Decimating Filter Megafunctions

Solution Brief 14 February 1997, ver. 1

Target Applications:
Communications
Digital Signal Processing

Family: FLEX® 10K, FLEX 8000

Vendor:

FASTMAN, Inc.
1613 Capitol of TX Hwy. S., Suite 222
Austin, Texas 78746
Tel. (512) 328-9088
Fax (512) 328-9317
mrt@fastman.com
http://www.fastman.com

Features

- Supports 4-, 8-, 16-, and 32-bit data widths
- Supports filters with 3-24 taps
- Utilizes symmetric, linear phase filters
- Customizable decimate-by-*n* options available through FASTMAN's custom design program

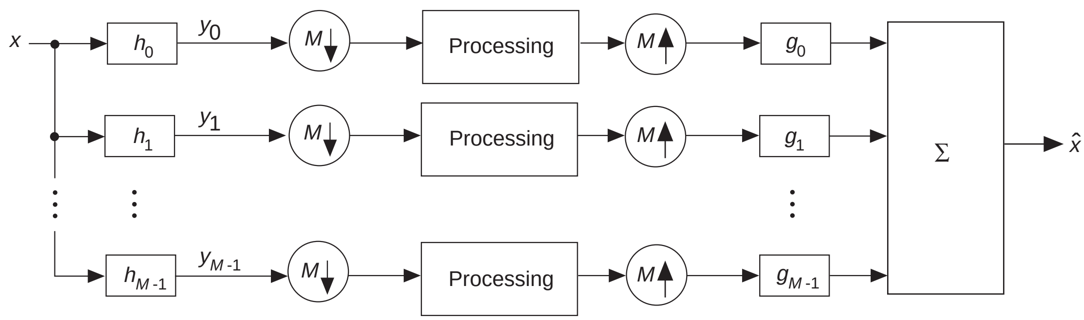
General Description

Decimating filters are finite-impulse response (FIR) filters that are used for filtering and down-sampling signals. Typically, decimating filters are used in filter banks to separate an incoming signal into frequency bands. The wavelet filter bank described in this solution brief uses FASTMAN's decimating-by-2 filter megafunction to process signals.

Functional Description

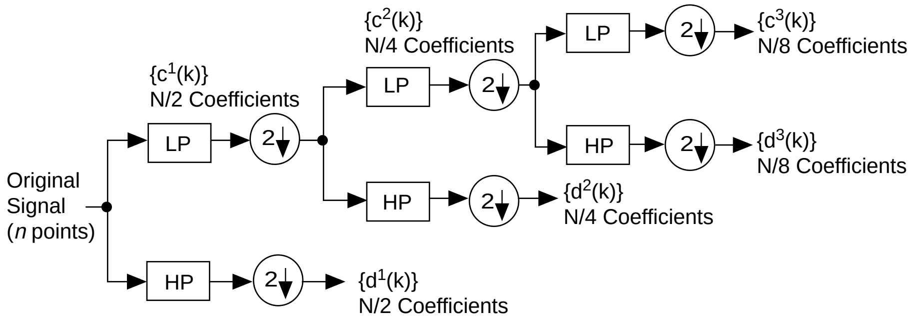
In the filter bank example in Figure 1, the incoming signal (x) is filtered into M subbands via bandpass filters h_0 through h_{M-1}. Because each subband signal (y_M) is confined to $1/M$th of the original frequency range, each signal can be decimated by a factor of M, which means only every Mth sample needs to be retained. Processing requirements on each subband signal vary according to the application. For example, in a compression application, some subband signals that do not contain frequencies of interest may be eliminated entirely, or may be severely quantized. In this case, only a small number of significant samples will be transmitted, resulting in significant data compression. After processing, the signal is reconstructed by up-sampling and applying the interpolating filter bank (filters g_0 through g_{M-1}). In a compression application, the up-sampling and interpolating filters are applied at the receiver. The outputs of the interpolating filters are summed to produce the output signal ($\hat{x}$).

Figure 1. Incoming Signal Processed through a Filter Bank



In a wavelet filter bank, wavelet coefficients are computed by applying multiple stages of a low-pass and high-pass filter pair, called a quadrature mirror filter pair, to the data signal. See Figure 1. At each stage (or scale) of the pyramid, the low-pass filter computes a smoother version of the signal and the high-pass filter brings out the signal's detail information at that scale. At the first stage, the filters are applied to the original, full-length signal. Then, at the next stage, the filter pair is applied to the smoothed and decimated low-pass output of the first stage. The wavelet coefficients consist of the accumulated detail components and the final smooth component.

Figure 2. Wavelet Filter Pyramid



The FASTMAN decimating-by-*n* filter megafunctions use shift registers to perform the decimating-by-*n* operation. For example, the decimating-by-2 filter megafunction efficiently computes every other output. (When creating a decimating-by-2 filter megafunction from a standard FIR filter, every other output is wasted.) Because most of the filter runs at the output clock frequency, which is half the input clock frequency, and because the filter multiplier is implemented as a pipelined vector multiplier using look-up tables (LUTs), the result of the FASTMAN decimating-by-2 filter is a fast and efficient design. See Figure 3.

Figure 3. FASTMAN Decimating-by-2 Filter Megafunction

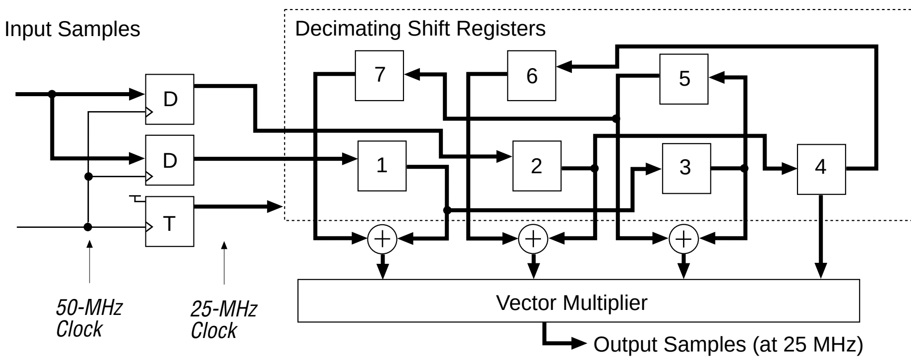


Table 1 lists typical device utilization of the FASTMAN decimating-by-2 megafunction.

Table 1. Typical Device Utilization

Implementation	Device Family	Speed Grade	f_{MAX}	Logic Cells	EABs
9-tap filter, 16-bit data word size	FLEX 10K	-3	65.0	1040	0
5-tap filter, 16-bit data word size	FLEX 10K	-3	62.5	921	0
8-tap filter, 8-bit data word size	FLEX 8000A	A-2	77.5	185	–
5-tap filter, 16-bit data word size	FLEX 8000A	A-2	55.0	920	–

ALTERA®

2610 Orchard Parkway
San Jose, CA 95134-2020
(408) 894-7000
http://www.altera.com