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RECONFIGURABLE VARIABLE DIGITAL FILTER IMPLEMENTATION WITH HIGH SPEED AND AREA EFFICIENCY

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Abstract: A reconfigurable implementation for changeable low pass, high pass, bandpass, and bandstop responses of FIR filters is described in this study. Warped filters are a form of variable digital filter that may be made by replacing each unit delay of a digital filter with an all-pass filter. They're often used in audio processing. However, to achieve variable low-pass or high-pass answers, warped filters need first-order all-pass transformation. In contrast, variable bandpass or bandstop responses require second-order all-pass transformation. We use warped filters in conjunction with the coefficient decimation approach to lessen the transformation of the warped filter. The cut-off frequency will be tuned using this warped filter coefficient, and the tap responses will be changed using the decimation coefficient. It generates changeable replies on the fly without updating the filter coefficients. For multiplication, a booth multiplier and a DA-based technique are presented. Computational speed and area efficiency will be achieved in this manner. The suggested design is tested for functional verification using the filter coefficients or filter structure.

Keywords—Coefficient decimation, variable digital filter (VDF), warped filter.

1. INTRODUCTION (*Heading 1*)

A variable digital filter (VDF) is a filter in which the frequency specification, such as the cut-off frequency Fc, may be changed on the fly using a limited number of parameters with little complexity overhead. A VDF is useful in various applications, including measuring, sound, and image processing. A warped filter [1] is one sort of VDF created by replacing each unit.

Delay of a digital filter with a proper order all-pass construction. The FC of the warped filter may be changed on the fly by adjusting the coefficients of an all-pass structure. Warped filters are often used for linear prediction, echo cancellation, loudspeaker equalization, spectrally changing an audio signal, detecting band-pass signals in broadband sounds, and other audio applications. [2]–[8]. Depending on the application, warped filters with variable low-pass, high-pass, band-pass, or band-stop responses may be created.

[6] uses warped filters for audio equalization applications, and the findings suggest that twisted FIR filters outperform regular FIR filters. Adaptive filters are used in [7] to identify band-pass signals in a broadband signal using the warping approach. A filter bank for low-power digital hearing aids based on warped filters is presented in [8]. It is made up of parallel variable low-pass, band-pass, and high-pass Filters. A coefficient decimation method (CDM) is developed to generate low-complexity VDFs with fixed coefficients. However, filters created using this method can only use a limited number of cut-off frequencies.

We offer a low-complexity VDF implementation using warped filters and CDM in this short. A fixed-coefficient low-pass prototype filter is employed in the suggested design. Reduced second-order all-pass transformation is used to create fixed-bandwidth bandpass/bandstop responses at an arbitrary center frequency, and the CDM approach is used to modify the bandwidth. Multiplexers are used to skip one delay element of a reduced second-order all-pass transformation, resulting in varied low-pass/high-pass responses. The suggested warped filter design is, to our knowledge, the first to give changeable low-pass, high-pass, bandpass, and bandstop responses on the fly without the need to update filter coefficients.

2. LITERATURE REVIEW

This section briefly reviews the warped filter [1] and the CDM technique [14].

2.1 Warped Filter

The frequency warping technique was proposed in [1] and further studied in [2]–[8]. Here, FIR filters are considered for the discussion. Consider Nth-order FIR filter (also called as prototype filter) with impulse response h(n) and its z-transform H(z). Let G(z) be the warped FIR version of H (z) obtained by replacing every delay with first-order all-pass structure A(z)

$$G(z) = H(A(z))$$

Here α is the warping coefficient that controls the warped frequency response.[15]. There are various implementations available for A(z) [15]. The single-multiplier all-pass structure [15], as shown in Fig. 1, is used here.

