Session 1532

Demonstrating Complex Communication Systems Principles Using Electronic Courseware and a Simple Computer Math Package

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Abstract

While computer simulation can be used to augment student understanding of complex systems and signals principles, knowledge of computer package specifics can form a major barrier to student understanding. A series of five electronic courseware modules for use in a senior-level communication systems course are described. The modules are designed to provide interactive step-by-step guidance to students performing system simulations using a mathematical simulation package. The system simulations are designed and run from within the courseware modules. Five such modules are described. Among the communication systems topics investigated in the exercises are quantization noise, distortion, companding, and Nyquist's criteria for zero intersymbol interference.

Introduction

In the study of communication systems, it is often difficult for students to develop a true understanding of the more complex systems and signal principles without exercising an appropriate communication system. However, the complexity of and costs associated with appropriate commercial or instructional communication hardware systems make such systems, in many cases, unattractive in a university setting. Computer simulation is often a more appropriate solution to augmenting student learning in the area of communications systems. A mathematical computation package, such as Mathcad, provides a suitable platform for the development of such simulation exercises. One drawback to this approach is the difficulty experienced by students not adept in use of the particular computer package.

Student knowledge of computer package specifics can be bypassed through the use of electronic courseware modules. A series of such original courseware modules has been developed at the University of San Diego. Among the communication systems topics investigated in the exercises are quantization noise, distortion, companding, and Nyquist's criteria for zero intersymbol interference. These modules, which make use of interactive multimedia presentation techniques, can be used by the students within a computer laboratory, or be made available as web pages that are internet-accessible. The exercises are appropriate for use as student laboratory exercises, as a supplement to hardware laboratory exercises, or as outside assignments for courses that do not have a laboratory component. One significant advantage of these modules is that they allow most of the student's effort to be devoted to understanding of communications systems rather than usage of a particular mathematical computation package. Another advantage is that the modules can be made available to the student without an extensive commitment of laboratory facilities. The paper describes courseware modules for the simulation exercises, and reports on the use of these exercises in a university setting to augment a course in communication system principles.

Course Setting and Motivation

Many electrical engineering programs include a senior-level course in communications systems. At the University of San Diego, students majoring in electrical engineering are required to take Communications Principles and Circuits (EEE 170) a four semester-credit course that includes three hours of lecture and one three-hour laboratory each week. This course has several prerequisites including upper-division mathematics courses, a course in signal and systems analysis, and two courses in electronics.

Despite the rather extensive course background of the students, the theoretical nature of the communication systems topics and the complexity and cost of appropriate hardware systems motivated the development of five simulation exercises. [1] While mathematical simulation proved a very effective laboratory topic for communication systems, student (and instructor) knowledge of the particular mathematical simulation package, in this case Mathcad, became a barrier to some. Those students who were less adept in the use of Mathcad were forced to devote as much effort to understanding the particulars of the tool as they were to understanding the systems and principles they were attempting to simulate.

