Final Exam

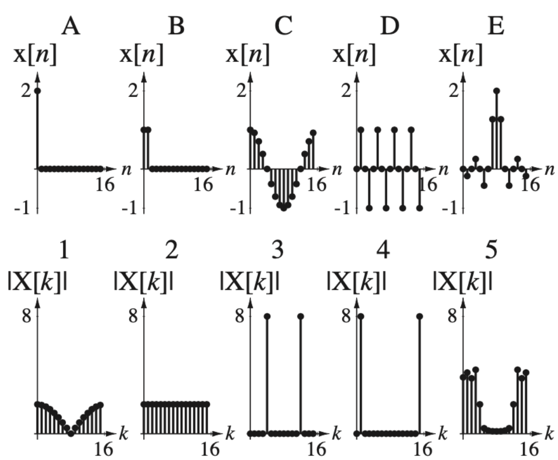
Signal and System, Fall 2022
School of BioMedical Convergence Engineering, PNU
Dec. 12. 14:00 - 17:00

I. Remark

- This is an open book exam. You can use any materials if you want.
- There are a total of 100 points in the exam. Each problem specifies its point total.
- You must SHOW YOUR WORK to get full credit.
- If you just copy your classmate's answers or chat with anyone through any messenger, your total point would be 0.
- [MATLAB] implies that you need to use MATLAB. When you need to plot continuous-time signal x(t), please find the sampling rate f_s in the problem and plot the sampled signal $x[n] = x(t)|_{t/f_s}$. You need to display "time" on x-axis (not just discrete index). Also, when you need to plot $|(X(f)|$ (CTFT spectrum), use 'fft' and 'fftshift' functions and eq. 6.19 in the textbook to draw approximated one. You need to display 'frequency' on x-axis (not just discrete index).

II. Problem Set

1) [10 points] In the figure below, match functions to their DFT magnitudes. It does not need to describe the reason.



2) [10 points] Given $x(t) = \cos(2\pi t/10) + 2\sin(2\pi t/5)$, what is the $c_x[k]$ (CTFS of $x(t)$ with the standard period $T = 10$)? Plot the $|c_x[k]|$ and $\angle c_x[k]$.

3) [10 points] Given $x(t) = \text{sinc}(20t)\text{sinc}(20t)\cos(150\pi t)$, Plot the $|X(f)|$ where $X(f)$ is the CTFT of $x(t)$. Find the Nyquist rate for the signal.

4) [10 points] [MATLAB] The signal $x(t)$ is given as $x(t) = 3\cos(20\pi t) - 2\sin(30\pi t)$ over a time range of $0 < t < 0.4s$. Graph the signal formed by sampling the function at the following sampling frequencies:
   a) $f_s = 120Hz$,
   b) $f_s = 60Hz$,
   c) $f_s = 40Hz$, and
   d) $f_s = 20Hz$.

   When does aliasing happen? What is the Nyquist sampling rate?

5) [10 points] Answer the following questions. You can use tables in the textbook.
   a) What is the CTFT of the function $h(t) = \delta(t) - (2f_1\text{sinc}(2f_1 t) - 2f_0\text{sinc}(2f_0 t))$ where $f_1 > f_0$?
   b) If the impulse response function of one system is $h(t)$, what is the role of the system?
   c) [MATLAB] Plot $h(t)$ over $-5s < t < 5s$. $f_1 = 130Hz$ and $f_0 = 110Hz$. Use $600Hz$ for the sampling frequency f_s.
   d) [MATLAB] Plot $|H(f)|$ over $-300Hz < f < 300Hz$.

6) [20 points] The purpose of the task is making a song. Find the music (score) of the song below. For every scale, use a cosine or sine function. Use the table below describing the sinusoidal frequency of every scale. Assume that the time period for a quarter note is 0.5 sec. The sampling frequency $f_s = 1/T_s$ should be 10000 Hz.

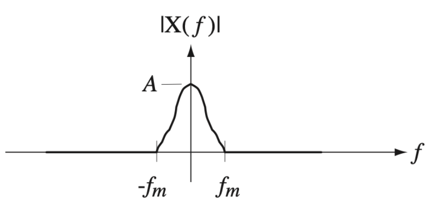
   a) [MATLAB] Use octave 3 for making the signal $x[n] = x(t)|_{t=nT_s}$ of the song. Plot $x(t)$ over time t. Also, plot $|X(f)|$ over frequency f. Use 'xlim([-700 700])' to see only the narrow range $-700Hz < f < 700Hz$. Listen the song x[n] using 'sound()'.
   b) [MATLAB] Down-sample the song as $y[n] = x[2n]$. Here, $y[n] = y(t)|_{t=nT_s}$. Plot $|Y(f)|$ over f. Also, use 'xlim([-700 700])' to

옥타브 및 음계별 표준 주파수

음계 \ 옥타브	1	2	3	4
C(도)	32.7032	65.4064	130.8128	261.6256
C#	34.6478	69.2957	138.5913	277.1826
D(레)	36.7081	73.4162	146.8324	293.6648
D#	38.8909	77.7817	155.5635	311.1270
E(미)	41.2034	82.4069	164.8138	329.6276
F(파)	43.6535	87.3071	174.6141	349.2282
F#	46.2493	92.4986	184.9972	369.9944
G(솔)	48.9994	97.9989	195.9977	391.9954
G#	51.9130	103.8262	207.6523	415.3047
A(라)	55.0000	110.0000	220.0000	440.0000
A#	58.2705	116.5409	233.0819	466.1638
B(시)	61.7354	123.4708	246.9417	493.8833

see the range $-700Hz < f < 700Hz$. Listen the signal $y[n] = y(t)|_{t=nT_s}$ using same sampling frequency f_s. Describe any change of the sound in terms of song time and pitch. Explain reasons of the change in detail.

7) [10 points] $X(f)$ is the CTFT of $x(t)$. Suppose $A = 1$ and $f_m = 10Hz$. $x[n] = x(t)|_{t=n/f_s}$. The graph of $|X(f)|$ is given as



a) Can $x(t)$ be time-limited signal? Demonstrate your answer in detail.
b) Plot DTFT of $x[n]$ if the sampling frequency f_s is $30Hz$

8) [20 points] Do as directed.

a) [MATLAB] Download the file $'handel\_corrupted.mat'$ from Plato. Load the file though MATLAB. Then, you can see 'data' and 'Fs' where 'data' records the corrupted song and 'Fs' denotes the sampling frequency. Let $x[n] = x(t)|_{t=nT_s}$ be the corrupted data. Plot $x(t)$ over t. Also, plot spectrum $|X(f)|$ over f. Listen $x[n]$ using 'sound()'. Check that a beep sound disturbs one classical music. You can see strong peaks at $f = 120Hz$ and $f = -120Hz$ in the spectrum due to the beep.
b) [MATLAB] Make a band-stop filter $h[n] = h(t)|_{t=nT_s}$ to eliminate the strong beef. Use $110Hz$ and $130Hz$ for cutoff frequencies of the filter. (hint.. use your answer of Problem 3. You only need to change the sampling frequency). Plot spectrum $|H(f)|$ over f.
c) [MATLAB] Conduct the filtering through $z(t) = h(t) * x(t)$. Plot spectrum $|Z(f)|$ over f. Listen $z(t)$ using 'sound'. You might clearly listen 'Hallelujah Chorus' from Handel's Messiah'.