DSP Midterm Exam

Spring 2022

Question 1: True or False

Given a DT signal $x(n) = \delta(n) - \delta(n-2)$, please select **T**rue or **F**alse for the following statements:

(a) **T** or **F**: The value of $x(n)$ at $n = 0$ is zero.

(b) **T** or **F**: The value of $x(n)$ at $n = 1$ is zero.

(c) **T** or **F**: The length of $x(n)$ is 2.

(d) **T** or **F**: The energy of $x(n)$ is 2.

(e) **T** or **F**: $x(n)$ is a periodic signal.

Question 2: Operations on DT signals

Two DT signals, $x_1(n)$ and $x_2(n)$, are given as follows:

$$x_1(n) = \delta(n) - \delta(n-1)$$
$$x_2(n) = \delta(n) + 2\delta(n-1) + \delta(n-2)$$

Sketch the following (showing your work):

(a) $x_1(n) + x_2(n+1)$

(b) $x_1(n) * x_2(n+1)$ [*Note*: The $*$ is convolution.]

Question 3: DTFT computation

A DT signal $x(n)$ is given as follows:

$$x(n) = 2\delta(n+1) + 4\delta(n) + 2\delta(n-1)$$

(a) Compute the signal's DTFT $X(e^{j\omega})$. You can use the table of DTFT transform pairs provided in class. You do not have to simplify your answer here in (a).

(b) Write an expression for the magnitude spectrum $|X(e^{j\omega})|$. For full credit, simplify your answer.

(c) Write an expression for the phase spectrum $\measuredangle X(e^{j\omega})$. For full credit, simplify your answer.

(d) Let $y(n) = 10x(n-1)$. Write $Y(e^{j\omega})$ in terms of $X(e^{j\omega})$.

(e) **BONUS**: Let $z(n) = x(n) * x(n-1)$. Write $Z(e^{j\omega})$ in terms of $X(e^{j\omega})$. [*Note*: The $*$ is convolution.]

Question 4: Short Answer

Answer the following questions in one short sentence or less:

(a) What will the spectrum look like for a DT signal that does not change in time?

(b) If you scale a DT signal by 2 (i.e., you double the heights of all of the samples), how does the signal's ***magnitude*** spectrum change?

(c) If you scale a DT signal by 2 (i.e., you double the heights of all of the samples), how does the signal's ***phase*** spectrum change?

(d) If you time-shift a DT signal by 2 to the right, how does the signal's ***magnitude*** spectrum change?

(e) If you time-shift a DT signal by 2 to the right, how does the signal's ***phase*** spectrum change?

(f) If you add $\delta(n)$ to a DT signal, how does the resulting spectrum change? In other words, given that $x(n) \overset{DTFT}{\longleftrightarrow} X(e^{j\omega})$, then $[x(n) + \delta(n)] \overset{DTFT}{\longleftrightarrow}$?

(g) If you multiply a DT signal by $e^{j\pi n}$, how does the resulting spectrum change? In other words, given that $x(n) \overset{DTFT}{\longleftrightarrow} X(e^{j\omega})$, then $\left[e^{j\pi n}x(n)\right] \overset{DTFT}{\longleftrightarrow}$?