EEE 391

Basics of Signals and Systems

MATLAB Mini Project 2

due: 20 April 2022, Wednesday by 23:00 on Moodle

In this assignment, you are going to implement the test procedures for three important system properties: linearity, time-invariance, and causality. The motivation is to understand these system properties conceptually as well as the implementation of discrete sequences and function level tests in MATLAB.

1 Implementation of an Example Test Procedure

The homework is provided with an example code to implement a specific system property test shown in Figure 1. The resource includes the following files:

i) *Example.m* : A simple `m` file to implement the given system property test.

ii) *System_Ex.m* : The ideal delay system that delays by two units of time: $y[n] = x[n-2]$.

iii) *EqorNOT.m*: Test if the two outputs in Figure 1 are the same or not.

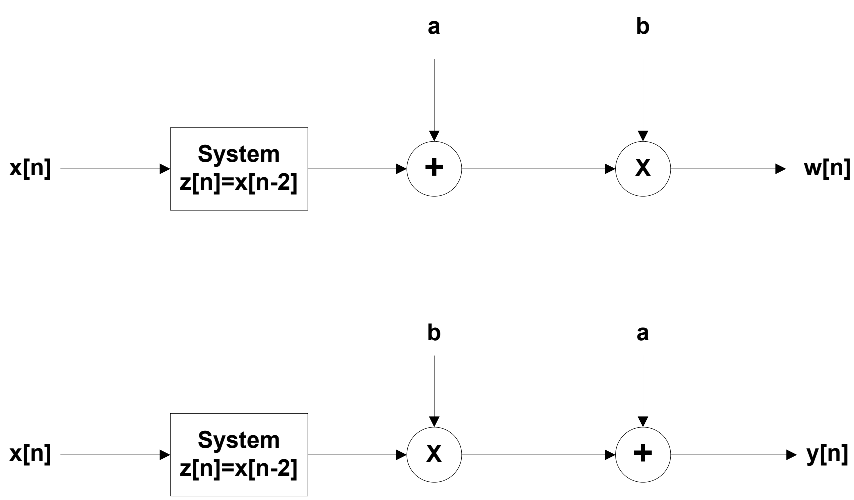

Figure 1: An example system property test.

As shown in the figure above, the given system implements two units of time delay, followed by an adder and a multiplier or vice versa. The adder adds the constant a to the incoming sequence whereas the multiplier multiplies the incoming sequence by b. If interchanging the order of addition and multiplication operations does not make any difference in the end result, a decision can be made about the corresponding system property. First, run this example and understand the implementation.

2 Implementing the Test Procedure for Linearity

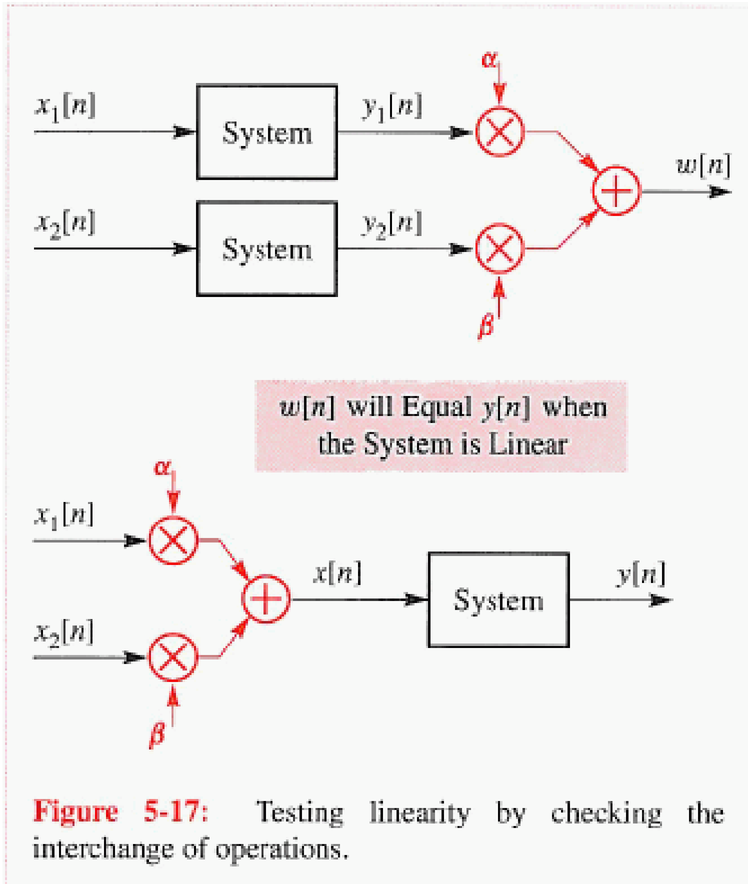

Figure 2: Linearity Test.

The test procedure for linearity is shown in the figure above. You are provided with two input sequences $x_1[n]$ and $x_2[n]$ and two arbitrary scaling constants α and β. First, you need to generate the two output sequences $w[n]$ and $y[n]$ according to Figure 2. If $w[n]$ and $y[n]$ are equal for all the given input sequences and α and β values that you have tested, you may conclude that the system passes the linearity test.

