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Sheet 4

Problem#1

6.1-2 Determine the Nyquist sampling rate and the Nyquist sampling interval for the signals: **(a)** $\text{sinc}\,(100\pi t)$; **(b)** $\text{sinc}^2\,(100\pi t)$; **(c)** $\text{sinc}\,(100\pi t) + \text{sinc}\,(50\pi t)$; **(d)** $\text{sinc}\,(100\pi t) + 3\,\text{sinc}^2\,(60\pi t)$; **(e)** $\text{sinc}\,(50\pi t)\text{sinc}\,(100\pi t)$.

Problem#2

6.1-3 A signal $g(t)$ band-limited to B Hz is sampled by a periodic pulse train $p_{T_s}(t)$ made up of a rectangular pulse of width $1/8B$ seconds (centered at the origin) repeating at the Nyquist rate ($2B$ pulses per second). Show that the sampled signal $\overline{g}(t)$ is given by

$$\overline{g}(t) = \frac{1}{4}g(t) + \sum_{n=1}^{\infty} \frac{2}{n\pi} \sin\left(\frac{n\pi}{4}\right) g(t) \cos n\omega_s t \qquad \omega_s = 4\pi B$$

Show that the signal $g(t)$ can be recovered by passing $\overline{g}(t)$ through an ideal low-pass filter of bandwidth B Hz and a gain of 4.

Problem#3

6.1-4 A signal $g(t) = \text{sinc}^2(5\pi t)$ is sampled (using uniformly spaced impulses) at a rate of: **(i)** 5 Hz; **(ii)** 10 Hz; **(iii)** 20 Hz. For each of the three case:

(a) Sketch the sampled signal.

(b) Sketch the spectrum of the sampled signal.

(c) Explain whether you can recover the signal $g(t)$ from the sampled signal.

(d) If the sampled signal is passed through an ideal low-pass filter of bandwidth 5 Hz, sketch the spectrum of the output signal.

Problem#4

6.2-1 The American Standard Code for Information Interchange (ASCII) has 128 characters, which are binary coded. If a certain computer generates 100,000 characters per second, determine the following:

(a) The number of bits (binary digits) required per character.

(b) The number of bits per second required to transmit the computer output, and the minimum bandwidth required to transmit this signal.

(c) For single error-detection capability, an additional bit (parity bit) is added to the code of each character. Modify your answers in parts **(a)** and **(b)** in view of this information.

Problem#5

6.2-2 A compact disc (CD) records audio signals digitally by using PCM. Assume the audio signal bandwidth to be 15 kHz.

(a) What is the Nyquist rate?

(b) If the Nyquist samples are quantized into $L = 65,536$ levels and then binary coded, determine the number of binary digits required to encode a sample.

(c) Determine the number of binary digits per second (bit/s) required to encode the audio signal.

(d) For practical reasons discussed in the text, signals are sampled at a rate well above the Nyquist rate. Practical CDs use 44,100 samples per second. If $L = 65,536$, determine the number of bits per second required to encode the signal, and the minimum bandwidth required to transmit the encoded signal.

Problem#6

Prob 6) A signal of bandwidth =1KHz is transmitted by binary PCM, the maximum tolerable error in sample amplitude is 0.2% of the peak signal amplitude ,the signal must be sampled at rate 20% above the nyquist rate .framing and synchronization requires an additional 0.5 % extra bits. Determine the minimum possible data rate needed for transmitting this signal.

Problem#7

6.2-6 A message signal $m(t)$ is transmitted by binary PCM without compression. If the SNR (signal-to-quantization-noise ratio) is required to be at least 47 dB, determine the minimum value of L required, assuming that $m(t)$ is sinusoidal. Determine the SNR obtained with this minimum L.