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RV COLLEGE OF ENGINEERING®

(An Autonomous Institution affiliated to VTU)

V Semester B. E. Examinations Nov/Dec-19

Electronics and Communication Engineering

COMMUNICATION SYSTEMS - I

Time: 03 Hours ***Maximum Marks: 100***

Instructions to candidates:

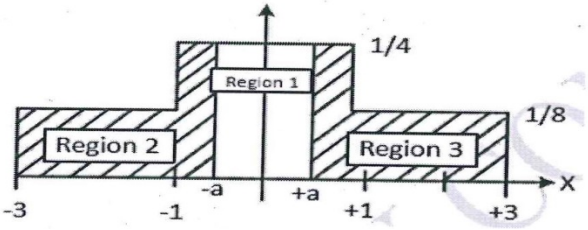
1. Answer all questions from Part A. Part A questions should be answered in first three pages of the answer book only.
2. Answer FIVE full questions from Part B. In Part B question number 2, 7 and 8 are compulsory. Answer any one full question from 3 and 4 & one full question from 5 and 6

PART-A

1	1.1	The carrier $C(t) = A\,Cos(2\pi 10^6 t)$ is angle modulated by the sinusoidal signal $m(t) = 2\,Cos(2000\pi t)$. The deviation constants are $k_p = 1.5 rad/V$ and $k_f = 3000 Hz/V$. Determine β_f and β_p.	01
	1.2	A signal, $x(t) = 10\,Cos\left(1000t + \frac{\pi}{3}\right) + 20\,Cos\left(2000t + \frac{\pi}{6}\right)$ is to be uniformly sampled for digital communication. What is the maximum allowable time interval between simple values that will ensure perfect signal reconstruction?	01
	1.3	A given FM signal has a maximum frequency deviation of $50Hz$ for an input sinusoid of unit amplitude and a frequency of $200Hz$. Determine the required frequency multiplication factor n to produce a maximum frequency deviation of $10kHz$.	01
	1.4	A band limited signal has a bandwidth equal to $3400Hz$ what sampling rate should be used to guarantee a guard band of $1200Hz$.	01
	1.5	Let $Y = 2X + 3$. If a random variable X is uniformly distributed over $[-1,2]$ then the pdf of y is _____.	02
	1.6	Draw the $HDB3$ and $NRZ - AMI$ waveform for the given data sequence [1000001100001101].	02
	1.7	A message signal is band limited to $3kHz$ and sampled at a rate of 33.3% more than the Nyquist rate. The maximum acceptable error in the sampled amplitude is 0.5% of peak amplitude if the quantized samples are binary encoded. Then the minimum bandwidth required to transmit encoded signal is _____.	02
	1.8	An audio signal with spectral components limited to frequency band of 300 to $3400Hz$ is passed through a compander to generate a PCM signal with a sampling rate of 8000 samples/sec, If the required output SNR is $30dB$ then the minimum quantization levels are _____. (Assume $\mu = 255$)	02
	1.9	A message source produces two independent symbols A and B with probabilities 0.55 and 0.45 respectively then the efficiency of the source is _____.	01

	1.10	A CRT terminal is used to enter alphanumeric data into a computer, the CRT is connected through a voice-grade telephone line having usable bandwidth of $3kHz$ and an output SNR of $10dB$ then the channel capacity is _____.	01
	1.11	An analog signal having $4kHz$ bandwidth is sampled at 1.25 times the Nyquist rate and each sample is quantized into one of 256 equally likely levels. Assume that the successive samples are statistically independent. Find the information rate of this source.	02
	1.12	Consider a single error correcting code for 4 data bits, number of check bits required are _____.	01
	1.13	The error correction capability of a linear block code having generator matrix $G = \begin{bmatrix} 100101 \\ 010111 \\ 001110 \end{bmatrix}$ is _____.	01
	1.14	The generator polynomial for a (7,4) Binary cyclic code is $g(x) = 1 + x + x^3$. Find the code vector in systematic form for a message vector 1110.	02

PART-B

2	a	Design an Armstrong indirect FM modulator to generate an FM carrier with a carrier frequency of $98.1MHz$ and maximum frequency deviation of $75kHz$. A $NBFM$ generator is available at a carrier frequency of $100kHz$ and a frequency deviation of $10Hz$. The stock room also has an oscillator with an adjustable frequency in the range of 10 to 11 MHz. there are also plenty of frequency doublers, triplers and quintuplers. Also draw the overall block diagram mentioning all the intermediate results.	06
	b	For a messasge signal $m(t) = 2\cos 100t + 18\cos 2000\pi t$, write the expression for PM and FM wave, when $A = 10$, $w_c = 10^6$, $k_f = 1000\pi$, and $k_p = 1$. Also find the bandwidth of FM and PM signal.	04
	c	Express a real bandpass signal $x(t)$ of bandwidth 'B'Hz existing over a frequency range $(f_U, f_L)Hz$ as an equivalent low pass signal. State the bandpass sampling theorem and determine the allowed sampling frequencies for a bandpass signal in the range $[920KHz - 940KHz]$.	06
3	a	Consider a random process $X(t)$ given by $X(t) = (A + 1)\,cos(t) + B\,sin(t)$, where A and B are independent random variables having a mean value as '0' and mean square value as '1'. Show that $X(t)$ is a covariance stationary.	06
	b	If the probability density function is divided into three regions as shown in the Fig. 3.b, find the quantization noise power for the quantization region between $-a$ to $+a$  Fig. 3.b	04
	c	Derive an expression for binary symbol transmission using a bipolar NRZ coded waveform and obtain the PSD.	06