3 Implementing the Test Procedure for Time Invariance

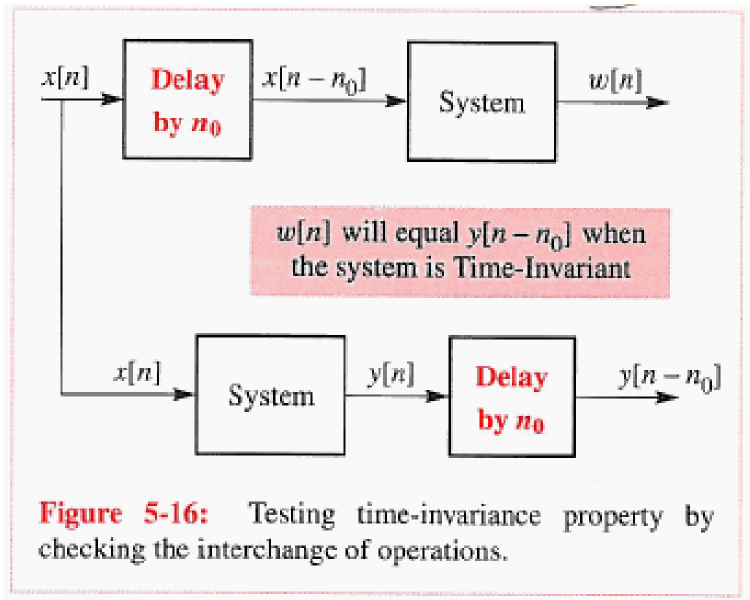

Figure 3: Time-Invariance Test.

The test procedure for time invariance is shown in the figure above. You are provided with some test input sequences $x[n]$ and a range of values for the delay parameter n_o. For the given input sequences, you need to generate the two output sequences $w[n]$ and $y[n - n_o]$ according to Figure 3. If $w[n]$ and $y[n - n_o]$ are equal for all the given input sequences and all the values of n_o that you have tested, you may conclude that the system passes the time-invariance test.

4 Implementing the Test Procedure for Causality

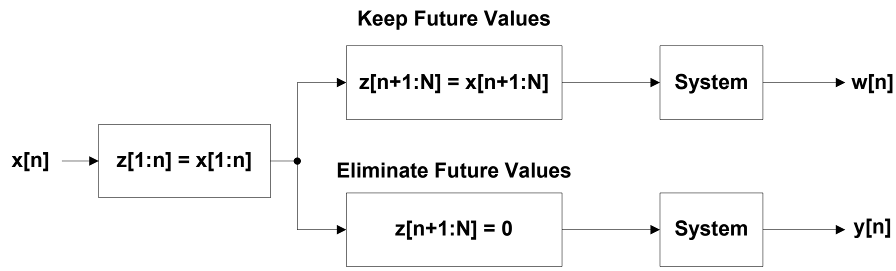

Figure 4: Causality Test.

As shown in the figure above, the system implements a causality test. You are provided with an input sequence and the current (present) value of the discrete-time index is n. First, you need to generate the sequence $z[n]$ which is initially set equal to $x[n]$. As the discrete-time index n changes from 1 to N, for a given value of n, in one case, set all the values of $z[n]$ that come after n equal to zero. In the other case, keep the sequence $z[n]$ as it is. Then, give each of the two sequences as input to the system. If the outputs $w[n]$ and $y[n]$ are the same for all values of the index n, you may conclude that the system is not dependent on the future values of the input, and therefore, causal. Since we are providing different future values in the two cases, this means that the future values are not being used by the system.

5 Given Systems and Constants

Implement the three test procedures described above and test the following systems for each of the three system properties:

a) $y[n] = nx[n+2]$

b) $y[n] = x[2n]$ (compressor)

c) $y[n] = 3x[n+4] + 5$

d) $y[n] = \big|x[n]\big|$ (absolute value system)

e) $y[n] = \sum_{k=1}^{n} x[k]$ (accumulator)

The input sequences and the constants are given as follows: $1 \leq n \leq N$ and $N = 10$

input sequence pairs to test for part 2 (linearity test):

$x_1 = [-3 \ \ -4 \ \ 2 \ \ 0 \ \ 1 \ \ 4 \ \ 3 \ \ 6 \ \ 3 \ \ 7]$; $x_2 = [2 \ \ 5 \ \ -1 \ \ 7 \ \ -3 \ \ 6 \ \ 12 \ \ -9 \ \ 8 \ \ -4]$;

and

$x_1 = [9 \ \ 23 \ \ 15 \ \ -10 \ \ 18 \ \ 14 \ \ 5 \ \ -1 \ \ 6 \ \ 11]$; $x_2 = [2 \ \ 5 \ \ -1 \ \ 7 \ \ -3 \ \ 6 \ \ 12 \ \ -9 \ \ 8 \ \ -4]$;

Take the range for both α and β in the linearity test from –5 to 5 (use integer-valued scaling constants but exclude zero). You need to test the given sequences for all 100 combinations of α and β.

input sequences to test for part 3 (time-invariance test):

$x = [-3 \ \ -4 \ \ 2 \ \ 0 \ \ 1 \ \ 4 \ \ 3 \ \ 6 \ \ 3 \ \ 7]$; and $x = [5 \ \ -11 \ \ 9 \ \ 2 \ \ 3 \ \ -6 \ \ 0 \ \ -7 \ \ 3 \ \ 10]$;

The range for the time delay n_o in the time-invariance test is from –50 to 50 (integer valued delay, again exclude zero). You need to test each given input sequence for all 100 values of n_o.

Submit the results of your own work in the form of a well-documented report on Moodle. Borrowing full or partial code from your peers or elsewhere is not allowed and will be punished. Please include all evidence (plots, screen dumps, MATLAB codes, MATLAB command window print-outs, etc.) as needed in your report. Append your MATLAB code at the end of your assignment, do not upload it separately. The axes of all plots should be scaled and labeled. Typing your report instead of handwriting some parts will be better. Please do not upload any photos/images of your report. Your complete report should be uploaded on Moodle as a single good-quality pdf file by the given deadline. Please DO NOT submit any files by e-mail.

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