
Show work on separate sheets of paper. Include all hand and Matlab plots and code.

[40] 1. For the system $y[n] = x[n] + 3x[n - 1] - 3x[n - 2]$:  
[05] (a) Determine the impulse response $h[n]$.  
[05] (b) Determine the frequency response function $H(e^{j\omega})$.  
[15] (d) If $x[n] = 1 + 2\cos(\frac{\pi}{3}n + 1) + 3\cos(\frac{2\pi}{3}n - 1) + 4\cos(\pi n)$, compute $y[n]$.  
[10] (e) If $x[n] = 2\cos(\frac{\pi}{3}n + 1) + 1 + 3\delta[n - 1]$, compute $y[n]$.  

Hint: Compute the response to the impulse separately, then use linearity.

[25] 2. Frequency response functions—what they look like:  
[05] (a) If $H(e^{j\omega}) = 1 + 2e^{-j2\omega} - 3e^{-j3\omega}$, determine impulse response $h[n]$.  
[10] (b) If $H(e^{j\omega}) = 1 + 2e^{j2\omega} - 3e^{j3\omega}$ compute the 4-point DFT of $h[n]$ without using your answer to (a). (I promised no more by-hand DFTs!)  
[10] (c) If gain $|H(e^{j\omega})| = \sqrt{(1 + 4\cos(\omega))^2 + (2\sin(\omega))^2}$, compute $h[n]$.  

Hint: What are real and imag parts? $\cos \theta = \frac{1}{2}(e^{j\theta} + e^{-j\theta})$. Delay by one.

[15] 3. Simple notch filtering to remove sinusoidal interference:  
[05] (a) Run the line of Matlab code below. This adds 2000 Hz interference to Handel.  
\[
\text{clear;load handel;X=y(27001:35192)'+10*cos(pi*4000*[1:8192]/8192);}
\]
Listen to X using \text{sound(X)}. Describe what you hear in words. Is this annoying?  
[10] (b) Run the line of Matlab code below. Insert a number ‘?’ so 2000 Hz is eliminated.  
\[
\text{Y=filter([1 ? 1],[1],X); YOU HAVE to fill in a number for ‘?’}
\]
Listen to Y using \text{sound(Y)}. Describe what you hear in words. Is this better? Adjust the amplitude of the 2000 Hz sinusoid if necessary for best results.

A simple power supply (like your calculator AC adapter) uses a transformer and diodes to generate a rectified sinusoidal voltage $x(t) = 19.7|\sin(377t)|$ (period = \frac{1}{120} sec).

Fourier series: $x(t) = 12.54 - 25.08 \sum_{k=1}^{\infty} \frac{\cos(754kt)}{4k^2-1}$ where $\frac{2(19.7)}{\pi} = 12.54$.

$x(t) \rightarrow [\text{RC CIRCUIT}] \rightarrow y(t)$. The frequency response of $[\text{RC CIRCUIT}]$ is:

Gain=$|H(f)|=1/\sqrt{1+(f/12)^2}$. Phase=$\angle H(f)=-\tan^{-1}(f/12)$. Note: $f$ is in Hertz.

(10) (a) Compute the Fourier series of $y(t)$ from the Fourier series of $x(t)$.  
by modifying the amplitude and phase of each sinusoid in $x(t)$ according to $H(f)$.  
Explicitly write out the first 5 terms@[2] of the Fourier series expansion of $y(t)$.  
(05) (b) Using Matlab, plot both $x(t)$ and $y(t)$ on the same plot for $0 \leq t \leq 0.1$.  
(05) (c) How big is the ripple (this will be evident) in the power supply output $y(t)$?

"Diplomacy is the art of saying ‘nice doggie’ until you can find a stick."