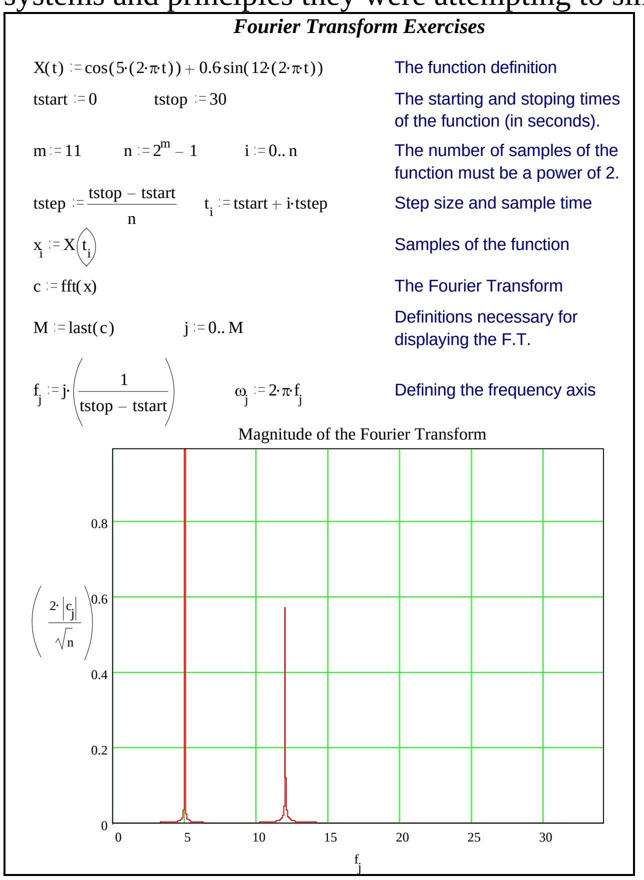

Figure 1 - Simulation 1: Digital Fourier Transform Concepts

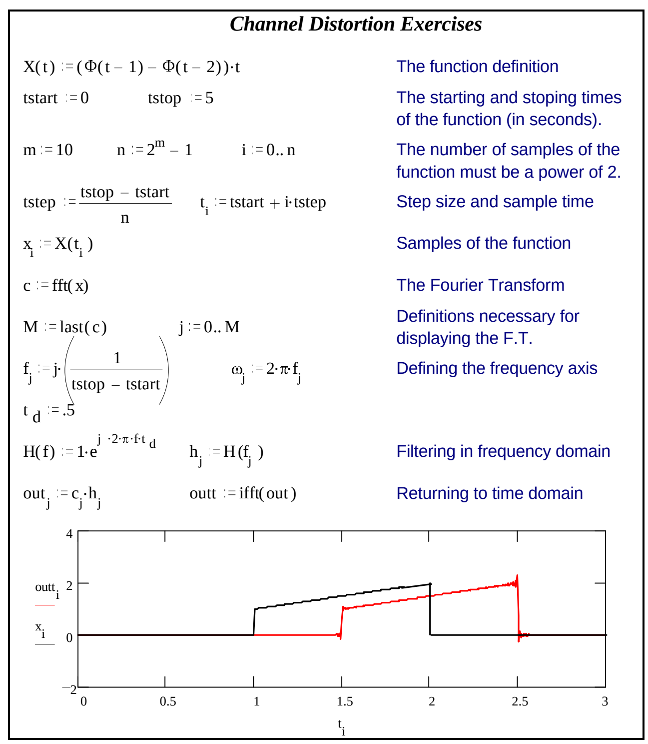

Figure 2 - Simulation 2: Distortionless Transmission through a Linear Channel

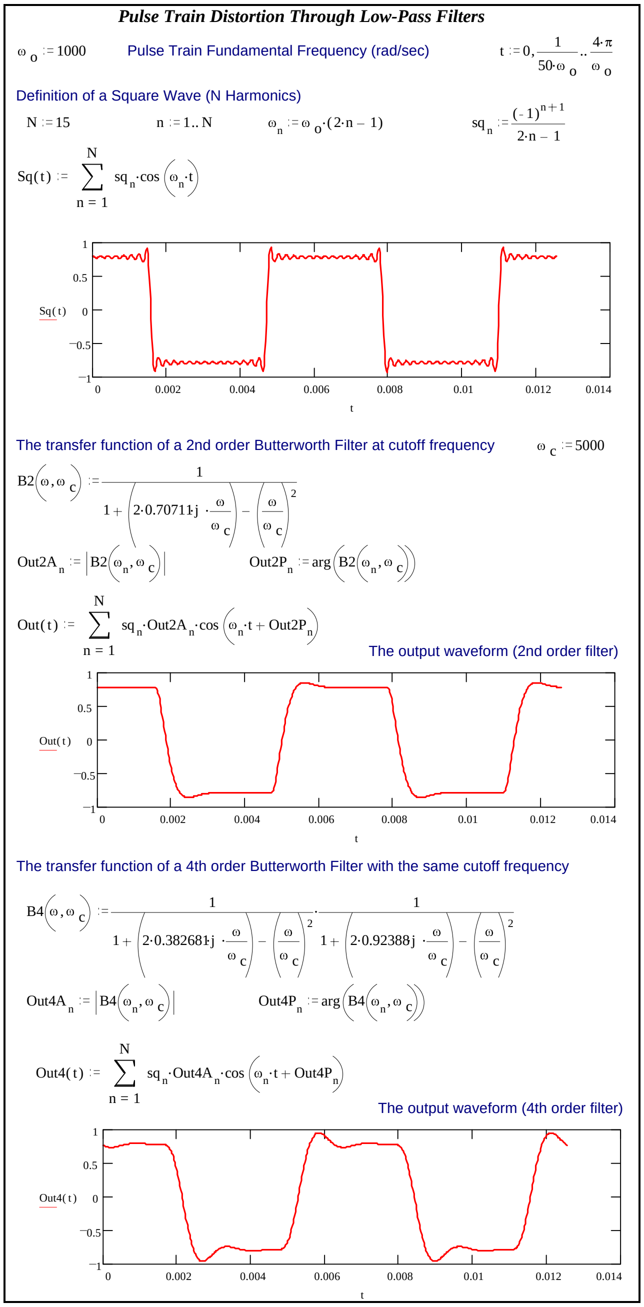

Figure 3 - Simulation 3: Pulse Distortion due to Low-Pass Filtering

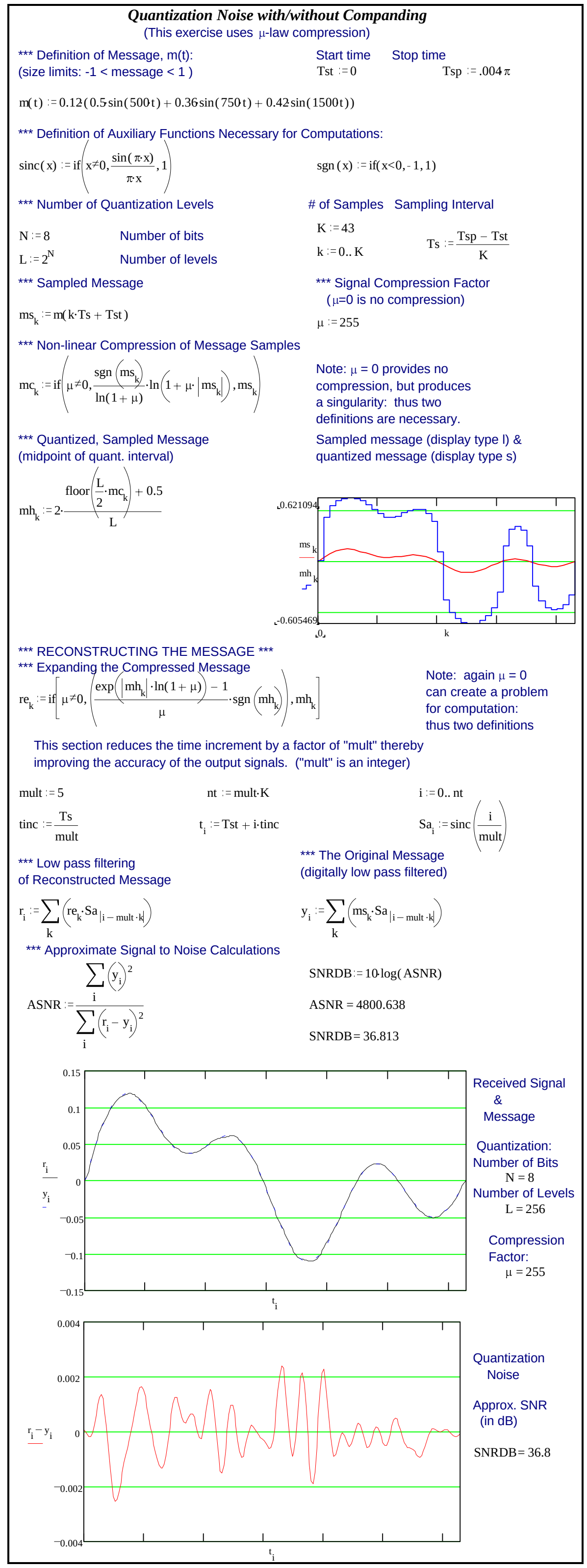

Figure 4 - Simulation 4: Quantization Noise without Companding

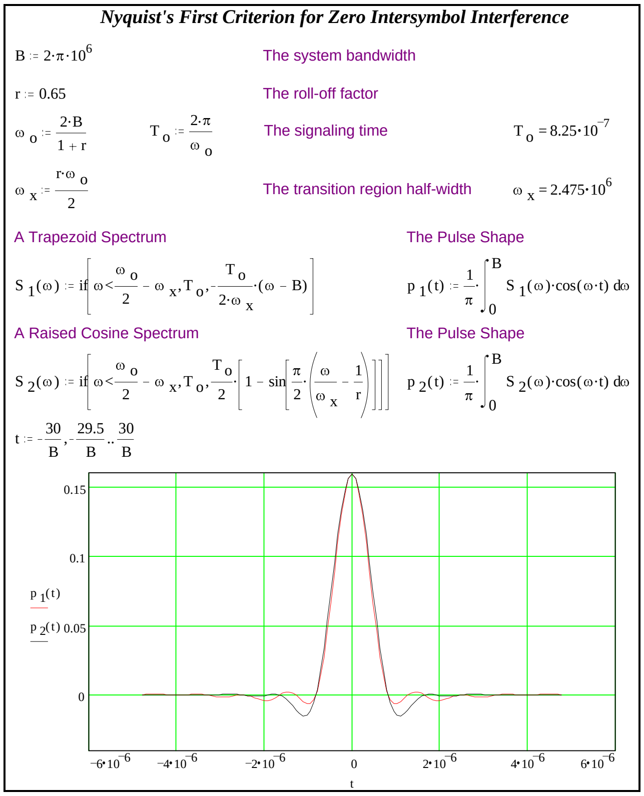

Figure 5 - Simulation 5: Pulse Shapes that meet the Nyquist Zero Intersymbol Interference Criteria

In response to this problem, a series of five electronic courseware modules were developed to provide the students with interactive step-by-step guidance in the particular features of the mathematics package involved in the simulation. The students can design and run the simulation from within the courseware module.

Electronic Courseware Modules

The electronic courseware modules were written using Asymetrix Toolbook II Assistant. [2] This software was provided to the University without cost through an NSF Undergraduate Faculty Enhancement Workshop. [3] This particular software