**BITS Pilani, Dubai Campus**

**Dubai International Academic City**

**B.E. (ECE), Third Year – Second Semester, 2012-2013**

**Comprehensive Examination**

**Course No. / Course Title: ECE C392 / Modern Communication Technologies**

**Duration: 3 hours Max. Marks: 80 Weightage: 40%**

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***Note:*** *Answer all questions. Appropriate assumptions may be made, where necessary.*

1. Discuss some of the important parameters to be considered on choosing a particular signaling format for transmission of binary data. Using the data sequence 10110001101, draw the waveforms for unipolar NRZ, bipolar RZ, and alternate mark inversion RZ signaling formats. What are the advantages and disadvantages of these three signaling formats. (6)
2. Name and write a brief note on the four types of channels that take active part during a mobile call. (4)
3. A mobile transmits 10 W power at a certain place. Express this power in terms of dBm. (2)
4. Write a brief note on the dynamic channel assignment strategy in cellular communications. What are its relative advantages and disadvantages over fixed channel assignment? (5)
5. A total of 33 MHz bandwidth is allocated to a FDD cellular system with two 25 kHz simplex channels to provide full duplex voice and control channels. Compute the number of channels available per cell if the system uses (i) 4-cell, and (ii) 8-cell frequency reuse technique. Assume 1 MHz os spectrum is allocated to control channels. Give a distribution of voice and control channels. (6)
6. Discuss briefly the physical factors that influence small-scale fading in a radio propagation channel. (6)
7. An aircraft is heading towards a control tower at 500 kmph at an elevation of 20°. Communication between the aircraft and the control tower occurs at 900 MHz. What is the expected Doppler shift? (4)
8. Give a mathematical representation for the QPSK signal and show its signal constellation diagram. (4)
9. ISI is one of the major obstacles to high-speed data transmission over mobile radio channels. Explain clearly one method for mitigating the effect of ISI. (5)
10. With a diagram, explain briefly the maximum ratio combining method of space diversity reception. (5)
11. A (4,3) linear code is generated by the matrix $[G]=\begin{bmatrix}1 & 1 & 0 & 0\\ 1 & 0 & 1 & 0\\ 1 & 0 & 0 & 1\end{bmatrix}$.

    Find the code words associated with each possible information word. What is the nature of the resulting code? What is the role of the redundant bit in each code word? (6)
12. Calculate the capacity of an AWGN channel with a bandwidth of 1 MHz and an S/N ratio of 40 dB? (3)
13. (i) How are multiple access radio protocols classified? Indicate the sub-classifications too. (2)
    (ii) In a ALOHA network, how does a terminal learn that its packet has collided? (2)
    (iii) What is meant by the term *vulnerable time*? By means of appropriate sketches, show that the vulnerable time for slotted ALOHA is one-half that of pure ALOHA. (4)
14. (i) Why is it difficult to implement CSMA/CD in a wireless environment? (2)
    (ii) Explain the p-persistent CSMA protocol with the help of a flow chart. (4)
15. If the refractive index of the core of an optic fiber is 1.47 and that of the cladding is 1.44, what is the angle of the cone of acceptance? (4)
16. Name and compare the two common types of light detectors used in fiber optics. (3)
17. What is a graded index waveguide and what are its advantages over the lens waveguide? (3)

