Preface for U of I DSP Laboratory*

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Abstract

The DSP Laboratory textbook is well suited for a variety of course organizations, and Connexions provides the ideal venue for the textbook.

This text builds on over fourteen years of DSP laboratory instruction and over ten years of collaborative development of instructional laboratory materials. The content has evolved in tandem with ECE 320: Digital Signal Processing Laboratory, a senior-level, two-credit-hour elective laboratory course at the University of Illinois at Urbana-Champaign, and to a large extent reflects its goals and structure. The material is nonetheless well suited for a variety of course organizations, and earlier versions of the material have been used with success at the University of Washington and elsewhere.

This text could be effectively used with several types of course structures, including

- a semester-long project-oriented DSP laboratory,
- a quarter- or semester-long DSP laboratory structured around weekly laboratory exercises,
- a hands-on laboratory supplement as part of a signal processing theory course,
- a self-study course in DSP implementation.

ECE 320 at the University of Illinois represents the first type of course. It consists of roughly two equal parts: a series of weekly laboratory assignments, including introduction to the Texas Instruments TMS320C549 microprocessor and DSP development environment, real-time FIR, IIR, and multirate filtering, spectral analysis using the FFT, and a digital communications transmitter. Students work together in pairs on these laboratory assignments and are orally quizzed individually after completing each weekly laboratory assignment. The materials for each week are a semi-self-paced tutorial with three major parts: a review of the signal processing concepts, a design or familiarization exercise (often MATLAB-based), and a real-time implementation assignment using the TMS320C549 microprocessor. After completion of these common modules in mid-semester, student teams conceive of a substantial real-time DSP project of their choice and spend the remainder of the semester designing, simulating, implementing, and testing it. Supplementary modules introducing students to the basics of digital communication (including phase-locked loops and delay-locked loops), adaptive filtering, speech processing, and audio signal processing accelerate students' progress on projects in these areas.

A course emphasizing signal processing algorithms might forgo a major project and instead use the supplementary modules to complete a quarter or semester of weekly laboratory assignments. A one-hour hands-on laboratory supplement to a signal processing lecture course could stretch the first few units (*e.g.*, through spectral analysis) over a semester, thereby reinforcing and enhancing students' understanding of the core signal processing theory and algorithms. Due to the self-paced, tutorial nature of the materials, a student can independently learn the aspects of real-time DSP implementation that interest them; students

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in our senior independent design course at the University of Illinois have successfully used the materials in this manner.

The laboratory materials and assignments reflect our belief that a thorough instruction in signal processing implementation requires exposure to assembly-language programming of fixed-point DSP microprocessors, as this represents an important component of current and at least near-future industrial practice. Instructors with other goals or perspectives may find most of the tutorial, design material, and assignments relevant even if they choose compiler-based or non-real-time implementation. Laboratories using different development systems or different DSP microprocessors will likely find almost all of the material well suited for their needs; only the hardware-specific language and instructions need be modified. Earlier versions of this material have been used with several different DSP microprocessors and development boards based on the Motorola DSP56000 and the Texas Instruments TMS320 families.

Connexions is an ideal venue for this text for several reasons. DSP hardware and development tools are evolving very rapidly, so a textbook produced through conventional publishers is likely to be almost obsolete before it is printed. Every university has a unique set of equipment, curriculum, and students, necessitating site-specific specialization of laboratory instructional material; conventional publishing is unable to produce textbooks cost-effectively with the rapid turnaround and low volumes thus required. We have always made our materials open, available, and free to other institutions to use in their own laboratory course development, so the open-source spirit of the Connexions project reflects our own philosophy and should more easily enable others to build on our experience. Finally, this material was created, modified, rewritten, and enhanced by a large and changing group of authors over a period of years in response to new ideas and evolving needs, goals, and equipment; its development thus embodies the Connexions philosophy.

The development of these materials would not have been possible without the active support and encouragement of many people and organizations. First, we express our gratitude to the corporations, particularly Texas Instruments, Motorola, and Hewlett-Packard/Agilent, whose generosity has equipped our instructional laboratory with state-of-the-art DSP development systems and instruments; our laboratory course would not be possible without their support. It would also have been impossible without the active support of the departmental leadership and the staff of the Electrical and Computer Engineering department, and particularly Dan Mast, for supporting, designing, equipping, and maintaining our instructional laboratory. We thank the Connexions team for their very substantial help in "connexifying" our materials, including conversion of the majority of the material into CNXML and MathML format; without their efforts, the text in this form would not exist. Support from the National Science Foundation in recent years enables continuing development of the course in response to student and industry needs. Most importantly, we are grateful to the generations of teaching assistants and students who have taught and learned from these materials over the past decade or more; it is their hard work, creative input, and dynamic interaction that have yielded this result.