



Digital Signal Processing: A Practical Approach (2nd Edition)

By Emmanuel Ifeakor, Barrie Jervis

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Modern coverage of the fundamentals, implementation and applications of digital signal processing techniques from a practical point of view.

The past ten years has seen a significant growth in DSP applications throughout all areas of technology and this growth is expected well into the next millennium. This successful textbook covers most aspects of DSP found in undergraduate electrical, electronic or communications engineering courses. Unlike many other texts, it also covers a number of DSP techniques which are of particular relevance to industry such as adaptive filtering and multirate processing. The emphasis throughout the book is on the practical aspects of DSP.

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Editorial Review

From the Inside Flap

Purpose of this book

This book was born out of our experience in teaching practically oriented courses in digital signal processing (DSP) to undergraduate students at the University of Plymouth and the Sheffield Hallam University, and to application engineers in industry for many years. It appeared to us that many of the available textbooks were either too elementary or too theoretical to be of practical use for undergraduates or application engineers in industry. As most readers will know from experience, the gap between learning the fundamentals in any subject and actually applying them is quite wide. We therefore decided to write this book which we believe undergraduates will understand and appreciate and which will equip them to undertake practical digital signal processing assignments and projects. We also believe that higher degree students and practising engineers and scientists will find this text most useful.

Our own research work over the last two decades in applied DSP has also inspired the contents, by identifying practical issues for discussion and presentation to bridge the gap between theoretical concepts and practical implementation, and by suggesting application examples, case studies, and problems.

The current great interest and developments in DSP both in industry and academia are likely to continue for the foreseeable future. The availability of numerous digital signal processors recognizes the commercial potential of DSP. Its major attraction lies in the ability to achieve guaranteed accuracy and perfect reproducibility, and in its inherent flexibility compared with analogue signal processing. In industry, many engineers lack the necessary knowledge and expertise in DSP to utilize the immense potential of the very powerful digital signal processors now available off the shelf. This book provides insight and practical guidance to enable engineers to design and develop practical DSP systems using these devices.

In academia, DSP is generally regarded as one of the more mathematical topics in the electrical engineering curriculum, and based on our experiences of teaching we have reduced the mathematical content to what we consider useful, essential, and interesting; we have also emphasized points of difficulty. Our experiences indicate that students learn best if they are aware of the practical relevance of a subject, and while more theoretical texts are essential for completeness and reference as the student matures in the subject, we believe in producing graduates equipped also with practical knowledge and skills. This book was written with these considerations in mind.

The book is not a comprehensive text on DSP, but it covers most aspects of the subject found in undergraduate electrical, electronic or communication engineering degree courses. A number of DSP techniques which are of particular relevance to industry are also covered and in a few years, we believe, these will find their way into undergraduate curricula. These include techniques such as adaptive filtering and multirate processing.

The emphasis throughout the book is on the practical aspects of DSP. C language programs are provided to enable readers to explore the concepts presented in the book, to design and analyse their own DSP systems, and to gain a deeper understanding of DSP.

Commercial DSP software is available and plays a key role in the design and analysis of DSP systems. However, with most commercial software, it is difficult actually to find out or follow how a given operation is performed. The programs given in this book are useful in verifying results obtained manually. For example, by inserting break points the user can check the intermediate results of computation and follow the way the computation is made. Having acquired a sound knowledge of the principles, commercial software packages with good graphics support and user-friendly interfaces may then be used in most designs.

Main features of the book

Provides an understanding of the fundamentals, implementation, and applications of DSP techniques from a practical point of view.

Clear and easy to read, with mathematical contents reduced to that which is necessary for comprehension.

DSP techniques and concepts are illustrated with practically oriented worked examples.

Provides practical guidance to enable readers to design and develop actual DSP systems. Complete design examples and practical implementation details are given, including assembly language programs for the TMS320C10 and C25 processors.

Provides C language implementation of many DSP algorithms and functions including programs for:

- digital FIR and IIR filter design,
- finite wordlength effect analysis of user-designed IIR filters,
- converting from cascade to parallel realization structures,

- correlation computation,
- discrete and fast Fourier transform algorithms,
- inverse z-transformation,
- frequency response estimation, and
- multirate processing systems design.

PC-based C programs are available on a computer disk to encourage readers to participate more actively in the learning process (see the section 'How to obtain the program disk for this book' in this preface for details).

Contains many real-world application examples.

Contains many end-of-chapter problems.

Use of realistic examples to illustrate important concepts and to reinforce the knowledge gained.

