Work in Progress - Modules and Laboratories for a Pathways Course in Signals and Systems

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Abstract – A gap between theory and practice in signals and systems courses is often reported at many universities as a key problem in recruiting signals and systems students. On the other hand, instructors often cite a lack of fundamental understanding in mathematics as an issue in this course. Students seem to be discontent with some of the abstraction of the signals and systems courses. In this work-in-progress paper, we describe a new pathways concept we introduced to address these problems by introducing in-depth discussions, several applications and hands-on exercises.

Index Terms – Signals and Systems, DSP, MATLAB, LabVIEW, Systems Pathways, Experiments.

INTRODUCTION

A common complaint among undergraduate students in signals and systems is an apparent disconnect between theory and practice and the lack of sufficient real-world homework problems. On the other hand, instructors often cite a lack of understanding of the fundamental mathematics background and inability to perform relatively simple calculations. In both cases, it is our view that students are accustomed to a different learning paradigm which does not fit well the abstraction of the signals and systems courses. Compounding the problem is a constant need to push material to lower levels so that senior and graduate courses address the more recent applications, which predominantly come from the digital/discrete-time domain.

Specialization courses in different areas are typically achieved by their own senior level *electives.* However, completing an Electrical Engineering (EE) degree without the basics in signal processing, communications, controls is a problem and a serious possibility for several students. To compensate for this possibility, EE faculty reorganized the curriculum and introduced the concept of "pathway courses." Pathways classes were introduced in the ASU EE curriculum based on local observations and student and faculty comments. These are designed to showcase the solutions of fundamental problems in each area, elaborate on how the theory is applied, and provide at least an elementary working knowledge on each subject. Pathway courses are not mandatory, but the students select 4 out of the possible 6. This provides a vast improvement over the previous scenario where students were only required to take senior elective courses from only two areas. A key problem then was that due to the lack of the necessary background, very little working knowledge and real-world applications were included or covered before the senior level. At its current implementation at ASU, the "pathways course" concept for Signals and Systems includes a sophomore-level introduction, the 3-credit *EEE203 Signals and Systems I* covering the basic theory: System properties, LTI systems, Convolution, Fourier-Laplace transforms, Frequency responses, Sampling and Reconstruction, introductory discrete-time systems and z-transform. Then, the pathways *EEE304 Signals and Systems II* discusses in more detail the formulation and solution of *four basic problems* with applications: a) Discrete-time Signals and Systems (Sampling, oversampling reconstruction), b) Signal Processing (Digital Filters, Spectral analysis, FFT), c) Communication Systems (Modulation: AM, FM, Multiplexing, Applications), d) Controls (Feedback systems: Nyquist stability, PI/PID controllers. Some of efforts towards using software tools to teach signals and systems have been reported in [1-3].

For all these problems and associated application areas, we are developing a modular structure that consists of lectures covering the theory in each of the three areas, a set of comprehensive laboratory exercises, and use-inspired homework and projects to illustrate the main theoretical points and provide a physical connection to cutting-edge applications. More specifically, the laboratory exercises and homework address the following fundamental problems in signals and systems applications: Filtering, sampling, modulation and feedback. In addition to demonstrating the fundamental concepts, the exercises provide an opportunity for the students to implement simple applications such as upsampling/downsampling signals, music equalization and phase locked loops. A detailed description of the exercises can be found in the next section.

An initial set of preliminary exercises have been drafted, pre-assessed, and partially implemented starting Fall 2009 by obtaining support through a small grant from National Instruments [1]. These exercises, originally MATLAB-based with some preliminary LabVIEW imports [2], were initially being used as an assignment or as a set of computer