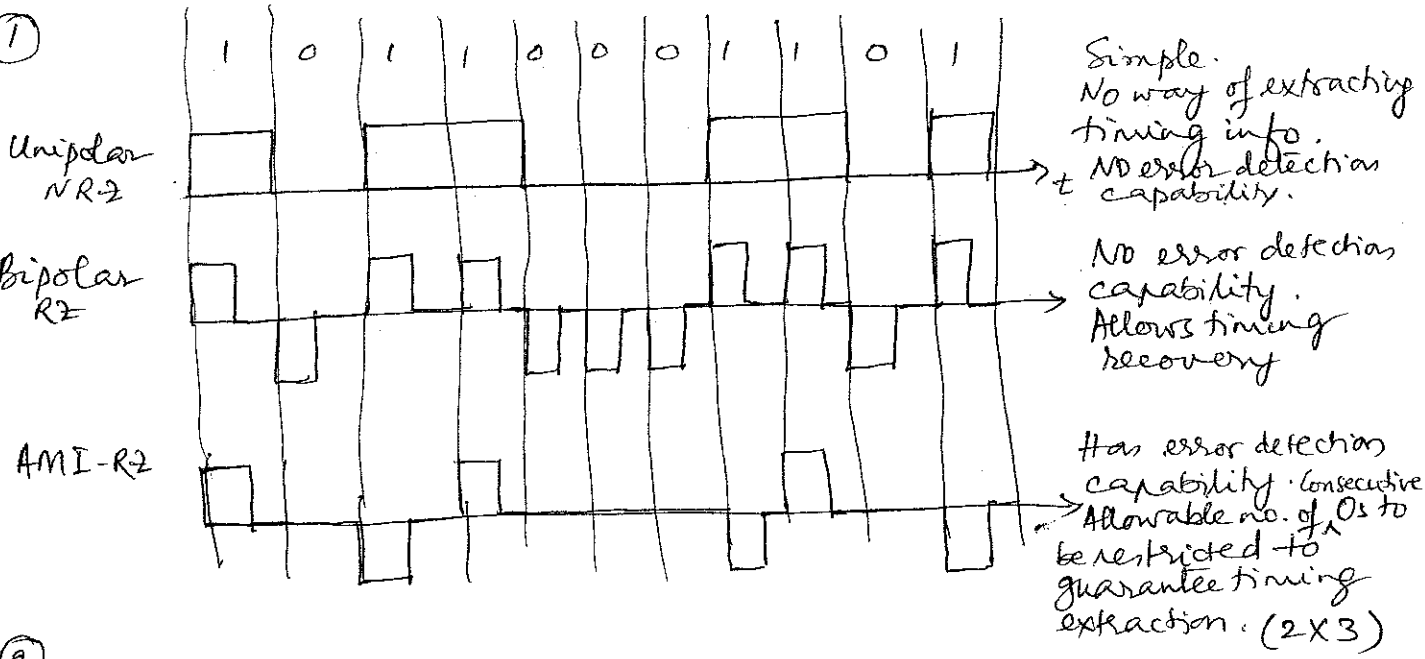
# II Semester, 2012-13

## ECE 392 MODERN COMMUNICATION TECHNOLOGIES

## COMPREHENSIVE EXAM

## SOLUTIONS / MARKING SCHEME

(1)




Simple. No way of extracting timing info. No error detection capability.

No error detection capability. Allows timing recovery

Has error detection capability. Consecutive Allowable no. of 1's to be restricted to guarantee timing extraction. (2×3)

(2) FCC, RCC, FVC, RVC
A brief note on each. (1×4 = 4)

(3) $10 \log_{10}\left(\frac{10\,W}{10^{-3}\,W}\right) = 10 \log_{10} 10^4 = 40$ dBm (2)

(4) Temporary assignment of channels.
Brief explanation as discussed in class. ] (3½)
Reduced likelihood of call blocking. Increased capacity as all channels available to all cells. (1½)
Heavy load on switching centre.

(5) One duplex channel = 2×25 = 50 kHz

Total duplex channels $= \frac{33\,MHz}{50\,kHz} = 660$.

Control channels $= \frac{1\,MHz}{50\,kHz} = 20$

(a) For N = 4, Total channels/cell $= \frac{660}{4} = 165$ (3)
Voice channels = 160, Control channels = 5

(b) N = 8 is not a valid option
Since $N \neq i^2 + ij + j^2$ ! (3)

(6) - Multipath propagation
- Speed of mobile
- Speed of surrounding objects
- Transmission bandwidth