The intended audience

The book is aimed at engineering, science and computer science students, and application engineers and scientists in industry who wish to gain a working knowledge of DSP. In particular, final year students studying for a degree in electronics, electrical or communication engineering will find the book valuable for both taught courses as well as their project work, as increasingly a greater proportion of student project work involves aspects of DSP. Postgraduates studying for a master's degree or PhD in the above subjects will also find the book useful.

Undergraduate students will find the fundamental topics very attractive and, we believe, the book will be a valuable source of information both throughout their course as well as when they go into industry.

Large commercial or government organizations who undertake their own internal DSP short courses could base them on the book. We believe the book will serve as a good teaching text as well as a valuable self-learning text for undergraduate, graduate and application engineers.

Contents and organization

Chapter 1 contains an overview of DSP and its applications to make the reader aware of the meaning of DSP and its importance. The chapter presents, from a practical point of view using real-world examples, many fundamental topics which form the cornerstone of DSP, such as sampling and quantization of signals and their implications in real-time DSP. Discrete-time signals and systems are introduced in this chapter, and discussed further in Chapter 3.

Discrete transforms, particularly the discrete and fast Fourier transforms (FFT), provide important mathematical tools in DSP as well as relating the time and frequency domains. They are introduced and described in Chapter 2 with a discussion of some applications to put them in context. The derivation of the discrete Fourier transform (DFT) from the Fourier transform and the exponential Fourier series provides a logical justification for the DFT which does not require coverage of the discrete Fourier series which would unnecessarily increase the length of the book (and the amount of work for the student!). The discussion has also been restricted to the description and implementation of the transforms. In particular, the topic of windowing has not been included in this chapter but is more appropriately discussed in detail in Chapter 10 on spectrum analysis.

In Chapter 3 the basics of discrete-time signals and systems are discussed. Important aspects of the z-transform, an invaluable tool for representing and analysis discrete-time signals and systems, are discussed. Many applications of the z-transform are highlighted, for example its use in the design, analysis and computation of the frequency response of discrete-time signals and systems. As in the rest of the book, the concepts as well as applications of the z-transform are illustrated with fully worked examples.

Correlation and convolution are fundamental and closely related topics in DSP and are covered in depth in Chapter 4. The authors consider an awareness of all the contents of this chapter to be essential for DSP, but after a preliminary scanning of the contents the reader may well be advised to build up his or her detailed knowledge by progressing through the chapter in stages. The contents might well be spread over several years of an undergraduate course.

Chapters 5, 6 and 7 include detailed practical discussions of digital filter design, one of the most important topics in DSP, being at the core of

From the Back Cover

The second edition of this popular text continues to provide practical coverage of the fundamentals of digital signal processing (DSP) using real-world applications and practical examples to illustrate key topics. Bridging the gap between theory and practice, the text also provides insight and guidance on how to use DSP techniques in order to design real engineering systems. This edition has been updated to include new topics of increasing importance to industry, as well as revising existing material to ensure currency and maximise clarity. MATLAB-based examples and exercises are now provided with the text and further problems have been added. This practical, introductory text covers most aspects of DSP found in undergraduate electrical, electronic or communications engineering courses. It additionally covers a number of DSP techniques, such as adaptive filtering and multirate processing, which are of particular relevance to those in industry or undertaking advanced studies. Key features

- Practical examples and real-world applications illustrate DSP techniques
- Mathematical content reduced to that necessary for comprehension
- C language implementation of many DSP algorithms and functions

New to this edition

- MATLAB-based examples and exercises included throughout
- Coverage of analogue I/O interface techniques for real-time DSP systems
- Increased coverage of new DSP processor architectures and hardware
- New topics on system identification, deconvolution, wavelet transform and parametric spectrum analysis
- Provides practical guidance and examples for DSP systems design
- Includes current applications in audio, medical and telecommunications engineering

Emmanuel Ifeachor is Professor of Intelligent Electronic Systems and Director of the Centre for Communications, Networks and Information Systems at the University of Plymouth, UK. Barrie Jervis is Professor of Electronic Engineering at Sheffield Hallam University, UK. This book evolved from the authors' extensive experience in teaching practically oriented courses in DSP to both undergraduates and engineers in industry. Their own research in applied DSP has influenced the contents of the book and provided many of the examples and case studies.

About the Author

Emmanuel Ifeachor is Professor of Intelligent Electronic Systems and Director of the Centre for Communications, Networks and Information Systems at the University of Plymouth, UK.

Barrie Jervis is Professor of Electronic Engineering at Sheffield Hallam University, UK.

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