## Electrical Engineering Department

## Digital Communication Systems (802421) – G1

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Term 2 (1435-1436)

First Exam, Sunday 16/06/1436 H

الاسم:                                                                                    الرقم الجامعي:

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Q1. Choose the correct answer: (21 *Marks*, 1 *Each*)

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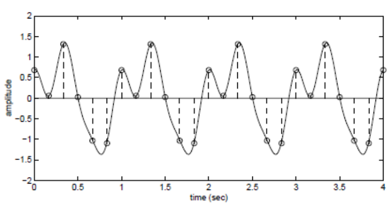
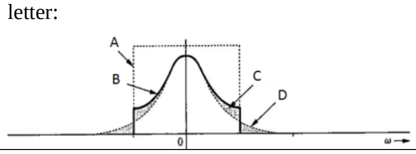
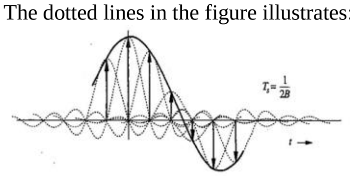
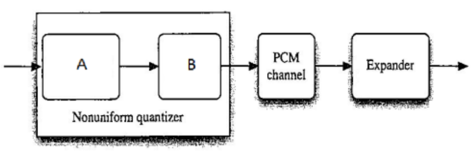
|---|---|---|
| 1. | At each regenerative repeater station in digital communication system, the received signal is: | a) Filtered and then amplified.<br>b) Amplified and then filtered.<br>c) Detected, corrected and retransmitted.<br>d) Detected and a clean signal is transmitted. |
| | | |
| 2. | Given the two signals $m_1(t)$ and $m_2(t)$ with bandwidths $B_1$ and $B_2$ (respectively). The bandwidth of the signal $m_1(t)*m_2(t)$ is: | a) The maximum of $B_1$ and $B_2$.<br>b) The minimum of $B_1$ and $B_2$.<br>c) The sum of $B_1$ and $B_2$.<br>d) The difference between $B_1$ and $B_2$. |
| | | |
| 3. | The signal shown in the figure is sampled at a rate 20% above the Nyquist rate. The bandwidth *B* of the signal shown (in Hz) is:<br><br> | a) 3<br>b) 2.5<br>c) 6<br>d) 5 |
| | | |
| 4. | In the following figure, Aliasing is appointed by the letter:<br><br> | a) A<br>b) B<br>c) C<br>d) D |
| | | |
| 5. | The solution to aliasing problem is to use antialiasing filter with cutoff frequency equals: | a) $f_s/2$<br>b) $f_s$<br>c) $2B$<br>d) $B$ |
| | | |
| 6. | Given an audio signal used for intelligibility application. If the signal is sampled at Nyquist rate and quantized using 518 levels, the data rate of the transmitted signal is calculated as: | a) $20{,}000 \times 2 \times \lceil \log_2(518) \rceil$<br>b) $3500 \times 2 \times \log_2(518)$<br>c) $7000 \times \log_2(1024)$<br>d) $20{,}000 \times 2 \times 10$ |
| | | |

**Commented [m1]:** No of samples per second is 6. This is the actual sampling rate in Hz.
$R_A = 6$ Hz $= 1.2\ R_N$
➔ $R_N = 6 / 1.2 = 5$ Hz
➔ $B = R_N / 2 = 2.5$ Hz

| | | |
|---|---|---|
| 7. | In the block diagram of digital communication system, the input to the Source Encoder is: | a) Continuous-time message signal.<br>b) 11000111010100.<br>c) PCM code.<br>d) PAM signal. |
| | | |
| 8. | Given the two signals $m_1(t)$ and $m_2(t)$ with bandwidths 100 and 40 Hz, respectively. The bandwidth of the signal $m_1^3(t)\times m_2^2(t)$ is: | a) 300<br>b) 380<br>c) 140<br>d) 340 |
| | | |
| 9. | In PPM modulation technique, which parameter of a periodic pulse train is varied (modified) by the sample values? | a) Amplitude<br>b) Width<br>c) Period<br>d) Location |
| | | |
| 10. | The dotted lines in the figure illustrates:<br><br> | a) Impulse response of the anti-aliasing filter at each signal sample.<br>b) Sampled signal at the receiver.<br>c) Reconstructed signal at the receiver.<br>d) Impulse response of the reconstruction filter at each signal sample. |
| | | |
| 11. | In communication system, as the distance increases from the transmitter: | a) The amplitude attenuation increases and noise power increases.<br>b) The amplitude attenuation decreases and noise power increases.<br>c) The amplitude attenuation increases and noise power decreases.<br>d) The amplitude attenuation decreases and noise power decreases. |
| | | |
| 12. | Which one of the following noises can be eliminated? | a) Interference from signals transmitted on nearby channels.<br>b) Random emissions.<br>c) Thermal motion of electrons in conductors.<br>d) Internal noise. |
| | | |
| 13. | A signal $m(t)$ is sampled using Nyquist rate, then quantized into 64 levels. If the quantizer accepts 5 mV maximum amplitude, the maximum possible quantization error is: | a) 0 mV<br>b) 0.156 mV<br>c) 0.078 mV<br>d) 2.5 mV |
| | | |
| 14. | By studying the advantages of digital communication, every two or three years, the cost of digital hardware: | a) Halves while performance doubles.<br>b) Doubles while performance halves.<br>c) Halves while performance also halves.<br>d) Doubles while performance also doubles. |
| | | |
| 15. | When using pulse modulation in digital communication, we can transmit several baseband signals simultaneously by using: | a) TDM & FDM (as in analog communication)<br>b) Only TDM (unlike analog communication)<br>c) Only FDM (as in analog communication)<br>d) TDM & FDM (unlike analog communication). |
| | | |