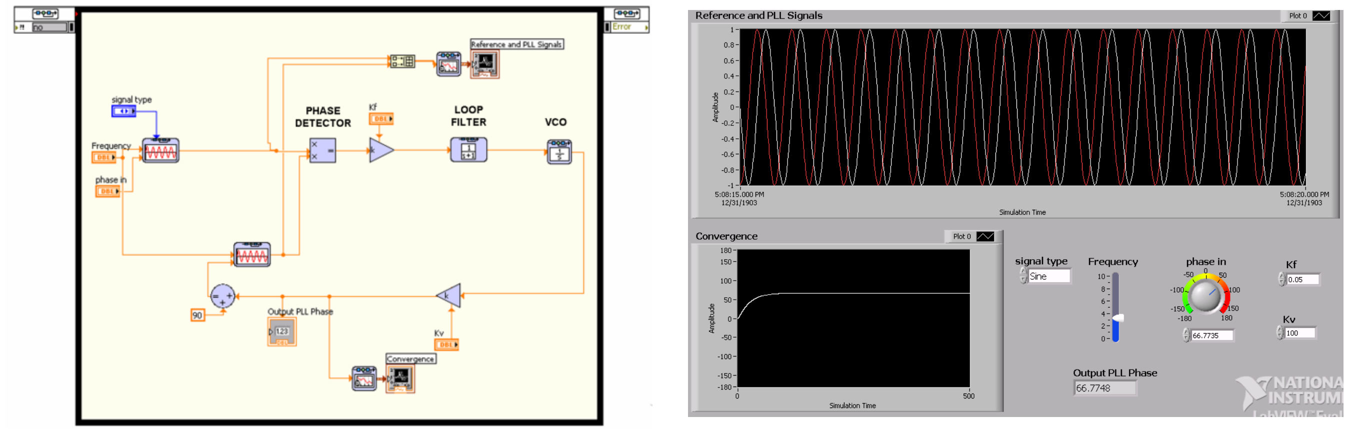

Figure 1. Block diagram and Front panel for the design of a Phase Locked Loop (PLL).

demonstrations in class. They are accompanied with minimal or no documentation and they are not necessarily well-suited for grading or monitoring of student learning. Despite these shortcomings, the initial experience with the delivery and the reception by the students is providing us with guidance and motivation for further improvements and wider online dissemination [1]. To strengthen the dissemination and assessment plan we are actively seeking a multi-university collaboration and government funding. We present below some preliminary laboratory exercises that we developed for this Pathways course.

PATHWAY COMPUTER EXERCISES USING LABVIEW

We choose LabVIEW for the computer exercises of this patheways course. Figure 1 illustrates the components of the LabVIEW VI. The availability of a wide range of functions and toolkits for study in signals and systems has motivated us to design LabVIEW exercises. The main objectives of these exercises are to provide students with an introduction to graphical programming and also enable them simulate the concepts learnt in the course. Students receive an introduction/review to Labview and GUI programming during an elongated first lab. They are assumed, however, to possess the basic programming skills as they enter the class. We are currently in the process of adjusting the first Signals and Systems course to contain a uniform instruction on Matlab, Labview and GUI programming. The exercises that the students performed in the pathways course are:

a) *Filter design and analysis*: In this exercise the students create and analyze a continuous-time LTI model system and convert it into a discrete-time system. Furthermore, they evaluate the response of the designed LTI system to arbitrary signals. Using the Digital Filter Design toolkit, students study the design and behavior of different FIR and IIR filters.

b) *Sampling, Aliasing and Equalization*: This laboratory emphasizes the effects of aliasing and considerations when oversampling is performed. Furthermore, they design a music equalizer by suitably altering the frequency characteristics of the system.

c) *Amplitude modulation*: This exercise introduces one of the basic modulation schemes, Amplitude Modulation (AM). In addition to the graphical approach used in the previous labs, this exercise introduces the MathScript functionality. Using the MathScript node enables students to combine the graphical programming with textual programming in LabVIEW.

d) *Feedback control*: This laboratory introduces some fundamental concepts in feedback control and linear Phase Locked Loops (PLL). Figure 1 illustrates the LabVIEW block diagram and the front panel for the design of a PLL.

CONCLUSIONS

In this paper, we presented the "pathways course" concept as implemented to enhance the Signals and Systems curriculum and reduce the educational disconnect between theory to practice . Modules, web-based laboratories and video lectures are currently being planned to complete an online version of the course. Different features in LabVIEW were used in designing the labs for this course. An overview of the exercises was given. Preliminary assessment results will be presented at the conference.

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