

# Preface

Signal Processing (SP) is a subject of central importance in engineering and the applied sciences. Signals are information-bearing functions, and SP deals with the analysis and processing of signals (by dedicated systems) to extract or modify information. Signal processing is necessary because signals normally contain information that is not readily usable or understandable, or which might be disturbed by unwanted sources such as noise. Although many signals are non-electrical, it is common to convert them into electrical signals for processing. Most natural signals (such as acoustic and biomedical signals) are continuous functions of time, with these signals being referred to as analog signals. Prior to the onset of digital computers, Analog Signal Processing (ASP) and analog systems were the only tools to deal with analog signals. Although ASP and analog systems are still widely used, Digital Signal Processing (DSP) and digital systems are attracting more attention, due in large part to the significant advantages of digital systems over their analog counterparts. These advantages include superiority in performance, speed, reliability, efficiency of storage, size and cost. In addition, DSP can solve problems that cannot be solved using ASP, like the spectral analysis of multicomponent signals, adaptive filtering, and operations at very low frequencies.

Following the recent developments in engineering which occurred in the 1980s and 1990s, DSP became one of the world's fastest growing industries. Since that time DSP has not only impacted on traditional areas of electrical engineering, but has had far reaching effects on other domains that deal with information such as economics, meteorology, seismology, bioengineering, oceanology, communications, astronomy, radar engineering, control engineering and various other applications.

This book is based on the Lecture Notes of Associate Professor Zahir M. Hussain at RMIT University (Melbourne, 2001–2009), the research of Dr. Amin Z. Sadik (at QUT & RMIT, 2005–2008), and the Notes of Professor Peter O'Shea at Queensland University of Technology.

Part I of the book addresses the representation of analog and digital signals and systems in the time domain and in the frequency domain. The core topics covered are convolution, transforms (Fourier, Laplace, Z, Discrete-time Fourier, and

Discrete Fourier), filters, and random signal analysis. There is also a treatment of some important applications of DSP, including signal detection in noise, radar range estimation for airborne targets, binary communication systems, channel estimation, banking and financial applications, and audio effects production. Design and implementation of digital systems (such as integrators, differentiators, resonators and oscillators) are also considered, along with the design of conventional digital filters. Part I is suitable for an elementary course in DSP.

Part II (which is suitable for an advanced signal processing course), considers selected signal processing systems and techniques. Core topics covered are the Hilbert transformer, binary signal transmission, phase-locked loops, sigma–delta modulation, noise shaping, quantization, adaptive filters, and non-stationary signal analysis.

Part III presents some selected advanced DSP topics.

We hope that this book will contribute to the advancement of engineering education and that it will serve as a general reference book on digital signal processing.

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**Prerequisites:**

Basic knowledge in calculus, programming, and circuit theory is recommended.

**Objectives:**

The book aims to facilitate the development of expertise in analyzing and synthesizing signals, both natural and synthetic. It provides various tools which can reveal the critical information contained in the time and frequency structure of signals of interest. The book also provides advanced applications and topics in signal processing, with MATLAB experiments to give practical experience in implementing analog and digital signal processing systems.

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