

UNIVERSITY OF THE PHILIPPINES DILIMAN
ELECTRICAL AND ELECTRONICS ENGINEERING INSTITUTE

EE 274 / COE 197E: Discrete Time Signals & Systems (DSP1)

Programming Exercise 03

DEADLINE: 23-OCT-2020

INSTRUCTIONS. This is an open-notes, open-books exercise, and can be done solo or by pair (For those under EE 274, you are required to do this individually). Write your name/s and student number/s on the topmost part of the lab report. The exercises are designed to be done in MATLAB or Octave. For convenience, use the **Publish** to **DOC/PDF** feature of MATLAB. Comment your answers to the questions.

Submit copies of your well-commented codes and automatically generated lab report in a compressed folder via UVLE no later than the designated deadline. Use the filename EE274_ProgEx03.zip or CoE197E_ProgEx03.zip. Anything submitted beyond the deadline will get a 0.6 multiplier penalty to the final score.

A. THE BILATERAL Z-TRANSFORM

The bilateral z-transform of a sequence $x(n)$ is defined as:

$$X(z) = Z[x(n)] = \sum_{n=-\infty}^{\infty} x(n)z^{-n}$$

where z is a complex variable. For any given sequence $x(n)$, the set of values of z for which $X(z)$ exists is called the region of convergence (ROC) and is given by:

$$R_{x^-} < |z| < R_{x^+}$$

for some positive numbers R_{x^-} and R_{x^+} .

Z-Transform of Sequences

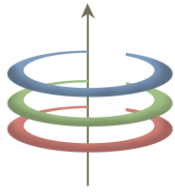
1. Determine the z-transform of the following sequences, using the definition for $Z[x(n)]$. Indicate the region of convergence for each sequence. Express $X(z)$ as a rational function in z^{-1} . You may comment your solutions in the script.

$$(a) \ x(n) = \left(\frac{4}{3}\right)^n u(1-n) \qquad (b) \ x(n) = 2^{-|n|} + \left(\frac{1}{3}\right)^{|n|}$$

2. Verify the z-transform expression by using Octave/Matlab. Use **deconv()** to generate the coefficients of the power-series expansion of $X(z)$. Note that computation of power-series expansion depends on causality of the signal. List the first 8 coefficients (for each letter).
3. Determine the z-transform of the sequence using the z-transform properties and table of common transform pairs.

$$x(n) = \left(\frac{1}{3}\right)^n u(n-2) + (0.9)^{n-3} u(n)$$

Express $X(z)$ as a rational function in z^{-1} . Indicate the region of convergence. Use **impz()** (or **filter()** with input $x(n) = \delta(n)$) to verify your results. Plot the first 20 samples.



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B. THE INVERSE Z-TRANSFORM

The inverse z-transform of a complex function $X(z)$ is given by the contour integral:

$$x(n) = Z^{-1}[X(z)] = \frac{1}{j2\pi} \oint_C X(z) z^{n-1} dz$$

where C is a counter-clockwise closed contour encircling the origin and lying in the ROC.

Inverse z-Transform

4. Determine the inverse z-Transform of

$$X(z) = \frac{1 - z^{-1} - 4z^{-2} + 4z^{-3}}{1 - \frac{11}{4}z^{-1} + \frac{13}{8}z^{-2} - \frac{1}{4}z^{-3}}$$

Using partial-fraction expansion method. The sequence is absolutely summable. In Matlab[®], the function **residuez()** can be used to solve partial fraction expansion of $X(z)$.

C. FOURIER TRANSFORM OF DT SIGNALS

Synthesis equation

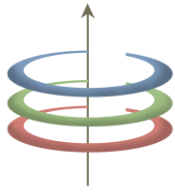
$$x(n) = \sum_{k=0}^{N-1} c_k e^{j2\pi kn/N}$$

Analysis equation

$$c_k = \frac{1}{N} \sum_{n=0}^{N-1} x(n) e^{-j2\pi kn/N}$$

Analysis of Signal frequency components

5. Generate the periodic even symmetric square pulse signal $x(n)$ from $[0,1]$. The period of the pulse is 1 second and a pulse width of 250 milliseconds with a sampling frequency of 8 KHz. Plot one period of the $x(n)$ and verify if you have the correct waveform.
- How many samples in one period?
 - How many samples with a value of 1?
 - How many zeros?
6. Using the analysis equation of the Fourier series, write a program that will compute the Fourier series coefficients (complex) of the periodic square pulse signal. Plot the magnitude and phase of the first 10 Fourier series coefficients (c_k).
- What is the fundamental frequency of the square pulse?
 - Enumerate the magnitude and phase of the first 10 coefficients of the Fourier series (c_0, c_1, \dots, c_{10})



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7. Using the synthesis equation for the Fourier series, synthesize the original square pulse using the first 10 Fourier coefficients. Generate a plot of the original square pulse and the synthesized square pulse.
- What is the average mean square error (MSE) of the original square pulse and the synthesized pulse?
 - If you use 20 Fourier coefficients, what will be the average MSE?
 - What is the effect on the fundamental frequency if I increase the pulse width to 300 ms? Explain.
 - What is the effect on the Fourier series coefficients if I change the pulse width?
 - What is the effect on the Fourier series coefficients if I change the period?

References:

<https://www.mathworks.com/>