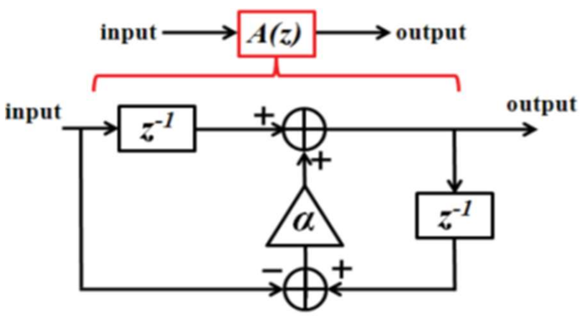

Fig 1. First-order single multiplier structure

3. PROPOSED VDF

Multiplication speed and area efficiency are the primary goals of the proposed VDF, which combines modified booth and distributed arithmetic with warped filtering and coefficient decimation. No other filter design is discussed in this brief. It is also possible to use this method to construct warped IIR filters.

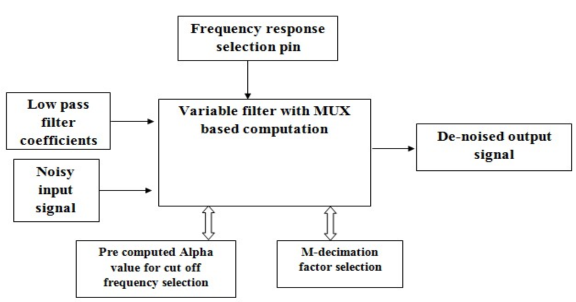

Fig. 2 *proposed VDF architecture*

A. Design of the Proposed VDF

Modified booth algorithm

Consequently, the filter coefficients may be hardwired. Multiplexers controlled by signal sel m are used to implement the CDM. The lookup table contains the sel m values for each M. (LUT). The modified version of Booth's method runs twice as quickly as the original. By combining successive bits in one operand to generate the signed multiples, the modified Booth method reduces the number of partial products. The multiplier and multiplicand are terms used to describe the two operands that make up a Booth encoded operand. Warped coefficient () and an input signal are multiplied using a booth multiplier radix 8. Four Bits are considered a group in the radix-8 booth multiplier. As a result, the speed of computing will be much enhanced.

B. Distributed arithmetic algorithm

Convolution with multiplier-less units may be implemented using distributed arithmetic, which replaces MAC operations with a sequence of LUT accesses and summations. Digital filters may be implemented in a different way using Distributed Arithmetic. The main concept is to use a table and a shifter-accumulator to replace all multiplications and additions. The DA-based technique is utilized to multiply the input signal and filter coefficients. In terms of cost and time efficiency, distributed arithmetic is an excellent option.

The warping coefficient and the decimation factor M are the two governing factors here.

It is suggested that this combination is both space and time-efficient.

4. DESIGN EXAMPLE PHASE IV

An appropriate design example is used to demonstrate the proposed VDF's performance. Half of the sampling frequency has normalized all of the frequency edges listed below. Let the peak bandpass and bandstop ripple requirements by 0.002 dB and 80 dB. The prototype filter has a cutoff frequency of 0.06 Hz and a transition bandwidth of 0.02. Figure 1 shows the magnified bandpass ripples and the varying low-pass responses achieved with the suggested VDF.

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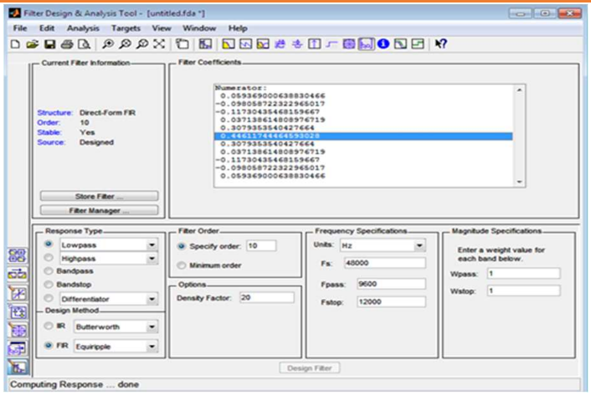


Fig.3 FDA tool for low pass coefficient extraction

Fc may be adjusted from 0.01% to 0.999%. The bandwidth of the transition is not constant and is determined by and M. It ranges from 0.002 to 0.1. Figure 1 shows the varied bandpass responses at the center frequency of 0.548 for = 0.15. The bandwidth grows as the value of M increases. The central frequency may be altered by modifying.

