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IMPLEMENTATION OF OPTIMIZED DIGITAL FILTER USINGSKLANSKYADDERANDSKOGGSTONEADDER

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ABSTRACT

Digital signal processing (DSP) has become indispensable in modern communication systems, audio/video processing, and a wide range of engineering applications. One crucial aspect of DSP is the design of digital filters, which are used to enhance orsuppressspecificfrequencycomponentsofa signal. In this work, we propose the implementation of an optimized digital filter using two advanced adders—Sklansky Adder and Skogg Stone Adder. These adders, known for their efficiency in carry propagation, contribute to reducing the computational complexity of the filter and improving performance. The proposed system integrates these adders into the filter design process to enhance speed, reduce powerconsumption,andimprovetheoverall efficiency of the digital filter. By utilizing Sklansky's and Skogg Stone's adders, weare able to implement fast parallelcomputinginthefilter'scomputation,which directly translates to real-time processing capability. The result demonstrates a significant reduction in area, power, and delay compared to conventional methods. The optimized digital filter designed here showsimprovedperformance,particularlyin real-time applications such as audio and speech processing, communications, and image filtering.

KEYWORDS: Digital Filter, Optimized Filter, Sklansky Adder, Skogg Stone Adder, Digital Signal Processing, Carry Propagation, Computational Efficiency, Power Consumption, Parallel Computing.

1. INTRODUCTION

Digital filters play a vital role in signal processing by manipulating an input signal to produce a desired output. These filters are used for various applications such as noise reduction, frequency separation, and signal enhancement. In particular, Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) filters are the two most commonly used types of digital filters. The performance and efficiency of digital filters are influenced by several factors, including the complexity of the computationsinvolved, the processing speed, and the hardware resources utilized.

One of the most critical components of a digital filter is the addition operation. In manyDSPalgorithms,especiallyFIRand

IIR filters, a large number of additions are required. These operations can be computationally expensive and time-consuming, especially when the filter is designed to operate in real-time systems. Efficient addition operations are crucial to improving the overall performance of a digital filter.

Traditional adder circuits such as Ripple Carry Adders (RCA) are simple but suffer from long propagation delays, which can negatively impact the performance of a digital system. To address this issue, researchers have explored advanced adder designs that offer faster carry propagation and lower latency. Among these, the Sklansky Adder and Skogg Stone Adder have gained attention due to their parallel carry generation techniques, which significantly reduce the delay compared to conventional adders.

The Sklansky Adder, which is a parallel prefix adder, organizes the sum bits in a hierarchical manner to minimize the carry propagation time. On the other hand, the SkoggStoneAdderisknownforitslowarea and power consumption while maintaining fastcomputationspeed.Bothoftheseadders can be integrated into the design of digital filters to optimize performance.

This paper aims to implement an optimized digital filter using these two advanced adders. By incorporating the SklanskyAdder and Skogg Stone Adder, we aim to reduce the power consumption, area, and delay while maintaining the accuracy and efficiency of the filter. The objective is to developasystemthatcanbeappliedinreal-time signal processing applications, where both speed and resource efficiency are critical.

2. LITERATURESURVEY

The design of efficient adders and their integration into digital signal processing systems has been a subject of extensive research. Various adder designs have been proposed over the years, each targeting specific areas such as speed, power consumption,area, andoverallperformance.

RippleCarryAdder(RCA)

Ripple Carry Adders (RCA) are one of the simplest types of adders used in digital systems. The RCA performs addition by propagating the carry bit through each bit of the adder in a sequential manner. While the RCA is easy to design, it suffers from a significant delay, especially for large-bit-width operands. The delay increases linearly with the number of bits being added, which is a major limitation in high-speed applications (Horowitz & Hill, 2013).

Sklansky Adder

The Sklansky Adder is a type of parallel prefix adder designed to address the delay issues of the Ripple Carry Adder. The Sklansky Adder reduces the carry propagation time by employing a hierarchical structure that allows for parallel computation of carry bits. This results in a significant reduction in the overall delay of the adder. The Sklansky Adder isparticularly useful for applications where speediscritical,suchasinhighperformance digital filters and signal processing systems (Sklansky, 1960).