} $(1\frac{1}{2} \times 4)$

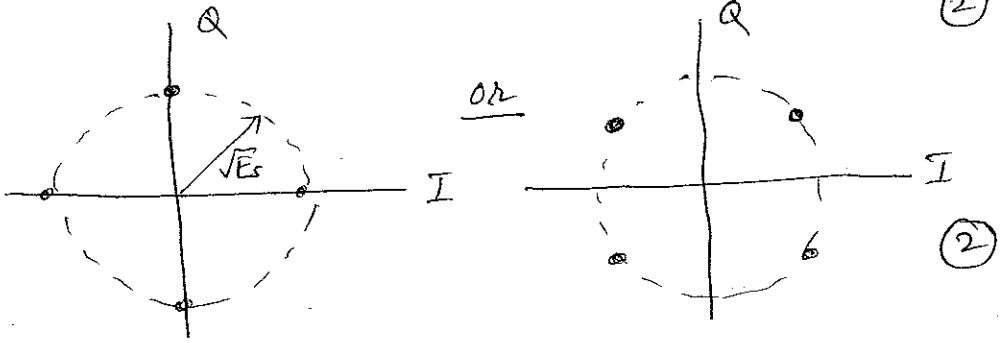
with a brief explanation of each.

(7) $v = 500$ kmph $= 500 \times \frac{3}{18}$ m/s ; $\lambda = \left(\frac{900 \times 10^6}{3 \times 10^8}\right) = \frac{1}{3}$ m.

$$f_d = \frac{v \cos\theta}{\lambda} = 500 \times \frac{3}{18} \times 3 \times \cos 20^\circ$$

$$= 390 \text{ Hz} \qquad (4)$$

(8) $$s_{QPSK}(t) = \sqrt{\frac{2E_s}{T_s}} \cos\left[2\pi f_c t + (i-1)\frac{\pi}{2}\right], \quad 0 \le t \le T_s, \quad i = 1, 2, 3, 4$$ (2)




(2)

(9) Answer to include Equalizer and its implementation using a transversal filter. (5)

(10) Theory, as discussed in class.

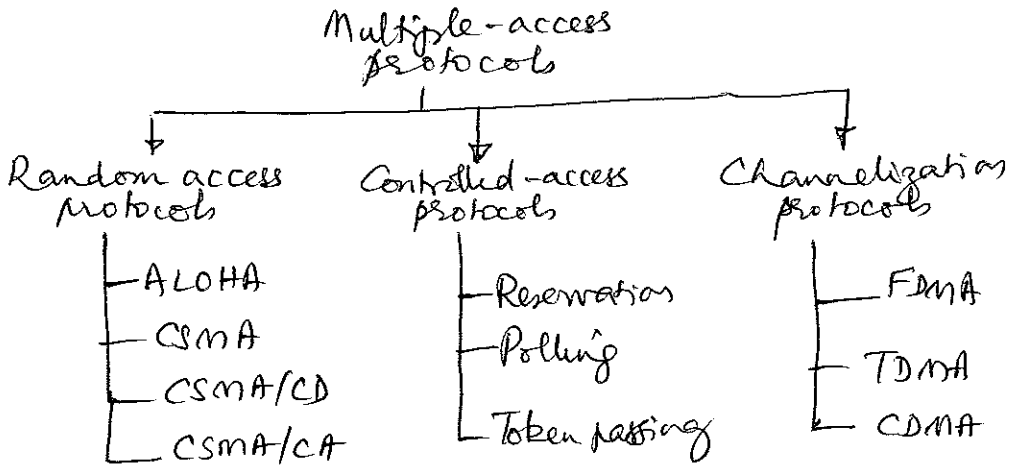
(11) Similar to numerical solved in class. Redundant bit acts as even parity check. (6)

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

$\frac{S}{N} = 40\,dB \Rightarrow 10^4$ ; $B = 10^6$

$\therefore C = 10^6 \log_2(1 + 10^4)$ bits/sec (3)

(13) (i)




(2)

(ii) Receipt of ACK signal within the wait-out time. (2)

(iii) Definition and figures as explained in the class. (4)

(14) (i) (ii) } As explained in class. (2) (4)

(15)

$$n_1 = 1.47, \quad n_2 = 1.44$$

$$\alpha = \sin^{-1}\sqrt{n_1^2 - n_2^2}$$

$$= 17.18^\circ$$

(4)

(16) Avalanche photodiode — Internal gain, more expensive, external support electronics needed.
PIN photodiode — economical, no support circuitry needed, used more often.
with a brief discussion. (3)

