Electrical Engineering Department

Digital Communication Systems (802421) - G2

Dr. Mouaaz Nahas

Term 2 (1434-1435)

First Exam, Thursday 03/061435 H

الاسم: الرقم الجامعي:

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Q1. Choose the correct answer: (19 *Marks*, 1 *Each*)

1.	In digital communication system, the filter placed before the sampler is called:	**a) Antialiasing filter.** b) Aliasing filter. c) Reconstruction filter. d) Low-pass filter.
2.	If the sinusoidal signal $m(t)$, band-limited to B Hz is sampled at B Hz, the reconstructed signal at the receiver will be:	a) Completely different AC signal b) Same as $m(t)$ waveform but with different amplitude c) Same as $m(t)$ waveform but with different frequencies **a) DC signal**
3.	The bandwidth of the signal $m(t) = \text{sinc}\,(50\pi t) + \text{sinc}^2\,(60\pi t)\ \text{sinc}\,(60\pi t)$ is:	a) 50 Hz **b) 90 Hz** c) 60 Hz d) 120 Hz
4.	If the number of quantization levels used in an A/D conversion is 262146, the minimum number of binary bits per sample is:	a) 20 b) 19 c) 18 d) None of the above
5.	Undersampling is the process of sampling a signal with a sampling frequency lower than Nyquist rate. Undersampling is therefore:	a) Good because it helps to avoid aliasing b) Good because it saves bandwidth. c) Bad because it reduces SNR and bandwidth. **d) Bad because it produces low quality or distorted signal at the receiver output.**
6.	An audio signal used for *intelligibility* application has the bandwidth B. If this signal is sampled, digitized then binary-coded using n bits per sample. Practical values for B and L can be:	**a) B = 3.5 kHz, L = 256** b) B = 3.5 MHz, L = 65,536 c) B = 15 kHz, L = 65,536 d) B = 20 kHz, L = 256
7.	Given the signal $m(t) = \sin\,(60\pi t) + \sin\,(100\pi t) + \sin\,(150\pi t)$. Nyquist sampling rate for this signal (in Hz) is:	**a) 150** b) 75 c) 300 d) 310
8.	Given the two signals $m_1(t)$ and $m_2(t)$ with bandwidths 100 Hz and 40 Hz, respectively. The bandwidth of $m_1^3(t).\ m_2^2(t)$ is:	a) 300 **b) 380** c) 140 d) 340

Commented [W1]: Bandwith of sinc ($50\pi t$) is 25 Hz

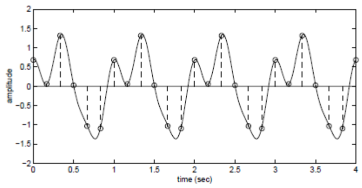
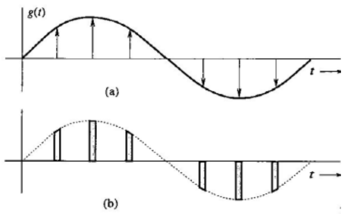
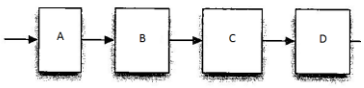
Bandwith of sinc^2 ($60\pi t$) is 60 Hz
Bandwith of sinc ($60\pi t$) is 30 Hz
Bandwith of sinc^2 ($60\pi t$) sinc ($60\pi t$) is 60+30=90 Hz

Bandwith of $m(t)$ is the higher between 25 and 90, it is 90 Hz.

Commented [m2]: $\log_2$ [ceiling(262146)] = 19

Commented [m3]: recall that the sinusoidal format is sin ($2\pi f t$).
Here, we have three frequencies:
f_1 = 30 Hz, f_1 = 50 Hz, f_1 = 75 Hz
Nyquist rate equals twice the highest frequency, that is 75 x 2 = 150 Hz.