has the necessary capabilities of allowing the design of modules that use animation, graphics, and sound. The most important capability of the software is that the modules can be made interactive; the simulations themselves can be designed and run from within the courseware modules.

The five different simulation exercises described here were written to be performed using Mathcad [4], although other mathematical computation packages would also provide a suitable platform. The advantage of the electronic courseware modules is their use in overcoming the student learning curve in the use of the particular mathematical computation package being used. The electronic courseware developed is, therefore, specific to Mathcad, the computation package of the exercises. The simulations that the student would produce for each of these exercises are shown in Figure 1 through Figure 5.

The five courseware modules developed were:

1. Digital Fourier Transform Concepts
2. Distortionless Transmission through a Linear Channel
3. Pulse Distortion due to Low-Pass Filtering
4. Quantization Noise without Companding
5. Pulse Shapes that meet the Nyquist Zero Intersymbol Interference Criteria

The exercises themselves are broken down into four to six steps. The courseware modules for each exercise then designed based upon these steps. Each module includes:

1. Title slide with a brief description of exercise
2. Objectives slide listing three or four goals of the exercise
3. A group of at least four slides for each step of the exercise

A group of slides is required for each step because each step must be initially described, then explained, then demonstrated, and finally performed by the student. In addition, the student is usually expected to answer a short question about what has been done. Figure 6 (a-f) shows give example slides from the first module. [5]

The demonstration of the step requires at least some graphical demonstration, and often makes use of the animation capabilities of the mathematical simulation package. The actual performance of the step requires the student to activate the simulator from within the courseware. The short-answer question regarding the step just performed can easily be included, allowing the student to receive immediate feedback regarding the correctness of the answer.