(17) Graded index waveguide — refractive index higher in the centre. Acts a continuous focusing element allowing small diameters and cornering.
Lens waveguide has small dia but is difficult for cornering. (3)

—x—

**BITS Pilani, Dubai Campus**

BE (Hons.) ECE Third Year, Second Semester, 2012-2013

**Test 2 (Open Book)**

**ECE C392 Modern Communication Technologies**

Duration: 50 min Max. Marks: 40 Weightage: 20%

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***Answer all questions.***

1. An eight-bit word is formed from four information bits and four parity bits, with the parity bits given by the following equations:

$$c_1 = u_2 + u_3 + u_4$$
$$c_2 = u_1 + u_2 + u_3$$
$$c_3 = u_1 + u_2 + u_4$$
$$c_4 = u_1 + u_3 + u_4$$

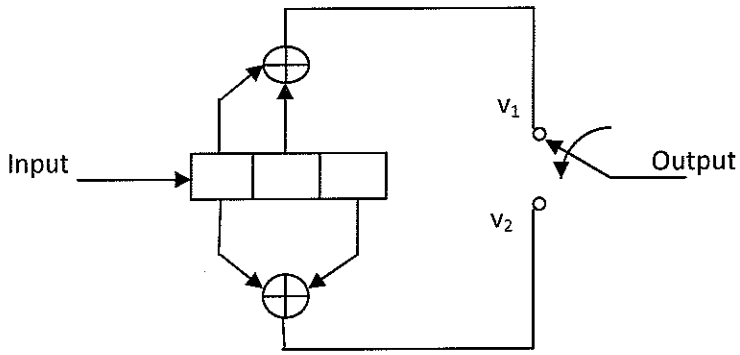
   a) Find the generating matrix [*G*].
   b) How many errors can be detected? Justify.
   c) How many errors can be corrected? Justify.
   d) Demonstrate the decoding process for any single message. (15 marks)

2. Consider the convolutional encoder shown below.

   a) Find the "impulse response" of the encoder.

   b) Find the output code word if the input sequence is all 1's (1 1 1 1 1 1 ...).

   c) Discuss the result of (b). (15 marks)




3. An antenna is connected to a preamplifier which has a noise figure of 2 dB over an effective bandwidth of 20 MHz. What will be the effective input noise temperature of the preamplifier if the antenna noise temperature is 25 K? Also, find the available noise power output of the preamplifier. (10 marks)

*** *Paper ends* ***

GOOD LUCK!

# ECE 392 MODERN COMMN TECH

## TEST 2

## SOLUTIONS / MARKING SCHEME

(1) (a) $G = \begin{bmatrix} 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$

follows from the equations for the parity bits. (4)

(b)

| Info bits | Codeword | Hamming weight |
|---|---|---|
| ⋮ | ⋮ | ⋮ |
| 0111 | 10000111 | 4 |
| ⋮ | ⋮ | ⋮ |
| 1101 | 00101101 | 4 |
| ⋮ | ⋮ | ⋮ |
| 1011 | 00011011 | 4 |
| ⋮ | ⋮ | ⋮ |
| 1110 | 01001110 | 4 |
| ⋮ | ⋮ | ⋮ |

To be done for all 16 cases.

Hamming distance, $d_{min} = 4$

No. of errors that can be detected (3)

$= d_{min} - 1 = 3$

(c) No. of errors that can be corrected

$d_{min} \geq 2t + 1$ (3)

$\Rightarrow t = 1$ bit

(d) $[H]^T = \begin{bmatrix} 1&0&0&0 \\ 0&1&0&0 \\ 0&0&1&0 \\ 0&0&0&1 \\ 0&1&1&1 \\ 1&1&1&0 \\ 1&1&0&1 \\ 1&0&1&1 \end{bmatrix}$

Let received code be $\bar{r} = 10110001$

$\bar{r}[H]^T = [0\ 0\ 0\ 0] \Rightarrow$ no error

Let 4th bit be in error in $\bar{r}$.