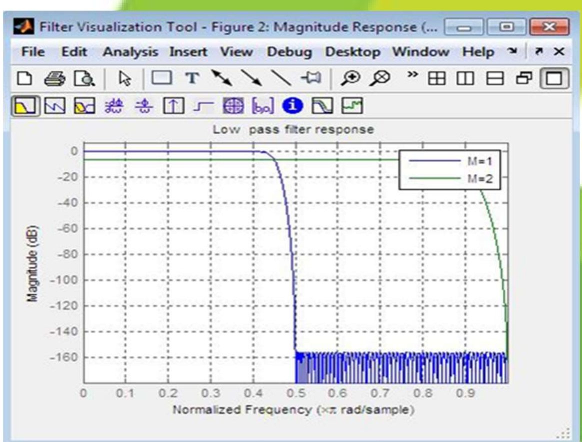


Fig.4 Variable low-pass responses using decimation factor

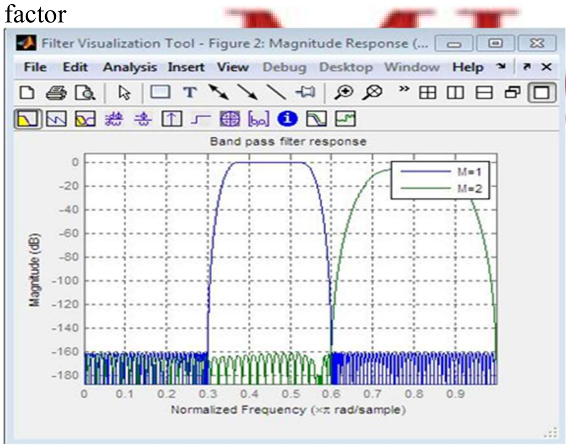


Fig.5 Variable band-pass responses using decimation

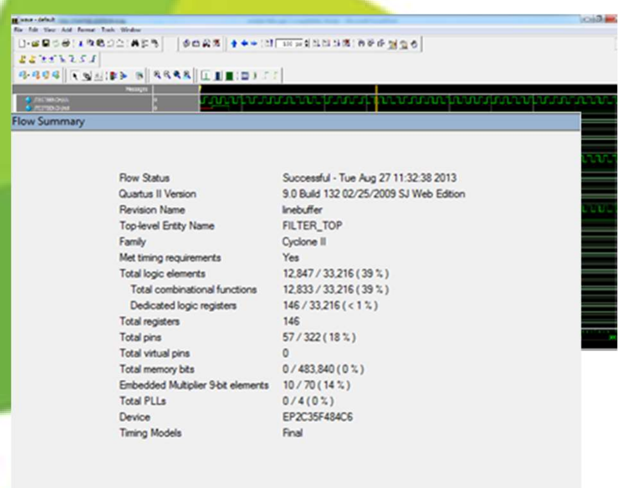
(1)

CDM does not affect phase or group delay characteristics of the proposed VDF since it uses the same all-pass transformation and CDM solely influences magnitude response. As no effect on phase or group delay characteristics of the proposed VDF since it uses the same all-pass transformation and CDM solely influences magnitude response. **DISCUSSION**

5. Simulation and Synthesis Design

VDF suggested in [1] and [7] are compared in terms of total gate counts to the proposed VDF in [1] and [7]. Four different circuits were designed using QUARTUS II EDA tools: an 8-bit multiplier, 4:1 multiplexer, and 32-bit adder. The CDM technique degrades the stopband attenuation with increasing decimation factor [14]. As a result, an overly complex prototype filter is required. Because of this, we have a prototype filter order of twenty for the proposed VDF, which is lower than 20 in the case of DA. In all situations, the transition bandwidth ranges between 0.002 and 0.1. The findings may be summarised in this way. Using MODELSIM6.4 and QUARTUS II, simulate fig.3's lowpass filter and synthesize fig.4.

