



The power of the USB-SC AM signal is the same as that of DSB-AM signal, 50% of the DSB-AM signal, < 50% of the DSB-AM signal or > 50% of the DSB-AM? Justify.

The diagram in the figure above shows frequency, phase or amplitude modulation?

Redraw it to show USB-SC AM modulation. Give justification.

How many carrier frequencies are present in the DSB-AM signal?

What must the min frequency of sampling be as per Nyquist criteria for the USB-SC AM signal?

[10.0] [C03] [BTL4]

10. Derive the mathematical expressions associated with demodulation of a Quadrature Carrier Multiplexed (QCM) signal. $u(t) = A \cdot m_1(t) \cdot cos(2 \cdot \pi \cdot f_c \cdot t) + A \cdot m_2(t) \cdot sin(2 \cdot \pi \cdot f_c \cdot t)$

What is the phase angle between the two message signals?

What is the optimum phase angle between the signals if we want to extend this modulation approach to 3 messages, m_1, m_2 & m_3 instead of just m_1 & m_2? Why?

[10] [C01] [BTL4]

11. Assume that $X(t)$ is a stationary Gaussian source with $\mu = 0$ and a power spectral density (psd) $S_x(f) = \begin{cases} 2 \; if \; |f| < 100 \; Hz \\ 0 \qquad otherwise \end{cases}$. Source is sampled at Nyquist rate.

1. *What is the sampling rate*? 2. *What is the variance*? 3. *What is the bit rate*?

An 8-level quantizer is used. Ref figure on the last slide:

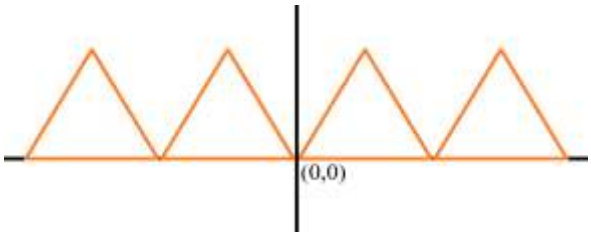
$\{a_1, a_2, a_3, a_4, a_5, a_6, a_7\} = \{-60, \; -40, \; -20, \; 0, \; 20, \; 40, \; 60\}$

$\{\hat{x}_1, \hat{x}_2, \hat{x}_3, \hat{x}_4, \hat{x}_5, \hat{x}_6, \hat{x}_7, \hat{x}_8\} = \{-70, \; -50, \; -30, \; -10, \; 10, \; 30, \; 50, \; 70\}$

4. *What is distortion gain in dB if quantization results in distortion power declining to 4dB*? Note: Distortion gain *is* $10log_{10}\left(\frac{Variance}{Distortion\ power}\right)$.

[15.0] [C03] [BTL3]

12. Derive the expression for fourier transform for the waveform shown.



Waveform period is 2 sec.

Waveform amplitude is 2 volt.

Plug in the values of n=0 and n=6 into the final equation and compute.

$\sin x = x - x^3/3! + x^5/5! \pm O(x^7)$ and $\cos x = 1 - x^2/2! + x^4/4! \pm O(x^6)$

FT for continuous periodic waveform is $X(n) = \frac{1}{T}\int_T x(t)e^{-jn\pi t}d\tau$

You may find it useful to know that $\int te^a dt = \frac{t \cdot e^{at}}{a} + \int e^{at}dt$

[15.0] [C03] [BTL4]

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Course Outcome /Bloom's Taxonomy Level (BTL) Mark Distribution Table

CO	Marks	BTL	Marks
CO01	**20**	BTL 1	**0**
CO02	**5**	BTL 2	**10**
CO03	**50**	BTL 3	**55**
CO04	**25**	BTL 4	**35**