Chapter IV

Efficient Multirate Filtering

Ljiljana D. Milić
Mihajlo Pupin Institute, Yugoslavia

Miroslav D. Lutovac
Telecommunications and Electronics Institute, Yugoslavia

Application of multirate techniques to improve digital filter design and implementation are considered in this chapter. FIR and IIR filter design and implementation for sampling rate conversion by integer and rational factors are presented. Sharp narrow-band and wide-band multirate design techniques are discussed. Accurate designs of FIR and IIR half-band filters are described in detail. Several examples are provided to illustrate the multirate approach to filter design.

INTRODUCTION

The multirate approach is used in practice to improve the computational efficiency of digital filters. In this chapter, we expose the basic multirate techniques that are essential for FIR and IIR filters: (a) polyphase decomposition, (b) multistage filtering, and (c) frequency-response masking techniques. We present the efficiency of multirate techniques through two main applications: (a) filters for sampling rate conversion and (b) filters with sharp transition bands.

For multirate systems, half-band filters are of particular importance. Half-band filters are used in sampling rate conversion by a factor of two and also as the basic building blocks in multistage systems. In this chapter, the attention is focused on the efficient and accurate design of FIR and IIR half-band filters.
FILTERS FOR SAMPLING RATE CONVERSION

Filters are used in decimation to suppress aliasing and in interpolation to remove imaging. The performance of the system for sampling rate conversion is mainly determined by filter characteristics. Since an ideal frequency response cannot be achieved, the choice of an appropriate specification is the first step in filter design. In Figure 1, three types of filter specifications used in practice are sketched. The first type of specification, shown in Figure 1(a), is used in interpolation when the spectrum of the signal to be interpolated is nonzero in the interval \([-\pi, \pi]\). In the case of decimation, this type of specification minimizes the aliasing in the decimated signal. The specifications shown in Figure 1(b) are used in interpolation when the highest frequency in the spectrum of the low-rate signal, \(|\omega_c|\), is band limited to \(\omega_c < \pi\), and in decimation when some aliasing from the adjacent band can be accepted. The specifications shown in Figure 1(c) contain several don’t care bands and are suitable for interpolation for the band limited low-rate signal, \(|\omega| < \pi\). In decimation, for a large \(M\) this type of specification may bring an excessive aliasing even in applications when some aliasing is accepted.

Figure 1: Three types of filter specifications for sampling rate conversion by factor \(M\)
Related Content

A Software Cost Model to Assess Productivity Impact of a Model-Driven Technique in Developing Domain-Specific Design Tools
www.igi-global.com/chapter/software-cost-model-assess-productivity/51979?camid=4v1a

Security Risks in Cloud Computing: An Analysis of the Main Vulnerabilities
www.igi-global.com/chapter/security-risks-cloud-computing/77740?camid=4v1a
Agile Software Development: The Straight and Narrow Path to Secure Software?
*International Journal of Secure Software Engineering* (pp. 71-85).
[www.igi-global.com/article/agile-software-development/46153?camid=4v1a](www.igi-global.com/article/agile-software-development/46153?camid=4v1a)

Gaits Classification of Normal vs. Patients by Wireless Gait Sensor and Support Vector Machine (SVM) Classifier