Fig.6 low pass filter simulation result



For example, the phase or group delay characteristics of the proposed VDF are equal to those of warped filters [1–8] since CDM influences only the magnitude response.

Fig.7 various low pass filter synthesis result

Using the same all-pass transformation and CDM only influences magnitude response, phase, or group delay characteristics of the proposed VDF, similar to those of warped filters [1–8].

6. CONCLUSION

This work uses a suggested MUX-based bypass representation to describe a novel hardware architecture with high-speed VARIABLE FIR filter efficiency. Predefined values in LUTs were used to send filter coefficients into the next tap. The alpha coefficient is multiplied by the Radix 8 booth multiplier to compute the input signal from the partial products of all potential sub-coefficients and data using the DA-based technique for each block. QUARTUS II EDA software developed and synthesized the proposed CDM-based VDF FIR filters.

References

[1] A. G. Constantinides, “Spectral transformations for digital filters,” Proc. Inst. Electr. Eng., vol. 117, no. 8, pp. 1585–1590, Aug. 1970.

[2] A. V. Oppenheim and D. H. Johnson, “Discrete representation of signals,” Proc. IEEE, vol. 60, no. 6, pp. 681–691, Jun. 1972.

[3] C. Braccini and A. V. Oppenheim, “Unequal bandwidth spectral analysis using digital frequency warping,” IEEE Trans. Acoust., Speech Signal Process., vol. 22, no. 4, pp. 236–244, Aug. 1974.

[4] A. Makur and S. Mitra, “Warped discrete-Fourier transform: Theory and applications,” IEEE Trans. Circuits Syst. I, Fundam. Theory Appl., vol. 48, no. 9, pp. 1086–1093, Sep. 2001.

[5] C. Asavathiratham, P. E. Beckmann, and A. V. Oppenheim, “Frequency warping in the design and implementation of fixed-point audio equalizers,” in Proc. IEEE Workshop Appl. Signal Process. Audio Acoust., Oct. 1999, pp. 55–58.

[6] S. Kinoshita, Y. Kumamoto, M. Abe, and M. Kawamata, “Highorder center-frequency adaptive filters using block-diagram-based frequency transformation,” in Proc. IEEE Int. Conf. Acoust., Speech Signal Process., Prague, Czech Republic, May 2011, pp. 4284–4287.

[7] N. Ito and T. L. Deng, “Variable-bandwidth filter-bank for low-power hearing aids,” in Proc. 3rd Int. Congr. Image Signal Process., vol. 7. Oct. 2010, pp. 3207–3211.

[8] A. V. Oppenheim, W. F. G. Mechlenbräuker, and R. M. Mersereau, “Variable cutoff linear phase digital filters,” IEEE Trans. Circuits Syst., vol. 23, no. 4, pp. 199–203, Apr. 1976.

[9] S. C. Chan, C. K. S. Pun, and K. L. Ho, “A new method for designing FIR filters with variable characteristics,” IEEE Signal Process. Lett., vol. 11, no. 2, pp. 274–277, Feb. 2004.

[10] P. Löwenborg and H. Johansson, “Minimax design of adjustable bandwidth linear-phase FIR filters,” IEEE Trans. Circuits Syst. I, Reg. Papers, vol. 53, no. 2, pp. 431–439, Feb. 2006.

[11] S. J. Darak, A. P. Vinod, and E. M.-K. Lai, “A new variable digital filter design based on fractional dProc. IEEE Int. Conf. Acoust., Speech Signal Process., Prague, Czech Republic, May 2011, pp. 1629–1632.