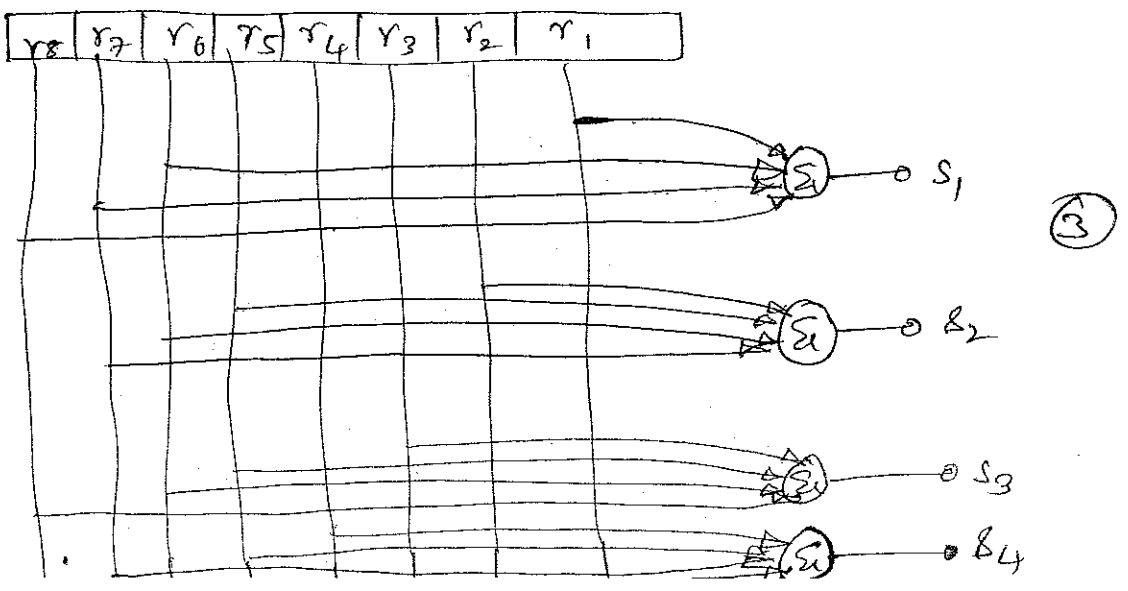
$\bar{r} = 10100001$
(↑ Error)

$\bar{r}[H]^T = [1\ 0\ 1\ 0\ 0\ 0\ 0\ 1] \begin{bmatrix} 1&0&0&0 \\ 0&1&0&0 \\ 0&0&1&0 \\ 0&0&0&1 \\ 0&1&1&1 \\ 1&1&1&0 \\ 1&1&0&1 \\ 1&0&1&1 \end{bmatrix}$

$= [0\ 0\ 0\ 1]$ which is the 4th row in $[H]^T$.

Hence, 4th bit is in error. (2)

Draw Syndrome decoder




(3)

(2) (a)

| Time | i/p | $x_0$ | $x_1$ | $x_2$ | $v_1$ | $v_2$ |
|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| 2 | 0 | 0 | 1 | 0 | 1 | 0 |
| 3 | 0 | 0 | 0 | 1 | 0 | 1 |

Impulse response of $v_1$ is (1 1 0)
Impulse response of $v_2$ is (1 0 1) (5)

∴ Imp. response of encoder is (1 1 1 0 0 1)

(b)

| I/p | output |
|---|---|
| 1 | 1 1 1 0 0 1 |
| 1 | 1 1 1 0 0 1 |
| 1 | 1 1 1 0 0 1 |
| 1 | 1 1 1 0 0 1 |
| 1 | 1 1 1 0 0 1 |
| ⋮ | ⋮ |

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modulo-2 sum's 1 1 0 1 0 0 0 0 0 0 ... all zeros (5)

(c) o/p code has weight 3. An error event of finite weight and duration produces an infinite number of decoding errors. This encoder is a catastrophic encoder. (5)

(3)

