



Multirate Signal Processing for Communication Systems

By Fredric J. Harris

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- *Effective sampling and resampling in time and frequency domains
- *Relationships between IIR Filter specifications and filter length (taps)
- *Window design and equal-ripple (Remez) design techniques
- *Square-Root Nyquist and Half Band Filters, including new design enhancements
- *Polyphase IIR Filters: up-sampling, down-sampling, and cascade up-down sampling
- *Polyphase interpolators and filters that perform arbitrary sample rate change
- *Dyadic Half Band Filters, including quadrature mirror and IIR Filters
- *Polyphase Channelizers, including M-path modulators, demodulator channel banks, simultaneous interpolation, and channel bank formation
- *Comprehensive coverage of recursive all-pass filters a topic never before covered in this detail
- *Comparisons with traditional DSP design techniques
- *Extensive applications coverage throughout

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Preface

Digital signal processing (DSP) has become a core body of material in undergraduate electrical engineering programs. Several threads branch from this core to enable related disciplines, such as communication systems, source coding, multimedia, entertainment, radar, sonar, medical and laboratory instruments, and others. *Multirate signal processing* is one of these major threads. Multirate signal processing is the body of material that deals with concepts, algorithms, and architectures that embed sample rate changes at one or more sites in the signal flow path.

There are two reasons to include multirate signal processing in the solution of a particular signal-processing task. The first is reduction in cost of the implementation. The second is enhanced performance of the implementation. We might also include a third, personal incentive, which is, that it is fun to apply clever concepts to solve problems. We can hardly complete a multirate DSP design without a smile and the accompanying thought, "Boy, this is neat!"

Traditional concepts developed in the DSP world are the same as those developed in the analog-processing world. In both domains we learn and use concepts such as convolution, Fourier transforms, transfer functions, poles and zeros, and others. When required to distinguish the two approaches we use the qualifier "discrete" when discussing the DSP version of these fundamental concepts. The reason the two approaches are so similar is that they both emphasize *linear time invariant* (LTI) systems for which the tools of analysis and synthesis are well developed.

Multirate signal processing brings to the designer an important tool not available to the traditional DSP designer, who to the first order applies DSP techniques to emulate analog systems. We note that the interface between the two versions of the world, continuous and discrete, is the sampling process. In the traditional DSP perspective, the sample rate is selected to satisfy the Nyquist criterion but is otherwise incidental to the problem. In multirate signal processing, sele...

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