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**Chapter XVII**

**One Method for Design of  
Narrowband Lowpass  
Filters**

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**ABSTRACT**

*This chapter describes a design of a narrowband lowpass finite impulse response (FIR) filter using a small number of multipliers per output sample (MPS). The method is based on the use of a frequency-improved recursive running sum (RRS), called the sharpening RRS filter, and the interpolated finite impulse response (IFIR) structure. The filter sharpening technique uses multiple copies of the same filter according to an amplitude change function (ACF), which maps a transfer function before sharpening to a desired form after sharpening. Three ACFs are used in the design, as illustrated in the accompanying examples.*

## INTRODUCTION

The digital filter design problem is concerned with finding a magnitude response (or, equivalently, a gain) that meets the given specifications. These specifications are usually expressed in terms of the desired passband and stopband edge frequencies  $\omega_p$  and  $\omega_s$ , the permitted deviations in the passband (passband ripple)  $R_p$ , and the desired minimum stopband attenuation  $A_s$  (Mitra, 2001). Here we consider the specifications given in decibels (dB). Figure 1 illustrates a typical magnitude specification for a digital lowpass filter.

Due to their complexity, narrowband lowpass FIR filters are difficult and sometimes impossible to implement using conventional structures (Milic & Lutovac, 2002).

The IFIR filter proposed by Neuvo, Cheng and Mitra (1984) is one efficient realization for the design of narrowband FIR filters. The IFIR filter  $H(z)$  is a cascade of two filters:

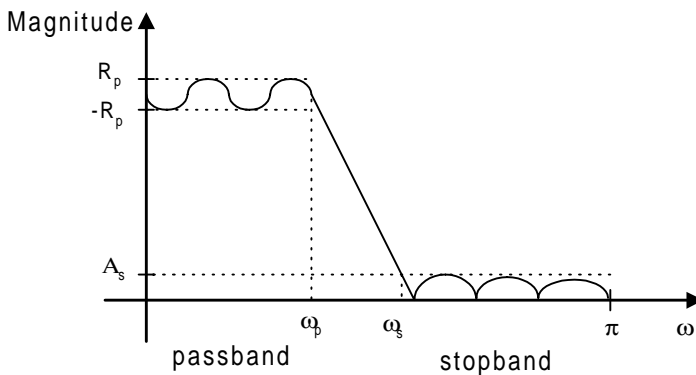
$$H(z) = G(z^M)I(z) \tag{1}$$

where  $G(z^M)$  is an expanded shaping or model filter,  $I(z)$  is an interpolator or image suppressor, and  $M$  is the interpolator factor. In this manner, the narrowband FIR prototype filter  $H(z)$  is designed using lower order filters,  $G(z)$  and  $I(z)$ . For more details on the IFIR structure, see Neuvo, Cheng and Mitra (1984).

The interpolation factor  $M$  is chosen so that the orders of filters  $G(z)$  and  $I(z)$  are equal or close to each other.

A linear increase of the interpolation factor results in the exponential growth of the interpolation filter order, as well as in the decrease of the shaping filter order. Our goal is to decrease the shaping filter order as much as possible and to efficiently implement the high-order interpolator filter. To do so, in this chapter, we propose to use RRS filter as an interpolator in the IFIR structure. Similarly, Pang, Ferrari and

*Figure 1. Lowpass Filter Magnitude Specification*



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