Milwaukee School of Engineering

Electrical Engineering and Computer Science Department

EE-3221 – Midterm Test – Dr. Durant

Wednesday 20 January 2021

May use textbook (electronic or printed), calculator, 8½" × 11" note sheet

Good luck!

Name: Answers

Page 2:	(~~15~~ 10 points)	______
Page 3:	(15 points)	______
Page 4:	(~~25~~ 30 points)	______
Page 5:	(~~20~~ 25 points)	______
Page 6:	(~~15~~ 20 points)	______
Total:	(100 points)	______

2:42
3:08

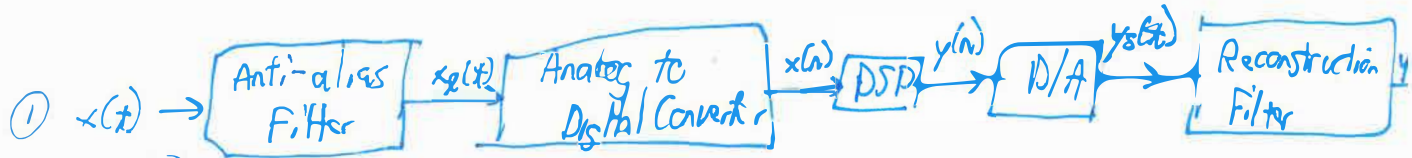
10

1. (5 points) Sketch the 5-component general DSP system diagram.

2. (5 points) Sketch the response of the ideal anti-aliasing filter in terms of f_s.

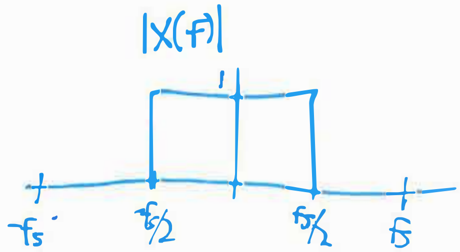
DROP ~~3.~~ (5 points) Sketch the magnitude ***and*** phase spectrum of x(t) = rect(t). See Table 5-6.

1



(-2) 3 comp version

2

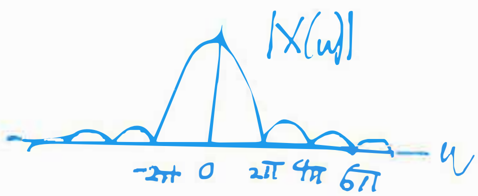


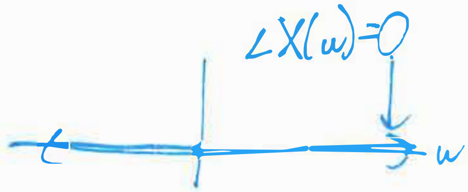
-(2) Bandlimited / repeating spectrum, but not |X(f)|

(+1) explained

(-1) $f_s/2$ v: f_s

3





(15)

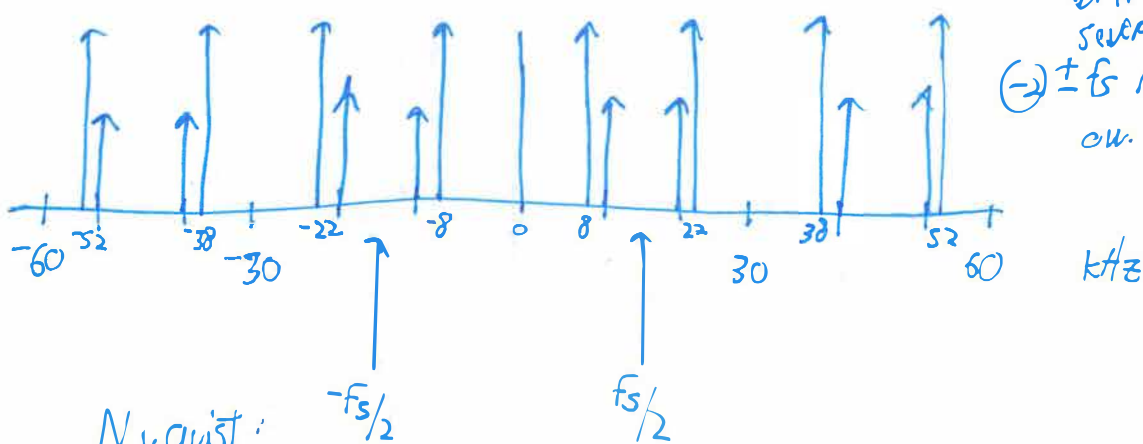
3 ~~4~~. (10 points) A signal with continual, sinusoidal components at 8 kHz and 20 kHz is sampled at 30 kHz. Sketch the magnitude spectrum from $-2f_s$ to $2f_s$. The 8 kHz signal has greater amplitude; for clarity, make the components due to it taller in your diagram.

4 ~~5~~. (5 points) Explain whether aliasing occurred in the above example.