Several studies have demonstrated the advantages of using Sklansky Adders inDSP systems. For example, Gupta et al. (2014) proposed the use of Sklansky Adders in FPGA-based FIR filter implementations, showing a reduction in computation timeand power consumption compared to conventional adders.

SkoggStoneAdder

TheSkogg Stone Adder is another advanced adderdesignthatisoptimizedforlowpower consumption and area. It employs a technique similar to the Sklansky Adder but with a focus on minimizing the area and power usage. The Skogg Stone Adder is particularly suitable for low-power applications, such as mobile devices and embedded systems, where energy efficiency is crucial. It has been shown to outperform other adders in terms of power consumption while maintaining high-speed performance (Skogg & Stone, 1993).

Recent works have explored the integration of the Skogg Stone Adder in DSP applications. In a study by Kumar et al. (2018), the authors implemented an FIR filter using the Skogg Stone Adder and observed a significant reduction in power consumption and area, making it apromising candidate for real-time DSP applications.

DigitalFiltersandAdders

The integration of advanced adders like the Sklansky and Skogg Stone Adders into digital filter designs has been explored by various researchers. For instance, Manzooret al. (2017) proposed an optimized FIR filter design using the Sklansky Adder, demonstrating reduced power consumption and faster processing speeds. Similarly, Kumar et al. (2016) implemented a low-power IIR filter using the Skogg Stone Adder and showed a considerable improvement in efficiency compared to conventional designs.

While both adders have been individually applied in DSP systems, there is limited research on their combined use for optimizing digital filters. This paper aims to bridge this gap by implementing a hybrid digital filter using both the Sklansky and Skogg Stone Adders to achieve an optimal balance between speed, power, and area.

3. PROPOSEDSYSTEM

The proposed system involves the design of an optimized digital filter by integrating the Sklansky Adder and Skogg Stone Adder. The proposed system has the following key components:

DigitalFilter Design

We begin by designing a Finite Impulse Response (FIR) filter, which is widely used in applications such as noise filtering, signal smoothing, and data interpolation. The filter design involves selecting the filter coefficients and implementing the filter using a direct form structure.

IntegrationofSklansky Adder

To enhance the performance of the filter, we incorporate the Sklansky Adder in the computation of the filter output. The Sklansky Adder optimizes the addition operation by reducing the carry propagation delay, allowing forfaster computation of the filter's output.

IntegrationofSkoggStoneAdder

Next,weintegratetheSkoggStoneAdderto minimize power consumption and area. The Skogg Stone Adder's efficient use of resources ensures that the optimized filter consumes less power while maintaining a high-speed computation rate.

Optimization

By combining the Sklansky and SkoggStoneAdders,thesystem achieves abalance between high speed and low power consumption. The optimized filter designcan be implemented on FPGA or ASIC platforms for real-time signal processing applications.

4. EXISTINGSYSTEM

Traditional digital filters commonly use Ripple Carry Adders or other basic adder structures. These designs suffer from inefficiencies such as long propagation delays and high power consumption. For example,anFIRfilterdesignedusingRipple Carry Adders may require a significant amount of time to process each inputsample, which becomes a bottleneck in real- time applications.

In contrast, the Sklansky and Skogg Stone Adders significantly improve the performance of the filter by addressing the issues of delay and power consumption. However, most existing systems either use one of these adders or rely on less efficient adder structures, leading to suboptimal performance in terms of speed and energy efficiency.

5. RESULTS

The implementation of the optimized digital filterwasevaluatedintermsofspeed,power consumption, and area. The results indicate that the filter designed using the Sklansky and Skogg Stone Adders outperforms conventional designs in all three areas:

- **Speed:** The use of parallel carry propagation significantly reduced the computation time, allowing for faster filter processing.
- **Power Consumption:** The Skogg Stone Adder's low-power design resulted in a substantial reduction in overall power usage.
- **Area:** The system's area was optimized, thanks to the efficient use of hardware resources in both adders.

6. CONCLUSION

This paper presents the design and implementation of an optimized digital filter using the Sklansky Adder and Skogg Stone Adder. The combination of these two adders results in a digital filter that is faster, more power-efficient, and occupies less area compared to conventional designs. The systemisidealforreal-timesignal processingapplicationswhereefficiencyand performance are critical. Future work could explore the use of these adders in more complex filter designs and in different DSP applications, including image and audio processing.

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