OR

4 a A class of modulated random signal $Y(t)$ is defined by $Y(t) = AX(t)\cos(\omega_c t + \theta)$, where $X(t)$ is the random message signal and $A\cos(\omega_c t + \theta)$ is the carrier. The random message signal $X(t)$ is a zero-mean stationary random process with autocorrelation $R_{xx}(\tau)$ and power spectrum $S_{xx}(\omega)$. The carrier amplitude A and the frequency ω_c are constants, and phase θ is a random variable uniformly distributed over $[0,2\pi]$. Assuming that $X(t)$ and θ are independent find the mean, autocorrelation and power spectrum of $y(t)$. 06

b Two random process $X(t) = A\,cos(\omega t + \theta)$ and $Y(t) = A\,sin(\omega t + \theta)$ Where A and ω are constants and θ is a uniform random variable over $[0,2\pi]$ Find the cross correlation of $Y(t)$ with $X(t)$ and the cross correlation of $X(t)$ with $Y(t)$. 04

c Derive an expression for binary symbol transmission using a Manchester coded waveform and obtain PSD. 06

5 a The random process $X(t)$ is defined by $X(t) = Y\cos(2\pi f_0 t + \theta)$, where Y and θ are two independent random variables, Y uniform on $[-3,3]$ and θ uniform on $[0,2\pi]$.

i) Find the autocorrelation function of $X(t)$ and its power spectral density.

ii) If $X(t)$ is to be transmitted to maintain an $SQNR$ of atleat $40dB$ using a uniform PCM system, what is the required number of bits/sample and the least bandwidth requirement in terms of f_0.

iii) If the $SQNR$ is to be increased by $24dB$, how many more bits/sample must be introduced and what is the new minimum bandwidth requirement for this case? 06

b Explain the working of $DPCM$ modulator and demodulator with a block diagram? 04

c Five analog signals $S1$ to $S5$ in table 5c are to be formatted as digital signals for transmission. The allowed overhead includes a 8bit frame header with a 2 bit frame sequence number. Design a multiplexing scheme clearly showing the framing line rates. What should be the P/D buffer size at the receiver? 06

Table 5c

Signals	*Bandwidth*	*Resolution levels*
$S1$	$32kHz$, *sampled 25% above Nyquist rate*	256
$S2, S3$	$4kHz$, *sampled 20% above Nyquist rate*	4096
$S4, S5$	$5kHz$, *sampled at Nyquist rate*	4096

OR

6 a In a satellite radio system, 128 stations of stereo quality are to be packed in one data stream. For each station two (left and right) signals of bandwidth $15{,}000Hz$ are sampled, quantized, and binary-coded into PCM signals. The transmitter must multiplex the data from 128 stations into a single stream via time multiplexing.

i) If the maximum acceptable quantization error in sample amplitudes is 0.25% of the peak signal voltage, find the minimum number of bits needed for a uniform quantizer.

		ii) If the sampling rate must be 20% higher than the Nyquist rate, find the minimum bit rate of the multiplexed data stream based on the quantizer in (i). iii) If 5% more bits are added to the multiplexed data for error protection and synchronization determine the minimum bandwidth needed to transmit the final data stream to receiver. Determine the binary pulse rate (bits per second) of the binary-coded signal, and the minimum bandwidth required to transmit this signal.	06
	b	For a sinusoidal modulating signal $m(t) = Acos(2\pi f_m t)$, derive an expression for the output $SQNR$ in a DM system under the assumption of no slope over load.	05
	c	Five analog signals $S1$ to $S5$ in table 6c are to be formatted as digital signals for transmission. The allowed overhead includes a 8bit frame header with a 3 bit frame sequence number. Design a multiplexing scheme clearly showing the framing line rates. What should be the P/D buffer size at the receiver? Table 6c *Signals* | *Bandwidth* | *Resolution levels* $S1$ | $16kHz$, *sampled at* 20% *above Nyquist rate* | 256 $S2$ | $32kHz$, *sampled at Nyquist rate* | 1024 $S3$ | $4kHz$, *sampled at* 25% *above Nyquist rate* | 512 $S4$ | $5kHz$, *sampled at* 20% *above Nyquist rate* | 128 $S5$ | $5kHz$, *sampled at Nyquist rate* | 128	05
7	a	Given messages $X1, X2, X3, X4, X5$ and $X6$ with probabilities of $\frac{1}{3}, \frac{1}{4}, \frac{1}{8}, \frac{1}{8}, \frac{1}{12}, \frac{1}{12}$ Construct a Ternary code applying Huffman encoding procedure, Determine the efficiency and redundancy of the code formed.	06
	b	The differential entropy of a random variable 'X' is defined as $H(x) = -\int_{-\infty}^{\infty} p(logp)dx$ Find the PDF for which $H(x)$ is maximum?	06
	c	A message source produces two independent symbols A and B with probabilities 0.4 and 0.6. If the symbols are received in average with 4 in every 100 symbols in error, calculate the transmission rate of the system provided that the channel is binary symmetric.	04
8	a	For a (7,4) Cyclic code the received vector is 1110101 and the generator polynomial is $g(x) = 1 + x + x^3$. Draw the syndrome calculation circuit and correct the single error in the received vector.	08
	b	For a (6,3) Linear block code the parity check digits are $C_4 = U_1 + U_2 + U_3$; $C_5 = U_1 + U_2$; $C_6 = U_1 + U_3$; Find i) Generator matrix and parity check matrix ii) Construct the code generated by the matrix and draw the encoder circuit. iii) Determine the error detecting and correcting capabilities of this code. iv) Decode the received words 101100 and 000110.	08