$F = 2\,dB \Rightarrow 1.5848$

$T_e = T_0(F-1)$

$= 300(1.5848-1)$

$= 175.5\,^{\circ}K$

$P_a = k(T_{ant} + T_e)\,B \cdot g_a$

$= 1.38\times10^{-23}(25+175.5)\,20\times10^{6}\times g_a$

$\simeq 6.9\times10^{-14} g_a\ W$ (10)

**BITS Pilani, Dubai Campus**

**B.E. (Hons.) ECE Third Year, Second Semester, 2012.2013**

**Test 1 (Closed Book)**

**ECE C392 Modern Communication Technologies**

Duration: 50 min  Max. Marks: 50  Weightage: 25%

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***Note:*** *Answer all questions. Appropriate assumptions can be made, where necessary.*

1. What roles do the channels FCC and RCC play in a cellular mobile network? (6)
2. Discuss, with the help of appropriate diagrams, the hand-off problem in cellular communication and how it is practically addressed. (8)
3. List the sequence of steps involved while connecting a land phone to a mobile station when the call is initiated by the land phone. (8)
4. Consider a cellular system having 2023 duplex channels to cover 1925 sq. km. and each cell area is 5 sq. km. for 7-cell reuse system. Compute the system capacity. (6)
5. Obtain the equivalent noise bandwidth of a passive RC low-pass filter. (8)
6. A mixer stage having a noise figure of 20 dB is preceded by an amplifier that has a noise figure of 9 dB and an available power gain of 15 dB. Calculate the overall noise figure referred to the input, in dB. (6)
7. Discuss in brief some countermeasures for combating narrowband fading. (8)

------ Paper ends ------

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------ Paper ends ------

# SOLUTIONS / MARKING SCHEME

1. Forward Control Channel – Used for controlling call activity. Call setup and diversion of call to unused channels. FCC transmits and receives call initiation and service request messages. Used for control signalling from BS to MS
Reverse Control channel – Used for call control purpose from MS to BS. Control channels are usually monitored by mobiles. (6 marks)

2. As discussed in class.
Answer to include illustration of handoff scenario at Cell boundary. Soft, Hard Handoff, MAHO, etc. (8 marks)

3. Landphone → PSTN → MSC
MSC broadcasts to all BSs. Using RCC the BS within the MS range is identified. BS sends alert to MS and ACK to MSC. FVC and RVC are set to called MS and the phone rings. (8 marks)

(4) Area of cluster $= 5 \times 7 = 35$ sq km

no. of clusters $m = \frac{1925}{35} = 55$

$N = 7 \quad k = \frac{S}{N} = \frac{2023}{7} = 289$

Capacity $C = m \times k \times N$

$= 55 \times 289 \times 7$

$= 11,265$ channels. (6 marks)

(5)

$$H(f) = \frac{1}{1 + j 2\pi f RC}$$

$$= \frac{1}{1 + j(f/B)}$$

where $B = \frac{1}{2\pi RC}$

$$|H(f)|^2 = \frac{1}{1 + (f/B)^2}$$

$$|H(0)|^2 = 1$$

$$B_N = \frac{1}{1} \int_0^\infty \frac{df}{1 + (f/B)^2} = \frac{\pi}{2} B = \frac{1}{4RC}$$ (8)

(6)

$F_2 = 20\,dB \Rightarrow 100$

$F_1 = 9\,dB \Rightarrow 7.94$

$G_1 = 15\,dB \Rightarrow 31.62$

$$F = F_1 + \frac{F_2 - 1}{G_1} = 7.94 + \frac{100 - 1}{31.62}$$

$= 11.07$

$= 10 \log_{10}(11.07)$

$= 10.44\,dB$ (6)

(7) To briefly discuss the various diversity techniques like time, freq, & space diversity. Also include bit interleaving technique (8 marks).