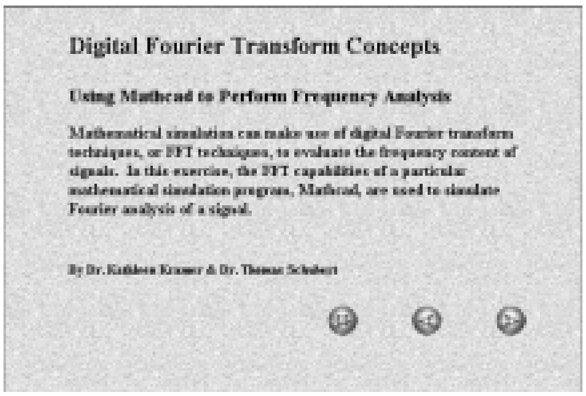

Figure 6a

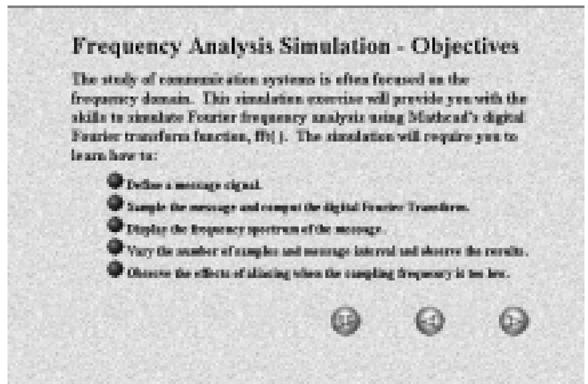

Figure 6b

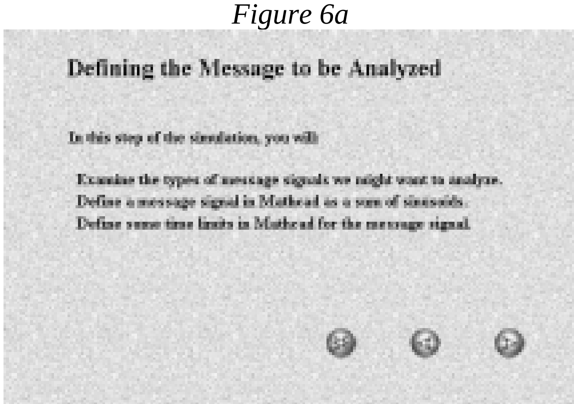

Figure 6c

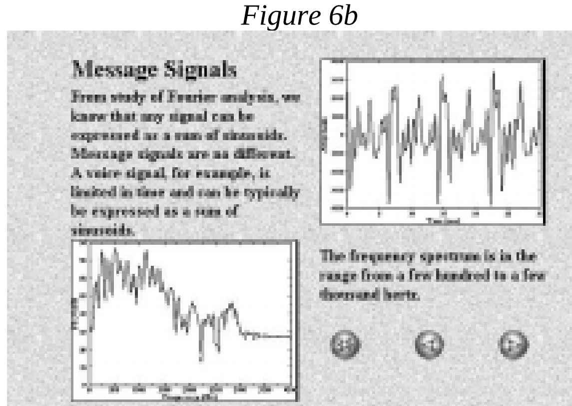

Figure 6d

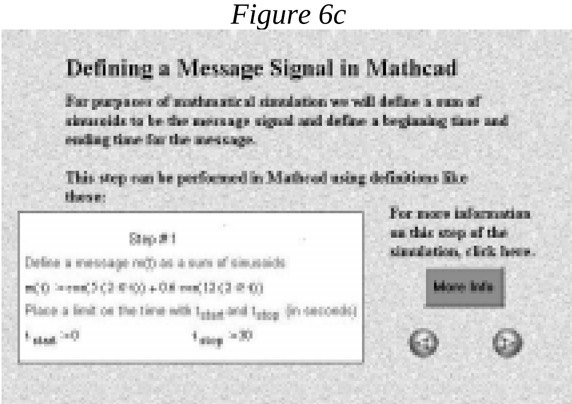

Figure 6e

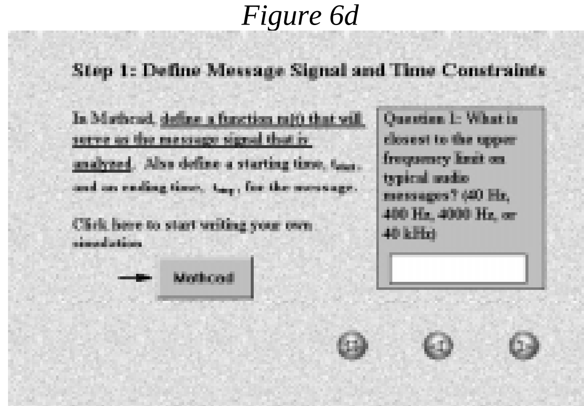

Figure 6f

Figure 6 - Sample slides from Module 1. a) Title slide b) Objectives c)-f) Group of slides for Step 1

Conclusion

The five electronic courseware modules are to be used to enhance student laboratory experiences within the senior-level required course in communications systems at USD in the Spring 1998 semester. Student experiences with the modules can be evaluated after the completion of that semester.

References

1. Thomas F. Schubert, Jr., "The Use of a Simple Computer Math Package to Demonstrate Complex Communication Systems Principles ", Frontiers in Education Conference Proceedings, November 1994.

2. *Asymetrix Toolbook II Assistant User Guide*, Asymetrix Corporation, Bellevue, Washington, 1997.

3. materials from "Electronic Courseware for Enhanced Learning in an Integrated Classroom/Laboratory Environment"[NSF-sponsored Faculty Enhancement Workshop], Bucknell University, Lewisberg, Pennsylvania, July 1997

4. *Mathcad User's Guide*, MathSoft Inc., Cambridge, Massachusetts, 1997.

5. Jason Woodward, images from http://www-mobile.ecs.soton.ac.uk, University of Southampton, UK.

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