Electrical Engineering Department

Digital Communication Systems (802421) – G2

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Term 1 (1435-1436)

First Exam, Thursday 20/01/1436 H

الاسم: الرقم الجامعي:

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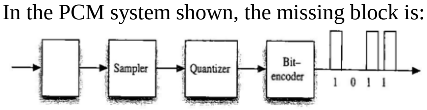
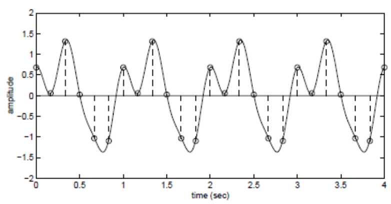
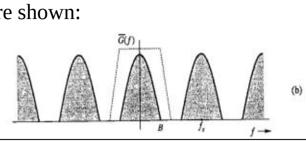
Q1. Choose the correct answer: (21 *Marks*, 1 *Each*)

1.	If a sinusoidal signal $m(t)$, band-limited to B Hz is sampled at B Hz, the reconstructed (recovered) signal at the receiver will be:	a) DC signal.
		b) Same as $m(t)$ waveform but with different amplitude.
		c) Same as $m(t)$ waveform but with different frequencies.
		d) Non-sinusoidal AC signal.
2.	In the PCM system shown, the missing block is: 	a) A/D converter.
		b) Bit encoder.
		c) Antialiasing filter.
		d) Time-division multiplexer.
3.	The bandwidth of the signal $m(t) = \text{sinc}^2\,(100\pi t) + \text{sinc}\,(60\pi t)$ is:	a) 50 Hz
		b) 60 Hz
		c) 100 Hz
		d) 120 Hz
4.	At each regenerative repeater station in digital transmission, the signal is:	a) Filtered and then amplified.
		b) Amplified and then filtered.
		c) Detected and corrected before re-transmission.
		d) Detected and a new signal is generated.
5.	Given that the number of quantization levels used in an A/D conversion is 1,048,581. The minimum number of binary bits that can be used to encode each sample is:	a) 19
		b) 20
		c) 21
		d) None of the above
6.	In Analog-to-Digital (A/D) conversion, the PWM signal is:	a) Analog and continuous.
		b) Analog and discrete.
		c) Digital and continuous.
		d) Digital and discrete.
7.	In the Compact Disk (CD) application where the audio signal bandwidth B is 20 kHz and the number of quantization levels is 65,536:	a) R_A = 40 kHz, Data Rate = 1.28 Mbps.
		b) R_A = 44.1 kHz, Data Rate = 1.4 Mbps.
		c) R_A = 40 kHz, Data Rate = 640 kbps.
		d) R_A = 44.1 kHz, Data Rate = 705.6 kbps.

Commented [m1]: The higher bandwidth.

*B*1 = 100 Hz.
*B*2 = 30 Hz.

8.	Given the two signals: $m_1(t) = \text{sinc}\,(200\pi t)$ $m_2(t) = \text{sinc}^2\,(80\pi t)$ The bandwidth of $m_1(t)\, m_2(t)$ in Hz is:	a) 80
		b) 100
		c) 180
		d) 280
9.	For the two signals given in Q.8, the bandwidth of $m_1(t) * m_2(t)$ in Hz is:	a) 80
		b) 100
		c) 180
		d) 280
10.	In practical digital communication systems, the signal obtained at the receiver output is: *Hint: recall the interpolation formula used at the receiver to recover the original message.*	a) $\sum_k m(kT_s)\text{sinc}(2\pi t - k\pi)$
		b) $\sum_k \hat{m}(kT_s)\text{sinc}(2\pi t - k\pi)$
		c) $\sum_k \overline{m}(kT_s)\text{sinc}(2\pi t - k\pi)$
		d) $\overline{m}(t) * \text{sinc}(2\pi Bt)$
11.	The signal shown in the figure is sampled at Nyquist rate, the sampling rate used (in Hz) is: 	a) 1
		b) 2
		c) 3
		d) 6
12.	In Q.8, the bandwidth B of the signal shown (in Hz) is:	a) 1
		b) 2
		c) 3
		d) 6
13.	In the figure shown: 	a) $T_s < 1/2B$
		b) $T_s > 1/2B$
		c) $G(f)$ is sampled at a rate above Nyquist rate
		d) a) and c)
14.	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 0.4 mV).	a) 50
		b) 100
		c) 200
		d) 300
15.	A signal $m(t)$ with maximum amplitude 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) 257

Commented [m2]: The sum of the two bandwidths.

$B1$ = 100 Hz.
$B2$ = 80 Hz.
➔ $B1 + B2$ = 180 Hz.

Commented [m3]: The lower bandwidth.

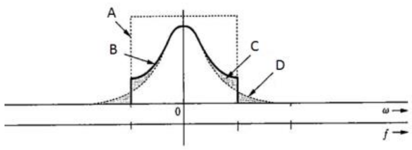
Commented [m4]: In each second, we have 6 samples. So Nyquist rate is 6 samples/sec (or 6 Hz).

Commented [m5]: Since Nyquist rate is 6 samples/sec (or 6 Hz), B is half this value which is 3 Hz.

Note that B here is the highest sinusoidal frequency.

Commented [m6]:
Min. amplitude allowed is 0.4 mV
Every 10 km, amplitude is attenuated by 0.2 mV
➔Every 30 km, amplitude is attenuated by 0.6 mV and amplitude becomes 0.4 mV.
➔ No. of repeaters = 3000 / 30 = 100

Commented [W7]:
$L = 2m_p / \Delta v$ = 10m / 0.039m = 256.4 ≈ 256
Here, no ceiling function is used. The ceiling function is used when finding *n* only.

16.	Given an audio signal with bandwidth 3.5 kHz. If the signal is sampled at Nyquist rate and quantized using 340 levels, the data rate of the transmitted signal is:	a) 28 kbps b) 63 kbps c) 56 kbps d) None of the above
17.	In the following figure, Aliasing is appointed by the letter: 	a) A b) B c) C d) D
18.	The solution to aliasing problem 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
19.	A signal $m(t)$ is sampled using Nyquist rate, then quantized into 64 levels. If the quantizer accepts 5 mV maximum amplitude, the minimum possible quantization error is:	a) 0 mV b) 0.156 mV c) 0.078 mV d) 2.5 mV
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. The minimum channel bandwidth required to transmit this signal is:	a) 2.304 kHz. b) 1.152 kHz. c) 900 Hz. 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 b) 54.77 c) 5.477 d) None of the above

Commented [m8]:
Nyquist rate = 7 kHz (sample/s).
L=340 → n = Ceiling [$\log_2$ (340)] = 9 bits/sample.
Data rate = 7 k x 9 = 63 kbits/s.

Commented [m9]:
$R_N = 2B = 200$ 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 x 256 = 2.304 kbps.
➔ B_T = Data Rate / 2 = 1.152 kHz.

Commented [m10]:
$\widetilde{m^2(t)}$ = 0.1 W.
Δv = 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 x $(500)^2$ x $0.1/(0.5)^2$ = 300,000

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

Useful relations:

$$\frac{W}{\pi}\,\mathrm{sinc}\,(Wt) \overset{F}{\longleftrightarrow} rect\,(\frac{\omega}{2W}) \qquad \frac{W}{2\pi}\,\mathrm{sinc}^2\,(\frac{Wt}{2}) \overset{F}{\longleftrightarrow} \Delta\,(\frac{\omega}{2W})$$

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

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

GOOD LUCK