York University

Department of Electrical Engineering and Computer Science

EECS 4214

Lab #3 Transmission of Signals through Linear Systems

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1. Purpose

In this lab, you will be introduced to modeling and simulation of linear systems in both time and frequency domains. Using a computer, you will learn how to apply both deterministic and random signals as inputs to linear systems and obtain the associated outputs.

2. Objectives

By the end of this project, you will be able to: 1) Study the behavior of filters and linearly-modeled communication channels for deterministic and random inputs. 2) Derive and plot the response of such networks in both time and frequency domains. 3) Analyze and simulate the transmission of serial pulse trains through channels with linear models.

3. References

1) Handouts on "Linear Systems" available on the course homepage on Learn.Lassonde.

2) Bernard Sklar text: Chapter 1.

Problem 1 **Transmission of a square wave signal through an LPF network**

In MATLAB®,

1.1 Generate 5 cycles of a 1-MHz sine wave (Duty Cycle=50%). Apply this signal at the input of a first-order RC low-pass filter (LPF) with a cut-off frequency of (a) 10MHz, (b) 1MHz, and (c) 100kHz.

1.2 Plot the input and also outputs of each one of the filters in the time domain.

1.3 Plot the Bode plot of the three filters.

1.4 Plot the FFT of the input signal, and also the FFTs of the outputs of the three filters.

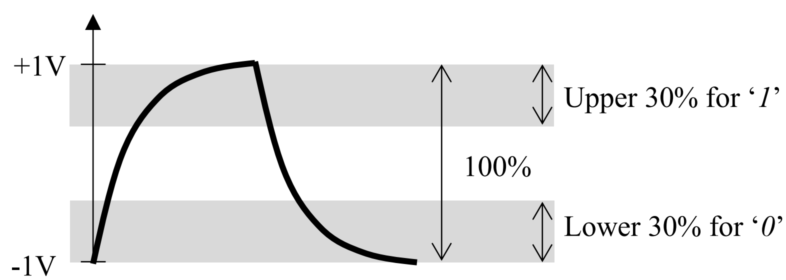
1.5 According to the results achieved in 1.2~1.4, discuss on the differences between the outputs of the filters.

By hand calculation (analytical calculations and/or using Bode plot),

1.6 Try to verify the results you obtained using computer simulations. In case you see difference between your calculations and computer simulations, specify what could possibly be the reason.

Problem 2 **Maximum bit rate**

Suppose that in Problem 1, the RC LPF with the bandwidth of 1MHz is the electrical model for a communication channel. This channel is used for the transmission of binary pulses switching between +1V and -1V (corresponding to 1 and 0 logic levels, respectively). Assume that the digital logic circuits at the receiver end recognize the lower and upper 30 percent of the pulse voltage swing as 0 and 1 logic values, respectively (as shown below).



2.1 By hand calculations, determine the maximum bit rate that can be transmitted through this channel.

2.2 Using MATLAB simulation, verify the result obtained in 2.1.

Problem 3 **Effect of an LPF on the white noise**

3.1 In MATLAB®, generate a white Gaussian noise for the duration of 1s, and apply it as the input to the filters of Problem 1. Plot the outputs of the filters in the time domain as well as their frequency spectra (FFT).

3.2 According to the results achieved in 1.3 and 3.1, discuss on the differences between the outputs of the filters.

Problem 4 **Butterworth Filter**

In this problem, we are to find the response of 1st-, 3rd-, and 5th-order low-pass Butterworth filters (n=1,3,5) to a square wave. Take the upper cutoff frequencies of all the three filters f_u=1MHz.

4.1 In MATLAB®, draw the "magnitude" Bode plot of the filters in the same plot.

4.2 Again only by MTLAB® simulations, find and plot the outputs of all the filters (all in the same plot) when the input is:

(a) A 100-kHz square wave, switching between +1V and -1V
(b) A 900-kHz square wave, switching between +1V and -1V
(c) A 1-MHz square wave, switching between +1V and -1V
(d) A 1.1-MHz square wave, switching between +1V and -1V
(e) A 10-MHz square wave, switching between +1V and -1V

4.3 Explain the differences between the outputs in terms of differences between the frequency characteristics of the filters.