**BITS Pilani, Dubai Campus**
**B.E. (Hons.) ECE Third Year, Second Semester, 2012-2013**
**Quiz 2 (Closed Book)**
**ECE C392 Modern Communication Technologies**
Duration: 20 min Max. Marks: 14 Weightage: 7%

Name:- _____ ID No.:- _____

*Answer all questions in the blanks provided against each question. Numerical answers should be supported with appropriate rough work in the space provided; otherwise, credit will not be given for the answer, even if correct.*

1. Controlled-access protocols include _____, _____ and _____. (1.5)
2. An 8-bit token is to be used on a 5-Mbps token-ring network. The propagation velocity is 200 m/μs. The minimum propagation distance needed for the ring circumference is _____ m. (2)
3. In FDMA, if $b$-bit packets are transmitted in $T$ seconds over each of the $M$ disjoint channels, the total bit rate is $R_{FD}$ = _____ bits/s. (1)
4. In the Poisson process model, if $\lambda$ is the average packet arrival rate in packets per second, the probability that $k$ packets arrive during an interval $\Delta t$ seconds is $P_k$ = _____, $k$ = 0, 1, 2,..., (1)
5. A slotted-ALOHA network transmits 200-bit frames on a shared channel of 200 kbps. If the system (all stations together) produces 500 frames per second, the throughput is _____. (2)
6. The vulnerable time for CSMA is _____. (0.5)
7. In CSMA/CA collisions are avoided through the use of three strategies: _____, _____, and _____. (1.5)
8. Consider the three functions

$$\psi_1(t)=\begin{cases}-A & -2\le t\le -1\\ A & -1\le t\le +1\\ -A & 1\le t\le 2\\ 0 & elsewhere\end{cases};\quad \psi_2(t)=\begin{cases}-A & -2\le t\le 0\\ A & 0\le t\le 2\\ 0 & elsewhere\end{cases};\quad \psi_3(t)=\begin{cases}-A & -2\le t\le 2\\ 0 & elsewhere\end{cases}$$

   (a) Verify that the three functions are pairwise orthogonal over the interval (-2, 2). Show the working in the space provided. (3)
   (b) The value of $A$ so that the functions become an orthonormal set is _____. (1.5)

***(Space for rough work. Use the other side of the sheet too, if required)***

**BITS Pilani, Dubai Campus**
**B.E. (Hons.) ECE Third Year, Second Semester, 2012-2013**
**Quiz 2 (Closed Book)**
**ECE C392 Modern Communication Technologies**
Duration: 20 min Max. Marks: 14 Weightage: 7%

Name:- SOLUTIONS ID No.:- _____

*Answer all questions in the blanks provided against each question. Numerical answers should be supported with appropriate rough work in the space provided; otherwise, credit will not be given for the answer, even if correct.*

1. Controlled-access protocols include Reservation, Polling and Token passing. (1.5)
2. An 8-bit token is to be used on a 5-Mbps token-ring network. The propagation velocity is 200 m/μs. The minimum propagation distance needed for the ring circumference is 320 m. (2)
3. In FDMA, if *b*-bit packets are transmitted in *T* seconds over each of the *M* disjoint channels, the total bit rate is $R_{FD}$ = $Mb/T$ bits/s. (1)
4. In the Poisson process model, if $\lambda$ is the average packet arrival rate in packets per second, the probability that *k* packets arrive during an interval $\Delta t$ seconds is $P_k = e^{-\lambda\Delta t}\sum_{k=0}\frac{(\lambda\Delta t)^k}{k!}$, k = 0, 1, 2,..., (1)
5. A slotted-ALOHA network transmits 200-bit frames on a shared channel of 200 kbps. If the system (all stations together) produces 500 frames per second, the throughput is 152. (2)
6. The vulnerable time for CSMA is propagation time, $T_p$. (0.5)
7. In CSMA/CA collisions are avoided through the use of three strategies: IFS, Contention window, and Acknowledgement. (1.5)
8. Consider the three functions

$$\psi_1(t)=\begin{cases}-A & -2\le t\le -1\\ A & -1\le t\le +1\\ -A & 1\le t\le 2\\ 0 & elsewhere\end{cases};\quad \psi_2(t)=\begin{cases}-A & -2\le t\le 0\\ A & 0\le t\le 2\\ 0 & elsewhere\end{cases};\quad \psi_3(t)=\begin{cases}-A & -2\le t\le 2\\ 0 & elsewhere\end{cases}$$

