Communications

Jan. 10th 2009

Total = 70 points. Marked from 73 points.

Part A: (47 points) to be solved in the space provided after each question

1. *(15 Points)*

Answer Question 1 in this table by blackening the correct cell. A correct answer is one point. A wrong answer is -0.25 points. No markings in the table might result in a "ZERO" grade.

	a	b	c	d
i				
ii				
iii				
iv				
v				
vi				
vii				
viii				
ix				
x				
xi				
xii				
xiii				
xiv				
xv				

i. When a signal is transformed into the frequency domain, we need to:
(a) Transform it back into time domain before transmission
(b) Apply Fourier Transform on any signal before we added to it
(c) Multiply it by a cosine to make it a passband signal
(d) None of the above

ii. Filtering a signal with a Low Pass Filter:
(a) Is equivalent to convolution
(b) Keeps only the low frequency components of the signal
(c) Will smooth the signal
(d) All of the above

If we add two signals whose frequency domain does not overlap
(a) We can separate them using filtering
(b) We have to apply Fourier transform on them before adding
(c) We cannot use the sum for VSB modulation
(d) We can only separate them using subtraction

iv. An AM modulated signal
(a) Saves power over DSBSC
(b) Saves BW over SSB
(c) Wastes BW over VSB
(d) All of the above

v. A superheterodyne receiver
(a) Cannot be used for FM signals
(b) Is a very large receiver, hence the name "super"
(c) Uses RF to IF conversion then deals with the signal in IF
(d) Is used for digital transmission of Video

vi. Carson's rule
(a) Is used to obtain an approximate BW for FM signals
(b) Cannot be used for NBFM
(c) Cannot be used for WBFM
(d) Can be used for AM signals whose modulation index is very high

vii. An FM signal with $\Delta f<B$,
(a) Has smaller BW than an AM signal
(b) Has higher BW than a DSBSC signal
(c) Has the same BW as an AM signal
(d) Cannot be transmitted using an antenna

viii. The SNR of a demodulated FM signal is
(a) Increases with the BW of the FM signal
(b) Is higher than that of a demodulated DSBSC signal
(c) Can be used as a measure of the quality of the signal
(d) All of the above

ix. A DSBSC signal
(a) Can be demodulated using an envelope detector if its amplitude is high enough
(b) Requires synchronization between the transmitter and receiver carriers
(c) Uses higher bandwidth than an AM signal
(d) Cannot interfere with an FM signal in the same band

x. The difference between analog and digital communications, is that
(a) We can only use analog communications to transmit speech
(b) We can only use analog communications to transmit TV
(c) Analog communications uses an analog signal to modulate a carrier
(d) All of the above

xi. A Fourier series is a tool that is used to
(a) Represent a periodic signal in terms of sines and cosines
(b) Represent a non-periodic signal in terms of sines and cosines
(c) Transform a signal so that it can be transmitted
(d) Allow us to use an oscilloscope to watch a signal

xii. A sequence of 1's and 0's
(a) Can never be obtained from an analog signal
(b) Can be obtained from an analog signal
(c) Cannot be used to modulate a carrier
(d) Can only be used to modulate a carrier whose frequency is higher than the Nyquist rate

xiii. The communications system valuable resources include
(a) Time
(b) Banwidth
(c) Power
(d) All of the above

xiv. A superheterodyne receiver is used to receive a radio station at 330 KHz where the IF frequency is 110KHz
(a) The local oscillator frequency can only be 440KHz
(b) The local oscillator frequency can only be 220KHz
(c) The local oscillator frequency can only be 440KHz or 220KHz
(d) We have to find out if this is an FM or an AM signal before we decide on the local oscillator frequency

xv. A difference between ASK and FSK is:
(a) We can only ASK when the digital signal is constructed from an analog signal
(b) Only FSK can be used if the numbers of 1's and 0's is more than 1000
(c) ASK uses a cosine while FSK uses a sine
(d) ASK vector space representation is stationary

Points)

Find the bandwidth required to transmit the modulated signal in each of (i)-(vi).

i. A signal m(t) whose bandwidth is 6KHz modulates a carrier of frequency 300KHz using AM modulation.

ii. A signal m(t) whose bandwidth is 24KHz modulates a carrier of frequency 36KHz using DSBSC modulation.

iii. A signal m(t) whose bandwidth is 10KHz modulates a carrier of frequency 10MHz using SSB modulation.

iv. A signal m(t) whose bandwidth is 10KHz modulates a carrier of frequency 36KHz using VSB modulation, where the excess bandwidth is 25%.

v. A signal m(t) whose bandwidth is 20KHz modulates a carrier of frequency 1MHz using FM modulation. The maximum value of m(t) is 2 and the modulation index k_f=5.

vi. A signal m(t) modulates a carrier of frequency 500KHz, where m(t)=x(t)+y(t). x(t) has a BW of 5 KHz, y(t) has a BW of 7 KHz.