Commented [W4]: 3x100 + 2x40 = 380

9.	For the two signals given in Q.9, The bandwidth of $m_1(t) * m_2(t)$ is:	a) 280 b) 140 c) 100 **d) 40**
10.	The signal shown in the figure is sampled at Nyquist rate, the bandwidth B of the signal (in Hz) is: 	a) 1 b) 2 **c) 3** d) 6
11.	Consider the two unmodulated and modulated signals shown in the figure. The modulated signal is: 	a) Flat-top PAM signal **b) Natural PAM signal** c) Natural PDM signal d) Natural PPM signal
12.	Which one of the following pulse-modulation techniques is the most power-efficient?	a) PWM b) PAM c) PPM **d) PCM**
13.	The block diagram below shows the building blocks of the complete PCM system. The blocks A, B, C and D (in order) are: 	a) LPF, Quantizer, Sampler and Bit-Encoder **b) LPF, Sampler, Quantizer and Bit-Encoder** c) Sampler, LPF, Quantizer and Bit-Encoder d) Sampler, LPF, Bit-Encoder and Quantizer
14.	In uniform quantization, SQNR increases as:	a) Quantization levels decrease b) Signal peak amplitude increases **c) Signal average power increases** d) Quantizer limits expand
15.	The sinusoidal signal $m(t)$ with frequency 50 Hz is to be sampled, the following condition should be satisfied for proper reconstruction:	**a) $f_s > 100$ Hz** b) $f_s = 100$ Hz c) $f_s \geq 100$ Hz d) None of the above
16.	A signal $m(t)$ with maximum amplitude 2.5 mV is sampled, quantized and digitally transmitted. If each quantization interval is 0.039 mV, the number of quantization levels used is:	a) 64 **b) 128** c) 256 d) None of the above

Commented [W5]: $m_1(t) * m_2(t) \leftrightarrow M_1(f)\, M_2(f)$
Bandwidth is the lower (smaller).

Commented [m6]: In each second, we have 6 samples. So Nyquist rate is 6 samples/sec (or 6 Hz). Therefore, B is half this value which is 3 Hz.

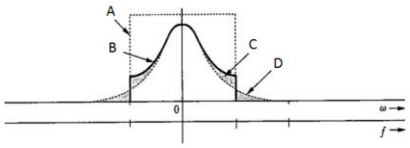
Note that B here is the highest sinusoidal frequency.

Commented [m7]: PPM is also power efficient as the modulated parameter is the pulse position while amplitude and width are fixed.

However, with PCM, we can use a rectangular pulse for the bit **1** (as with PPM) and no pulse for the bit **0**, allowing more power to be saved.

Commented [W8]: Since there is an impulse (high power) at f = 50 Hz.
B = 50 Hz, so f_s should be larger than (but not equal to) $2B$ = 100 Hz.

Commented [W9]: $L = 2m_p / \Delta v = 5m / 0.039m = 128.21 \approx 128$

17.	In the following figure, Aliasing is appointed by the letter: 	a) A
		b) B
		c) C
		d) D
18.	Aliasing is described mathematically as:	a) Lost tail of $G(f)$ beyond $\lvert f \rvert < f_s/2$.
		b) Lost tail of $G(f)$ beyond $\lvert f \rvert > f_s/2$.
		c) Tail of $G(f)$ beyond $\lvert f \rvert < f_s/2$ inverted back on $G(f)$.
		d) Tail of $G(f)$ beyond $\lvert f \rvert > f_s/2$ inverted back on $G(f)$.
19.	The solution to aliasing is:	a) Passing the signal $G(f)$ into a low pass filter with cutoff frequency $2f_s$ Hz
		b) Passing the signal $G(f)$ into a low pass filter with cutoff frequency f_s Hz
		c) Passing the signal $G(f)$ into a low pass filter with cutoff frequency $f_s/2$ Hz
		d) There is no practical solution

Q2. Solve this question on the back side of this page. (3 *Marks*)

A television signal (video and audio) has a bandwidth of 4.5 MHz. This signal is sampled, quantized, and binary coded to obtain a PCM signal.

(a) Determine the sampling rate if the signal is to be sampled at a rate 20% above the Nyquist rate.

(b) If the samples are quantized into 1024 levels, determine the number of binary pulses required to encode each sample.

(c) Determine the binary pulse rate (bits per second) of the binary-coded signal, and the minimum bandwidth required to transmit this signal.

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Useful relations:

$$2B\text{sinc}(2\pi Bt) \overset{F}{\longleftrightarrow} rect\left(\frac{f}{2B}\right)$$

$$B\text{sinc}^2(\pi Bt) \overset{F}{\longleftrightarrow} \Delta\left(\frac{f}{2B}\right)$$

$$S_o = \widetilde{m^2(t)}$$

$$N_o = N_q = \frac{m_p^2}{3L^2}$$

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Q2. **Solution:**

(a) $R_N = 2B = 9 \text{ MHZ}$.

$R_A = 1.2 \times 9 \text{ M} = 10.8 \text{ MHZ}$.

(1.2 → 20%)

Actual sampling rate (R_A)

(b) $L = 1024$

$n = \log_2 1024 = 10$ bits / sample.

(c) Binary Pulse rate $= n R_A = 10 \times 10.8 \text{ M}$

$= 108 \text{ M bps}$.

Min. bandwidth $= \frac{n R_A}{2} = 54 \text{ MHZ}$.