Birla Institute of Technology and Science, Pilani.
ECE/ EEE / INSTR F243: Signals and Systems
AY: 2022-23, Semester: II
MATLAB-BASED ASSIGNMENT: Open Book

Max Marks: 20 **Date: 17-04-2023**

Instructions:

- **Please make sure you add a title, axis labels, x-axis limit and y-axis limit, and legend (if required) to each of your figures.**
- **Use different markers for different curves within a plot.**
- **The marks will be deducted if the figures are not clear and/or any of these are not mentioned.**

- **Submission date: Monday, 24-04-2023 (2:30 to 5:00 pm), Hard copy**
- **Submission room: Analog and Digital Lab (Room #2241)**
- **Sign the submission sheet kept with the lab instructor (Mr. Manoj and/or Mr. Amitabh)**
- **Submission after the deadline is not allowed.**

Submission format:

The first page should contain the following information:

- **Name:**
- **BITS ID:**
- **Tutorial section #:**
- **Name of tutorial Instructor:**
- **Total number of printed pages in the assignment**

Every page should contain a header containing (Name and BITS ID)

Every page should contain a footer containing (page number/total # of pages)

Maximum page limit: 4 (printed back to back) (avoid single-side printing)

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Q1. An LTI system has input $x(t)$, output $y(t)$, and impulse response $h(t)$.

An input signal $x(t)$ is represented as $x(t) = \sum_{i=0}^{M} \frac{1}{(2i+1)} \sin\big((2i+1)2\pi N t\big)$. Plot $x(t)$ for one second with M = 1, M = 2, and M = 8 in the same figure (use hold on command).

Assuming $h(t)$ as a sinc function of appropriate amplitude and width, compute the output $y(t)$ such that it has maximum frequency content of 3N Hz when M = 8.

Where $\boldsymbol{N} = \boldsymbol{X} +$ sum of last two digits of your BITS ID, (where $\boldsymbol{X}$ is **2 for A3**, **4 for A8, 6 for AA,** and **7 for all dual degree and other** students).

Sketch the magnitude spectrum $|Y(f)|$ of the signal $y(t)$.

Ensure your x-axis is in frequency (in Hz), containing both positive and negative frequencies.

Comment on your observations.

Note: Use “conv” “fft” and “fftshift” command in MATLAB. **(5M)**

Q2. The discrete system function of a causal LTI system is given by:

$$H(Z) = \frac{1 + aZ^{-1} + Z^{-2}}{1 - bZ^{-1} + Z^{-2} - cZ^{-3}}$$

The constants a, b, and c correspond to the last three digits of your BITS ID number (e.g., if 2020A3PS0123P, then a = 1, b = 2 and c = 3). However, based on your BITS ID number, if a = 0, then replace by 4, if b = 0, then replace by 2 and if c = 0, then replace by 1. If a = b = c, then replace only b with the 4th digit of your BITS ID (e.g., 2020A3PS0222P). Sketch the pole-zero diagram of H(z) and display the poles and zeros. Also, plot the magnitude and phase spectrum of H(z) in the frequency range $-2\pi < \omega < 2\pi$. **(5M)**

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Q3 a) Generate a signal $x(t)$ with a total duration of 20 ms (0 to 20 ms), in which the first 10 ms (i.e., 0 to 10 ms), there is a single tone sinusoidal $x_1(t) = A\cos(2\pi f_c t)$, where A (signal amplitude) = 7 volts, and for the rest of the duration, the signal is zero. Use the sampling frequency (Fs) = **X**00 kHz (where **X** is the 6th digit of your BITS ID: 2020A**3**PS0123P; if it is non-numerical, take **X=5**) and the signal frequency (f_c) of the signal is 1**XXX** (where **XXX** is the last three digits of your BITS ID number, that is, if the ID is 2020A3PS0**123**P, then the frequency = 1123Hz).

b) Now, a new signal $x_2(t) = x\left(b - \frac{3}{2}t\right)$ is generated, where $x(t)$ is the same as in 3a) and the constant ***b*** (in ms) is the last digit of your BITS ID number (2020A3PS012**3**P). However, based on your ID number, if ***b*** = 0, then select ***b*** = 9.

Plot the signals $x(t)$, $x(t+b)$ and $x_2(t)$ as a function of time. Show the results as subplots of 4x1. The x-axis range must be the same for all the signals to be plotted in 4 x 1 to show the effect of the operation performed. **(5M)**

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Q4. The transfer function of an electric circuit is given below.

$$H(s) = \frac{A}{B}$$

$$A = a_1 * 10^3 s^8 + a_2 * 10^{-9} s^7 + a_3 * 10^{16} s^6 - a_4 * 10^2 s^5 + a_5 * 10^{28} s^4 + a_6 * 10^{12} s^3 + a_7 * 10^{17} s^2 + a_8 s + a_9 * 10^{15}$$

$$B = b_1 * s^{10} + b_2 * 10 s^9 + b_3 * 10^{11} s^8 + b_4 * 10^{10} s^7 + b_5 * 10^{15} s^6 + b_6 * 10^{10} s^5 + b_7 * 10^{15} s^4 + b_8 * 10^{10} s^3 + b_9 * 10^{10} s^2 + b_{10} * 10^4 s + b_{11} * 10^{03}$$

The constants $\boldsymbol{a_1}$ to $\boldsymbol{a_9}$ and $\boldsymbol{b_1}$ to $\boldsymbol{b_{11}}$ correspond to your BITS ID No. as per the relations given below.

$a_1 = a_2 = a_5 = a_7 =$ the last second digit of your BITS ID No. If $a_1 = 0$, then replace it with the first digit of your bits id.

$a_3 = b_2 = b_3 =$ the last digit of your BITS ID No., if $a_3 = 0$, then replace it with twice of the first digit number of your BITS ID No.

$b_1 = b_5 = b_8 =$ is the third digit of your BITS ID No.

$a_6 = a_9 = b_6 = b_7 = b_{10} = b_{11} =$ is the sum of the first three digits of your BITS ID No.

$b_9 =$ maximum digit of your BITS ID No.

$a_4 = a_8 =$ x*x (here x=maximum digit of your BITS ID No.)

$b_4 =$ minimum digit of your BITS ID No. (min. =0 then take min=0.5).

Sketch the pole-zero diagram and bode plot and comment on its stability. Comment on the value of circuit elements and related time constants.