   (a) Verify that the three functions are pairwise orthogonal over the interval (-2, 2). Show the working in the space provided. (3) $\int\psi_1(t)\psi_2(t)dt=\int\psi_2(t)\psi_3(t)dt=\int\psi_3(t)\psi_1(t)dt=0$
   (b) The value of *A* so that the functions become an orthonormal set is 1/2. (1.5)

***(Space for rough work. Use the other side of the sheet too, if required)***

**BITS Pilani, Dubai Campus**
**B.E. (Hons.) ECE Third Year, Second Semester, 2012-2013**
**Quiz 1 (Closed Book)**
**ECE C392 Modern Communication Technologies**
Duration: 20 min Max. Marks: 16 Weightage: 8%

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Name:- _____ ID No.:- _____

*Answer all questions in the blanks provided against each question. Numerical answers should be supported with appropriate rough work in the space provided; otherwise, credit will not be given for the answer, even if correct.*

1. For room temperature of 300 K, the r.m.s. thermal noise voltage across a parallel RC combination ($R = 10\ k\Omega$ and $C = 0.1\ \mu F$) is _____. (3)
2. Noise Figure of a two-port device is defined as the ratio of
   _____
   _____
   _____. (2)
3. The equivalent noise temperature at 290 K of an electronic device having a noise figure of 10 dB is _____. (2)
4. The expression for the link (power) budget is: _____. (1)
5. State the Channel Coding Theorem: (2)
   _____
   _____
   _____
   _____
   _____
6. A geostationary satellite is located at a distance of 40,000 km from an Earth station. At the satellite a source at a frequency of 4 GHZ radiates a power of 10 watts through an antenna with a gain of 20 dB. The effective aperture area of the receiving antenna is 10 $m^2$. The path loss is _____ dB. (3)
7. A given source can transmit three messages *A*, *B*, and *C*. The first two messages occur with the same probability *p*. Plot in the space below the entropy of the source as a function of *p*. (3)

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***(Space for rough work. Use the other side of the sheet too, if required)***

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**B.E. (Hons.) ECE Third Year, Second Semester, 2012-2013**
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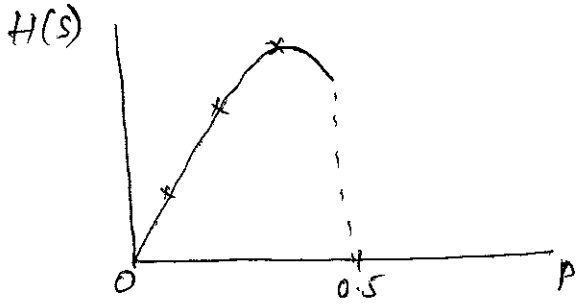
Duration: 20 min Max. Marks: 16 Weightage: 8%

Name:- SOLUTIONS ID No.:- _____

*Answer all questions in the blanks provided against each question. Numerical answers should be supported with appropriate rough work in the space provided; otherwise, credit will not be given for the answer, even if correct.*

1. For room temperature of 300 K, the r.m.s. thermal noise voltage across a parallel RC combination (R = 10 kΩ and C = 0.1 μF) is $2.03 \times 10^{-7}$ V. (3)
2. Noise Figure of a two-port device is defined as the ratio of the total noise power in the load (output) to the noise power delivered to the load by the source alone. (2)
3. The equivalent noise temperature at 290 K of an electronic device having a noise figure of 10 dB is 2610 K. (2)
4. The expression for the link (power) budget is: $EIRP + G_R - L_p - L_o$. (1)
5. State the Channel Coding Theorem: (2)
   As long as $R < C$, there exists a coding technique such that the prob of error in the received message can be made to arbitrarily $\to 0$.
6. A geostationary satellite is located at a distance of 40,000 km from an Earth station. At the satellite a source at a frequency of 4 GHZ radiates a power of 10 watts through an antenna with a gain of 20 dB. The effective aperture area of the receiving antenna is 10 $m^2$. The path loss is 196.5 dB. (3)
7. A given source can transmit three messages *A*, *B*, and *C*. The first two messages occur with the same probability *p*. Plot in the space below the entropy of the source as a function of *p*. (3)




***(Space for rough work. Use the other side of the sheet too, if required)***