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A Student Guide

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Digital Signal Processing

A Student Guide

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To
Jennifer and Hong

**Pay attention to your teacher
and learn all you can.**
Proverbs 23.12

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Preface

Digital signal processing (DSP) systems have developed at a rapid pace over the past two decades, and in recent years they have made a very considerable impact in many areas of signal processing applications. There is no doubt that in the next ten to twenty years the application of DSP systems will grow extensively in response to the ever-growing market demand to provide and rapidly process more and more signal-data transmitted over various forms of communication channel. Clearly DSP techniques will be particularly significant for the development and effective operation of networked super information highways, and we may confidently expect DSP to have far-reaching effects in enabling the development and expansion of new/enhanced world-wide communication systems. To promote and sustain these advances there will be a continuing requirement for engineers, scientists and technologists to have a good working knowledge of DSP concepts, design methods, and practical implementation considerations. Consequently this implies that DSP should form a significant part of the core study material in relevant technician, undergraduate and postgraduate courses, particularly those associated with electronic engineering and computer systems disciplines.

The purpose of this book is to provide a basic students' guide to DSP and associated practical applications. The book differs from the general form of textbook by presenting theoretical and practical concepts in an introductory-summary format, underpinned and demonstrated by a significant number of worked examples. It is intended that this form of presentation will enable the reader to immediately concentrate on understanding the significance of the principles described; and therefore in trying to achieve this objective we have deliberately tried to avoid presenting verbose descriptions and cumbersome and difficult proofs. We have tried to demonstrate how practical DSP results may be obtained by straightforward application of the processes/algorithms presented. Worked examples (signified by ♦ WE prefix) and a number of detailed practical case studies are presented to show how the DSP principles may be applied to solve practical problems.

The first chapter introduces some of the main principles of digital signals and DSP systems which students need as basic foundation knowledge before progressing further with their DSP studies. In Chapter 2 the required mathematical concepts of the z-transform and the inverse z-transform are summarised and demonstrated. For students who find DSP mathematics difficult to understand and handle, it is recommended that they use the worked examples

for tutorial study purposes and additionally use the end-of-chapter problems to test their understanding of the principles studied. By adopting this tutorial study approach for all of the DSP topics presented in this book, the reader should be able to work towards understanding the theoretical and practical principles described, and will be able to test their knowledge and understanding by solving the given problems. The discrete Fourier transform, the fast Fourier transform and other important allied topics are presented in Chapter 3. Some popular and useful design methods applicable to non-recursive (FIR) and recursive (IIR) digital filters are described in Chapter 4. Also in Chapter 4 we have included some basic considerations that must be given to quantisation effects in designing and implementing DSP processing operations. In Chapter 5 (the final chapter) hardware and software aspects of DSP system implementation are discussed in sufficient detail to enable the reader to build and test a simple low-cost hardware-based digital filter demonstrator. Two forms of implementation have been summarised: (i) a basic self-build M6802 microprocessor-based system, and (ii) a TMS320C26 based system (available off-the-shelf from Texas Instruments as the TMS320C2x DSP Starter Kit). Either is suitable for laboratory/project hands-on investigative signal processing activities, and considerable valuable experience can be gained by building/installing, programming and testing both forms of implementation. Thus by actually making the hardware process applied signals in real-time to satisfy the specified performance requirements, a student is able to learn about the various practical stages involved in producing a practical DSP system.

We believe that all students should be positively encouraged to extend their basic DSP knowledge and to develop research expertise by searching out several publications on a particular topic. We have therefore deliberately avoided directing the reader to specific references for additional information, instead we have provided a bibliography of DSP books which collectively contain a wealth of invaluable information, and which, as a starting point in seeking new/enhanced knowledge, the student could consult after the basic concepts presented in this book have been studied and understood.

This book is primarily intended for students wishing to gain an introduction to the basic principles of DSP and related topics. However, it is a fact of life that students and teachers share common interests in knowledge transfer, from one to the other, and we therefore sincerely hope that this book can serve the needs of student and teacher alike.

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