**Commented [W2]:** (3 x 100) + (2 x 40) = 380

**Commented [m3]:** $m_p$ = 5 mV, L = 64
Max. quantization error = $\Delta v$ / 2 = $m_p$ / L
= 5m / 64
= 0.078 mV.
Note that:
Min. quantization error = 0.

| | | |
|---|---|---|
| 16. | The signal $m(t) = \cos(200\pi t) + \sin(100\pi t)$ is to be sampled, quantized and digitally transmitted. For complete recovery (reconstruction) of the signal $m(t)$, the following condition should be satisfied: | a) $f_s \geq 100$ Hz<br>b) $f_s \geq 200$ Hz<br>c) $f_s > 100$ Hz<br>d) $f_s > 200$ Hz |
| 17. | A PCM signal with 1 mV amplitude is to travel along 3000 km. If the amplitude is attenuated by 0.2 mV every 10 km, find the minimum number of regenerative repeaters required to withstand this distortion (given that the minimum amplitude which can be interpreted by the receiver as high voltage is 0.2 mV). | a) 50<br>b) 75<br>c) 100<br>d) 300 |
| 18. | In digital quantization, the relation between the SNR and transmission bandwidth is: | a) $SNR\ \alpha\ (2)^{B_T/B}$<br>b) $SNR\ \alpha\ (2)^{2B_T/B}$<br>c) $SNR\ \alpha\ (2)^{B/B_T}$<br>d) $SNR\ \alpha\ (2)^{2B/B_T}$ |
| 19. | In the blockdiagram shown below, systems A and B are:<br> | a) A is nonlinear compressor. B is uniform quantizer.<br>b) A is linear compressor. B is uniform quantizer.<br>c) A is uniform quantizer. B is nonlinear compressor.<br>d) A is uniform quantizer. B is linear compressor. |
| 20. | An ECG signal $m(t)$ band-limited to 100 Hz is sampled at a rate 28% above the Nyquist rate. The maximum acceptable uniform quantization error is 0.2% of the peak signal amplitude $m_p$.<br><br>The minimum channel bandwidth required to transmit this signal is: | a) 2.304 kHz.<br>b) 1.152 kHz.<br>c) 900 Hz.<br>d) 1.8 kHz. |
| 21. | In Q. 20, If the "mean-square" value of $m(t)$ is a 0.1 Watt and the amplitude of each quantization level is 2 mV, the "signal-to-quantization-noise" (SQNR) ratio of the quantizer output (in dB) is: | a) 300,000<br>b) 54.77<br>c) 5.477<br>d) None of the above |

**Commented [m4]:** We have two sinusoids with different frequencies. The total bandwidth is the higher frequency which is $200\pi$ (rad/s). That is 100 Hz.

Since there is an impulse (high power) at $f = 100$ Hz, sampling rate must be larger than (and not equal to) Nyquist rate which is $2B = 200$ Hz.

**Commented [W5]:** Min. amplitude allowed is 0.2 mV
Every 10 km, amplitude is attenuated by 0.2 mV
➔Every 40 km, amplitude is attenuated by 0.8 mV and amplitude becomes 0.2 mV.
➔No. of repeaters = 3000 / 40 = 75

**Commented [m6]:** $R_N = 2B = 200$ Hz.
$R_A = 1.28\ R_N = 256$ Hz.
Max. quantization error = $\Delta v / 2$
$= m_p / L = 0.2\ m_p / 100$.
➔$L = 500$
➔$n$ = Ceiling [$\log_2 (500)$] = 9 bits/sample.
➔Data Rate = $n\ R_A = 9 \times 256 = 2.304$ kbps.
➔$B_T$ = Data Rate / 2 = 1.152 kHz.

**Commented [m7]:** $\widetilde{m^2(t)} = 0.1$ W.
$\Delta v = 2$ mV = $2m_p / L$ ➔ $m_p = 500$ mV.

SQNR is:
$$\frac{S_o}{N_o} = 3L^2 \frac{\widetilde{m^2(t)}}{m_p^2}$$
$= 3 \times (500)^2 \times 0.1/(0.5)^2 = 300,000$

➔ SQNR in dB = $10 \log_{10} (300,000) = 54.77$

**Useful relations:**

$$\frac{W}{\pi}\operatorname{sinc}(Wt) \xleftrightarrow{F} rect\left(\frac{\omega}{2W}\right) \qquad \frac{W}{2\pi}\operatorname{sinc}^2\left(\frac{Wt}{2}\right) \xleftrightarrow{F} \Delta\left(\frac{\omega}{2W}\right)$$

Where $W$ in the right-hand-side is the bandwidth and $\omega$ is the frequency variable, both in (rad/s).

$$\Delta v = \frac{2m_p}{L} \qquad N_o = N_q = \frac{m_p^2}{3L^2} \qquad \frac{S_o}{N_o} = 3L^2 \frac{\widetilde{m^2(t)}}{m_p^2}$$

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