Name Answers

**EE-3220-11 – Dr. Durant – Quiz 7**
**Winter 2014-'15, Week 7**

1. (1 point) A voice signal sampled at 10 kHz is intermittently jammed with a loud, 1 kHz tone. Begin the design an IIR notch filter to suppress this tone. What are the radii and angles of the poles and zeros? Present angles in terms of π (e.g., 0.7π).

$\omega_0 = \frac{f}{f_S} \cdot 2\pi = \frac{\pi}{5}$

$z = 1\angle \pm\frac{\pi}{5}$

$p = 0.99\angle \pm\frac{\pi}{5}$

2. (1 point) In MATLAB, x = [4 -3 2 -1] and h = [2 1 0 -1]. y = conv(h,x) is executed and correctly gives y = [8 -2 1 -4 2 -2 1]. What is the value of y2 produced by attempting to perform the convolution with the DFT y2 = ifft(fft(h).*fft(x))? (½) same

circular convolution

8 -2 1 -4
↳ 2 -2 1

10 -4 2 -4

3. (1 point) What is the relationship between the DTFT and the DFT? (Hint: Consider the domain where each is defined.)

The DFT samples the DTFT.

That is, the DFT evaluates the DTFT only at $\omega = \frac{2\pi}{N} \cdot k$, N = # of time samples = # of Freq. samples, $0 \le k < N$

4. (2 points) An analog signal is sampled at 48 kHz. A 256-point DFT is computed. What is the resolution of the DFT in hertz?

$\frac{48\text{kHz}}{256} = \frac{3}{16}\text{kHz} = \frac{3000}{16}\text{Hz} = \frac{375}{2}\text{Hz} = 187.5\text{ Hz}$

5. (2 points) The 256-point sample above 0-padded to 512 samples and then a 512-point DFT is computed. State both the spectral resolution and spectral density of the result.

resolution is unchanged = 187.5 Hz
density doubled ($\frac{512}{256}$) ∴ $\frac{187.5}{2} = 93.75$ Hz

(-3/4) in Hz?
(-3/4) reversed

6. (1 point) Calculate $w_8$, the $12^{th}$ root of unity that represents the minimum magnitude negative angle phase shift in an 12-point DFT. Give your answer in polar form with the angle expressed as a multiple of π.

$W_{8,12} = e^{-j\frac{2\pi}{12}} = e^{-j\frac{\pi}{6}} = \boxed{1\angle\frac{-\pi}{6}}$

$f_s \geq 3$ kHz, use 3 kHz

7. (2 points) A signal containing frequencies up to 1500 Hz is sampled, and a DFT is computed. If the frequency spacing of the DFT must be no greater than 0.2 Hz, what is the minimum number of samples needed?

resolution

$\frac{3000\text{Hz}}{N} = 0.2\text{Hz}$

$N = 15000$ samples

(-1/4) 2x for aliasing

Name Answer

**EE-3220-21 – Dr. Durant – Quiz 7**
**Winter 2014-'15, Week 7**

1. (1 point) A voice signal sampled at 12 kHz is intermittently jammed with a loud, 2 kHz tone. Begin the design an IIR notch filter to suppress this tone. What are the radii and angles of the poles and zeros? Present angles in terms of π (e.g., 0.7π).

$\omega_0 = \frac{2}{12} 2\pi = \frac{\pi}{3}$

$z = 1 \angle \pm \frac{\pi}{3}$

$p = 0.99 \angle \pm \pi/3$

2. (1 point) In MATLAB, x = [4 -3 2 -1] and h = [2 1 0 -1]. y = conv(h,x) is executed and correctly gives y = [8 -2 1 -4 2 -2 1]. We attempt to perform the convolution in the DFT domain, y2 = ifft(fft(h).*fft(x)), but get the circular convolution result [10 -4 2 -4] instead. Correct the statement assigning to y2 so that it correctly uses the DFT and inverse DFT to compute the standard, linear convolution.

y2 = ifft(fft(h,7).*fft(x,7));

or [h 000]

or [h zeros(1,3)], etc

3. (1 point) What is the relationship between the DTFT and the DFT? (Hint: Consider the domain where each is defined.)

* The DFT samples the DTFT. (↔ DFT is time-limited DTFT, results in sampling in freq.)

DTFT defined for $\forall \omega \in \mathbb{R}$ (all real values)

DFT defined @ $\omega = \frac{2\pi}{N} k$, N samples (in both time & freq.)

$k = 0 \ldots N-1$

4. (2 points) An analog signal is sampled at 16 kHz. A 128-point DFT is computed. What is the resolution of the DFT in hertz?

$\frac{16\ kHz}{128} = \frac{1}{8}\ kHz = \frac{1000}{8}\ Hz = \boxed{125 Hz}$

OR: in $\frac{rad}{samp}$: $\frac{2\pi}{128}$, to Hz → $\frac{2\pi}{128} \cdot \frac{fs}{2\pi} = \frac{fs}{128} = \ldots$

5. (2 points) The 128-point sample above 0-padded to 1024 samples and then a 1024-point DFT is computed. State both the spectral resolution and spectral density of the result.

resolution is unchanged: 125 Hz

density increased by $\frac{1024}{128} = 8 \rightarrow \frac{125}{8} Hz = \boxed{15.625 Hz}$

$8\overline{)125}\ 15.625$
45
50
20
40

(-3/4 pts not Hz)

(-3/4 not rounded)

6. (1 point) Calculate $w_9$, the 9th root of unity that represents the minimum magnitude negative angle phase shift in a 9-point DFT. Give your answer in polar form with the angle expressed as a multiple of π.

$W_N = e^{-j\frac{2\pi}{N}}$

$W_9 = e^{-j\frac{2\pi}{9}} = \boxed{1\angle -\frac{2\pi}{9}}$

7. (2 points) A signal containing frequencies up to 2000 Hz is sampled, and a DFT is computed. If the frequency spacing of the DFT must be no greater than 0.05 Hz, what is the minimum number of samples needed?

(-1/4 if forgot units)

$f_s \geq 2f_{max} = 4000 Hz$

let $f_s = 4000$ Hz exactly to minimize N

$res = \frac{F_s}{N} \leq 0.05 Hz$

$N \geq \frac{F_s}{0.05Hz} = \frac{4000}{0.05} = 80{,}000$

minimum is $\boxed{80{,}000}$ samples