DSA-Assignment-2

Deadline: 6th April, 2023

Instructions

1. Deadline for the assignment is **6th April, 2023**
2. Solve all the question and submit a handwritten document
3. Plagiarism will be penalised
4. Submit a pdf of the form <**roll_no**>**_dsa2.pdf**

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1 Signals

1. Indicate if the following signals are periodic signals. If periodic, find the fundamental period.
   (a) $x[n] = sin^2(3n + \pi)$
   (b) $x[n] = e^{j\pi n/8}$
   (c) $x[n] = cos(\pi n/10)cos(\pi n/30)$
   (d) $x[n] = sin(4\pi n + 3)$
   (e) $x[n] = cos(\pi n^2/3)$
   (f) $x[n] = \sum_{k=-\infty}^{\infty}(-1)^k\delta(n-k)$

2. Find the odd and even parts of the following discrete signals
   (a) $x[n] = \sqrt{2}cos((an + 1/4)\pi)$
   (b) $x[n] = e^{jan\pi} + e^{jn\pi/b}$

3. Determine whether the following signals are energy or power signals or neither
   (a) $x[n] = \begin{cases} 0 & n < 0 \\ n & n \geq 0 \end{cases}$
   (b) $x[n] = cos(n\pi/2)$
   (c) $x[n] = \begin{cases} 3^n & n < 0 \\ (1/2)^n & n \geq 0 \end{cases}$
   (d) $x[n] = a^n u(n),\ a \in R$
   (e) $x[n] = e^n\delta(n-4)$

2 Systems

1. Determine whether or not the following systems are time invariant
   (a) $y(t) = t^2 x(t-1)$
   (b) $y[n] = x[n-1] + x[n+1]$
   (c) $y[n] = \frac{1}{x[n]}$
   (d) Consider a system S with input $x[n]$ and output $y[n]$ related by $y[n] = x[n](g[n] + g[n-1])$.
      i. If $g[n] = 1$ for all n, show that S is time invariant.
      ii. If $g[n] = n$, show that S is not time invariant.
      iii. If $g[n] = 1 + (-1)^n$, show that S is time invariant.

2. Determine whether or not the following systems are linear
   (a) $y(t) = x(sint)$
   (b) $y(t) = \begin{cases} 0 & t < 0 \\ x(t) + x(t-2) & t \geq 0 \end{cases}$
   (c) $y(t) = \frac{d(x(t))}{dt}$
   (d) $y[n] = \sum_{m=0}^{M} ax[n-m] + \sum_{m=1}^{N} bx[n-m]$
   (e) $y[n] = ax[n] + b\frac{1}{x[n-1]}$

3. Determine whether or not the following systems are causal
   (a) $y(t) = x(t-2) + x(2-t)$
   (b) $y(t) = [cos(3t)]x(t)$
   (c) $y(t) = \int_{-\infty}^{2t} x(k)dk$
   (d) $y[n] = \sum_{k=0}^{\infty} x[n+k]$
   (e) $y[n] = \sum_{k=0}^{\infty} x[n-k]$

3 Sampling Frequency

1. What is aliasing? What can be done to reduce aliasing?
   Let $x(t) = \frac{1}{2\pi} cos(4000\pi t)cos(1000\pi t)$ be a continuous-time signal.Find the Nyquist rate and Nyquist interval for this signal.

2. A waveform, $x(t) = 10cos(1000t + \pi/3) + 20cos(2000t + \pi/6)$ is to be uniformly sampled for digital transmission.What is the maximum allowable time interval between sample values that will ensure perfect signal reproduction? If we want to reproduce 1 hour of this waveform, how many sample values need to be stored?

3. Consider three signals $x1(t)$ and $x2(t)$ and $x3(t)$ with Fourier transforms satisfying:

$$X1(\Omega) = 0, 120 \leq |\Omega|$$
$$X2(\Omega) = 0, |\Omega| \leq 60, |\Omega| \geq 100$$

Determine the minimum frequency Ω_s at which we must sample the following signals to prevent aliasing.

   (a) $x(t) = x_1(t) + x_2(t)$

   (b) $x(t) = x_1(t)x_2(t)$

   (c) $x(t) = cos(3.6\pi t + 9.23)$

4 Quantization

1. Consider the analog waveform x(t) and answer the following questions.

$$x(t) = \begin{cases} -2\sin(\pi x/4) & 0 \leq x < 4 \\ x - 4 & 4 \leq x < 5 \\ 1 & 5 \leq x < 7 \\ 8 - x & 7 \leq x \leq 10 \end{cases}$$

It is sampled at 1000 Hz and quantized with a 2-bit quantizer with input range -2V to 2V.

   (a) Indicate the sample points.

   (b) State the quantization intervals and the corresponding digital words.

   (c) Sketch the digital word assigned to each sample point.

   (d) Indicate the stream of bits generated after the quantization is complete.

   (e) What is the resulting bit rate?

   (f) What is the quantization error?

Answer all of the above questions for a 3-bit quantizer as well.

2. Mention advantages/disadvantages of increasing quantization bits.