Find the number of bits per second in the following

vii. A signal m(t) whose bandwidth is 4KHz is sampled at the Nyquist rate and quantized using a 3-bit quantizer

viii. A signal m(t) whose bandwidth is 6KHz is sampled at twice the Nyquist rate and quantized using a quantizer which has 16 levels

ix. A signal whose bandwidth is 200KHz and is sampled at half the Nyquist rate using a 10-bit quantizer

x. Ten signals are time division multiplexed and sent over a single connection. Each signal is generated by sampling a speech signal at 8KHz and quantizing each sample using 8 bits. Every frame composed of 12800 sample, an 8-bit sequence is used for synchronization purposes. What is the overall rate on the connection?

(17 points)

i. An analog radio system is designed such that each station occupies 8KHz. It is required to use a digital modulation scheme instead of the analog one. Assume that the radio is used to transmit mainly speech with BW=3.2KHz, and that the same quality audio can be produced by quantizing the speech signal at 8 bits per sample. Suggest a pulse shape and a constellation for using digital modulation while occupying the *exact* same bandwidth as the original analog modulation.

ii. A quantizer assigns the following bits to the input values:

0 to 0.25	00
0.25 to 0.5	01
0.5 to 0.75	10
0.75 to 1	11

A discrete time signal is input to this quantizer at a rate of 20 samples per second. The output of this quantizer is used in a binary PSK system. If it is required that we use 2 cycles of the carrier within each transmitted bit, what is the carrier frequency to be used ?

If the first 3 input samples are 0.12, 0.81, 0.29, draw the modulated signal transmitted to correspond to these 3 samples.

For iii-v: A signal sampled at 10KHz and quantized at 3 bits per sample is to be transmitted using digital modulation. Use the positive half of the frequency spectrum in calculating your bandwidth

iii. What is the bandwidth required for transmission if we use a rect pulse as the pulse shaper and use "baseband"?

Note: Use the BW of the main lobe only

iv. What is the bandwidth required for transmission if we use a sinc pulse as the pulse shaper and use "pass band"?

v. What is the bandwidth required for transmission if we use a raised-cosine pulse with r=0.1 as the pulse shaper and use "pass band"?

Part B (26 points)

I- Choose [illegible] one answer for each of the following questions. A correct answer score is 1 point. Total this part 10 points

1- In digital communication systems, main signal deterioration measure is:
(a) Signal to noise ratio.
(b) Phase and attenuation coefficients.
(c) Bit error rate.
(d) None of the above.

2- Frequencies used to implement the 12-key dual tone multi-frequency (DTMF) keypad are – relative to voice channel-
(a) In-band
(b) Out-of-band
(c) Low frequency
(d) None of the above

3- A tandem exchange can be used to:
(a) Connect local exchanges together.
(b) Connect regional exchanges to national exchanges.
(c) Connect national exchanges together.
(d) All of the above

4- In call set up process, when a subscriber goes off hook, the exchange first;
(a) Identifies the calling party.
(b) Allocates storage for dialed digits.
(c) Receives the dialed digits.
(d) None of the above.

5- In call set-up procedure, the terminating exchange sends an answer message if:
(a) it receives all the information necessary to establish the link.
(b) the continuity check failed
(c) the called subscriber goes off-hock.
(d) the called subscriber goes on-hook.

6- In a noisy telephone channel if the maximum signal to noise ratio is 2000 for an antipodal signal, the maximum bit rate that can be achieved (assuming telephone channel of 3kHz bandwidth) is about :
(a) ≈ 9,900 bps
(b) ≈ 19,800 bps
(c) ≈ 33,000 bps
(d) ≈ 66,000 bps
(e) None of the above.

7- At the end of a telephone call, the calling subscriber circuit turns idle if
(a) the originating exchange receives a clear back (CBK) signal
(b) the originating exchange receives a clear forward (CLF) signal.
(c) the originating exchange receives a release register (RLG) signal.
(d) None of the above

8- The capacity of a T-switch (number of time slots) is limited by
(a) Memory size.
(b) Memory access time.
(c) Number of control words.
(d) All of the above.

9- To build the most economical local network assuming an established quality of service, the following issues must be considered.
(a) Geographic extension of local area of interest
(b) Number of inhabitants and telephone density
(c) Calling habits
(d) All of the above
(e) Items (a) and (b) above.