(-3) some key images, but missing several

(-2) $\pm f_s$ resp. o.w. correct

(3 ~~5~~)



(4 ~~5~~) Nyquist:

$20\text{ kHz} > f_s/2 = 15\text{ kHz}$

$\therefore$ Aliasing occurs

Images: $\pm 20 \pm n \overbrace{30\text{ kHz}}^{f_s}$

$20 - 1 \cdot 30$

-10

$\therefore$

10 kHz, which we see above

30

5 ~~6~~. (5 points) Write the non-0 portion of the sequence resulting from $x(n) = \left(\frac{-2}{3}\right)^n (u(n+2)-u(n-3))$. Clearly indicate the *n=0* position in your sequence.

6 ~~7~~. (~~5~~ 10 points) Based on the samples you calculated, calculate the energy of x(n).

7 ~~8~~. (5 points) Based on the samples you calculated, write the sequence for the transformed signal w(n) = x(2n+2)

8 ~~9~~. (10 points) Let f_s = 2000 Hz, f_1 = 800 Hz. Prove that the sampled signal is periodic and calculate its period *N*.

(5) ~~5~~ $x = \left\{ \frac{9}{4}, \frac{-3}{2}, \underline{1}, \frac{-2}{3}, \frac{4}{9} \right\}$

(-1) various shifts by 2
(-1) l extra sample

(6) ~~3~~ $E_x = \sum x_n^2 = \frac{81}{16} + \frac{9}{4} + 1 + \frac{4}{9} + \frac{16}{81}$

(-2) forgot square
(-1) show n=0

$= \frac{117}{16} + 1 + \frac{52}{81}$

$= 8.954\ldots$

(7) ~~8~~

n	2n+2	w(n) = x(2n+2)
-3	-4	0
-2	-2	9/4
-1	0	1
0	2	4/9
1	4	0
2	6	0

$w = \left\{ \frac{9}{4}, 1, \frac{4}{9} \right\}$

(-2) No ~~[illegible]~~ samples w/o other Tag prms
(-1) dilation
(-1) truncation

(8) ~~2~~ $\Omega = \frac{F_1}{f_s} \cdot 2\pi = \frac{8}{20} \cdot 2\pi = \frac{2}{5} \cdot 2\pi = \frac{4\pi}{10}$

radians/sample

$\Omega = \frac{k}{N} 2\pi$

Lowest integer solution (exists) & is

$k = 2$ $\boxed{N=5}$

Analog cycles needed to get discrete-time cycle to repeat

(-4) mishandle π to get non-periodic formula
(-1) Good, but state n

25

9 ~~10~~. (~~20~~ 25 points) Calculate the convolution [7 -1 6] * [2 5 3 4]. Show your work.

x h

9 ~~10~~

$y[n] = \sum_k x[k]h[n-k]$

k	x[k]	n = 0	1	2	3	4	5
0	7	14	35	21	28		
1	-1		-2	-5	-3	-4	
2	6			12	30	18	24
		14	33	28	55	14	24

y = {14, 33, 28, 55, 14, 24}

-3 generally right, maybe a few (products) terms mixed around

20

10 ~~1~~1. (5 points) Given the difference equation y(n) = 0.5 y(n-1) + 5 x(n) - 3 x(n-2), identify all the a and b coefficients of the standard form with proper subscripts.

11 ~~1~~2. (5 points) Calculate the first 5 terms of the impulse response.

12 ~~1~~3. (~~5~~ 10 points) Explain why the system with the above difference equation is stable.

(10) $y(n) - \frac{1}{2}y(n-1) = 5x(n) - 3x(n-2)$

$a = [1 \ \ -\frac{1}{2}] = [a_0 \ \ a_1]$ $\quad b = [5 \ \ 0 \ \ -3] = [b_0 \ \ b_1 \ \ b_2]$

(-1) a & b reversed!

(11) $x \to \delta \quad y \to h \quad h(n) = \frac{1}{2}h(n-1) + 5\delta(n) - 3\delta(n-2)$

n	h(n)
0	$0 + 1\cdot 5 - 0 = 5$
1	$\frac{1}{2}\cdot 5 + 0 - 0 = 2.5$
2	$\frac{1}{2}\cdot 2.5 + 0 - 3 = -1.75$
3	$\frac{1}{2}\cdot -1.75 + 0 - 0 = -0.875$
4	$\frac{1}{2}\cdot -0.875 + 0 - 0 = -0.4375$

(-1) forgot $\frac{1}{2}$, o.w. ok

(12) Absolutely summable h(n)

$$\sum |h(n)| = \underbrace{5 + 2.5}_{} + 1.75 + 0.875 + 0.4375 + \cdots$$

$$= 7.5 + \frac{1.75}{1 - \frac{1}{2}} \leftarrow \text{sum of geo. series}$$

$$= 7.5 + 3.5 = 11 \ (< \infty) \ \text{"finite"}$$