10- Among the advantages of GEO satellites:
(a) Simple tracking process.
(b) Short propagation delay.
(c) Good coverage at far northern and southern latitudes.
(d) None of the above
(e) items (a) and (c) above

II Indicate at the left of each statement whether it is true (√) or false (×). A correct answer gets (1) . Total this part: 13 Points.

1. [ ] The maximum time delay in a T-switch is equal to the duration of a single time slot.
2. [ ] In the E1 frame, the first two time slots contain synchronizing bit pattern and some trouble-shooting bit patterns.
3. [ ] The bandwidth required to transmit a base band binary sequence of rate 8000 bps is 16 KHz.
4. [ ] ADSL technology extends the bandwidth of a telephone channel from 4 KHz to nearly 1 MHz and equal download and upload speeds are assumed.
5. [ ] A telephone that is busy 10% of the time represents a load of 0.1 Erlang on that particular line.
6. [ ] Lost calls clear means that a user will immediately reattempt the call on receipt of a congestion signal.

7. [ ] A geostationary orbit is also geosynchronous, but has an equatorial orbit to provide fixed communication platform with respect to the Earth.
8. [ ] Medium Earth Orbit (MEO) satellites are useful for communications and navigation purposes because of the lower number of satellites required compared to lower altitude satellites
9. [ ] Among the disadvantages of FDMA is the lack of flexibility in case of reconfiguration.
10. [ ] Among the advantages of TDMA is the all stations transmit and receive on the same frequency.
11. [ ] A band-limited waveform can be accurately reconstructed if sampled at a rate *less or equal to* its double bandwidth.
12. [ ] The theoretical limitations on transmission rate over a telephone line are inversely proportional to the bandwidth.
13. [ ] Among the assumption on which Erlang formula are based on is that calls occur individually and collectively at random, i.e., in accordance with Poisson distribution and the inter-arrival time between calls also obeys Poisson distribution.

Traffic Table

TABLE D.1 Maximum Offered Load Versus B and N^a

N/B	0.01	0.05	0.1	0.5	1.0	2	5	10	15	20	30	40
1	.0001	.0005	.001	.005	.010	.020	.053	.111	.176	.250	.429	.667
2	.014	.032	.046	.105	.153	.223	.381	.595	.796	1.00	1.45	2.00
3	.087	.152	.194	.340	.455	.602	.899	1.27	1.60	1.93	2.63	3.48
4	.235	.362	.439	.701	.869	1.09	1.62	2.05	2.50	2.95	3.89	5.02
5	.452	.649	.762	1.13	1.36	1.66	2.22	2.88	3.45	4.01	5.10	6.60
6	.728	.996	1.15	1.62	1.91	2.28	2.96	3.76	4.44	5.11	6.51	8.19
7	1.05	1.39	1.58	2.16	2.50	2.94	3.74	4.67	5.46	6.23	7.86	9.80
8	1.42	1.83	2.05	2.73	3.13	3.63	4.54	5.60	6.50	7.37	9.21	11.4
9	1.83	2.30	2.56	3.33	3.78	4.34	5.37	6.55	7.55	8.52	10.6	13.0
10	2.26	2.80	3.09	3.96	4.46	5.08	6.22	7.51	8.62	9.68	12.0	14.7
11	2.72	3.33	3.65	4.61	5.16	5.84	7.08	8.49	9.69	10.9	13.3	16.3
12	3.21	3.88	4.23	5.28	5.88	6.61	7.95	9.47	10.8	12.0	14.7	18.0
13	3.71	4.45	4.83	5.96	6.61	7.40	8.83	10.5	11.9	13.2	16.1	19.6
14	4.24	5.03	5.45	6.66	7.35	8.20	9.73	11.5	13.0	14.4	17.5	21.2
15	4.78	5.63	6.08	7.38	8.11	9.01	10.6	12.5	14.1	15.6	18.9	22.9
16	5.34	6.25	6.72	8.10	8.88	9.83	11.5	13.5	15.2	16.8	20.3	24.5
17	5.91	6.88	7.38	8.83	9.65	10.7	12.5	14.5	16.3	18.0	21.7	26.2
18	6.50	7.52	8.05	9.58	10.4	11.5	13.4	15.5	17.4	19.2	23.1	27.8
19	7.09	8.17	8.72	10.3	11.2	12.3	14.3	16.6	18.5	20.4	24.5	29.5
20	7.70	8.83	9.41	11.1	12.0	13.2	15.2	17.6	19.6	21.6	25.9	31.2

III – Write all equations and make the necessary steps to find the correct answer . You can make use of the given traffic table. (3 Points)

A PBX provides access to outgoing public telephone lines. If there are 60 requests per hour for the public lines with an average holding time of 9 minutes; how much public lines are needed to achieve blocking probability less than 2%?

If the request rate is doubled, find the blocking probability in this new case.