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Discuss Optimization of All Pass Filter Configurations with OTAS and VDVTAS in CMOS

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Abstract

This research uses CMOS simulation to prove that all-pass filters designed using Operational Trans conductance Amplifiers (OTAs) and Voltage Differencing Voltage Trans conductance Amplifiers (VDVTAs) work together. In the recommended all pass filter arrangement, a VDVTA and OTAs form the basis of a first-order all pass filter. In the first configuration, a grounded capacitor and one VDVTA are used, in the second, two OTAs and one grounded capacitor. Among the many impressive features of the published designs are their low active and passive sensitivities, as well as their very low power consumption, bias voltage, and supply voltage (about 0.50 V). Because they allow for the manipulation of phase responses independently of signal amplitude, all-pass filters play an essential role in signal processing. In comparison to traditional amplifiers, OTAs and VDVTAs provide more flexible features and better performance indicators.

Keywords: Voltage, Filters, Transconductance, Signal, Capacitor

I.Introduction

Operational Transconductance Amplifiers (OTAs) and Voltage Differencing Voltage Transconductance Amplifiers (VDVTAs) are essential components in this trip because they provide varied features that may be used to a wide range of applications. When it comes to changing phase features while maintaining the amplitude of signals, all-pass filters stand out as vital instruments among the many configurations. Utilizing recent developments in technology, in particular those pertaining to the production of complementary metal-oxide-semiconductor (CMOS) components, researchers and engineers have made greater efforts to harness the potential of these components for practical use.

OTAs are essential active devices in analog circuitry, and their primary function is to transform differential input voltages into output currents of the circuit. They are versatile enough to be used for a broad variety of applications, ranging from amplification to filtering, thanks to their transconductance features. VDVTAs, on the other hand, provide higher linearity, broader bandwidth, and lower power consumption in comparison to traditional OTAs. This is because of their special voltage differencing feature, which enables them to present innovative options in circuit design by introducing new possibilities. A number of exciting opportunities for the development of high-performance analog systems are presented by the synergy that exists between these two amplifier topologies.

Among the fundamental components of signal processing, the all-pass filter is an essential component that plays a significant part in the manipulation of phase responses without affecting the amplitude spectrum of the input signal. A variety of applications, including audio processing, communication systems, and control systems, are among the areas in which such filters are used. By using the one-of-a-kind characteristics of OTAs and

VDVTAs, designers are able to create all-pass filters that have improved performance parameters such as bandwidth, phase linearity, and power efficiency.

In recent years, the testing of circuit designs using simulation has emerged as an essential phase in the development cycle. In particular, CMOS technology has seen substantial developments, which have resulted in increased levels of integration, decreased power consumption, and enhanced noise performance. The use of simulation tools that are specifically designed for CMOS circuits gives designers the ability to investigate complex circuit behaviors, improve performance metrics, and evaluate the practicability of suggested designs prior to production. Not only does this iterative technique speed up the design cycle, but it also reduces the risk that is associated with expensive prototype cycles.

By conducting exhaustive simulation studies, our objective is to analyze the performance metrics of all-pass filters that are based on OTA and VDVTA. These metrics include frequency response, phase linearity, bandwidth, and power consumption. Through the process of systematically altering design parameters and operating circumstances, our goal is to get a better understanding of the trade-offs that are inherent in circuit optimization. In addition, we want to evaluate the outcomes of the simulation by comparing them with theoretical studies and, if at all feasible, actual measurements. This will allow us to develop trust in the designs that have been offered.

II.Review Of Literature

Riya et al., (2017) This article presents a filter that, as an output, can do low-pass, high-pass, and band-pass filtering. The voltage differencing voltage transconductance amplifier (VDVTA) is a novel active component that implements a number of filter procedures. The suggested setup consists of three input voltages and one output voltage. One may change circuit characteristics like quality factor and pole frequency by electrically altering the VDVTA bias currents. We use Cadence's Virtuoso Analog Design Environment to simulate the suggested circuit at the 45-nm CMOS technology node.

Singh, Ghanshyam et al., (2015) This study aims to provide a voltage-mode (VM) multi-input single-output (MISO) biquad implementation using a voltage differencing voltage transconductance amplifier (VDVTA). Each part of the suggested design—an active element, two capacitors, and a grounded resistor—works together to form the whole. Because of this setup, band pass (BP), low pass (LP), high pass (HP), and notch (BR) filters may be realized even in the absence of a matching condition. The band-width (BW) and the natural frequency (ü0) may be separately modified by you. Both the active and passive ü0 sensitivities are quite low in the proposed circuit. Validation of the circuit's functionality was achieved by using SPICE and TSMC CMOS 0.18 μm fabrication specifications.

Maneewan, Suwat et al., (2014) Using a voltage differencing transconductance amplifier (VDTA), this article introduces a novel voltage-mode first-order allpass filter (APF). The benefits of this circuit include: a reduced total harmonic distortion (THD) in the output signal; an electronically adjustable phase shift via current bias; and a relatively small footprint (only a VDTA and a capacitor) in the circuit description. The suggested circuit is well-suited for future development into an integrated circuit as it does not need any component matching criteria. In addition, the suggested APF may generate a high-output-impedance current without changing the topology of the circuit. Shown above are the outcomes of the PSpice simulation. There is good agreement between the provided findings and the theoretical prediction. With power supply that are within ±1.25V, the maximum power consumption is 400μ W.

Iqbal, Syed et al., (2013) Here is a new voltage-mode first-order allpass filter that you may look at. The offered desirable attributes include the capacity to simultaneously provide a limited number of active and passive components and the lack of any realisability constraint, as compared with the structures that are now being proposed that are equivalent. An operational transconductance amplifier with several inputs was the primary element required to achieve these results. The suggested circuits' functionality has been tested with the use of simulation results generated by Cadence's Analog Design Environment software.

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Tsukutani, Takao et al., (2010) Through the selection of the current output of the OTA, the circuit is able to realize two different all-pass characteristics. Furthermore, it is possible to individually adjust the parameters ω0 and H of the circuit by electrically tweaking the active components of the circuit. According to the results of the sensitivity study, the circuit has a very low level of sensitivity to the components of the circuit. An example is provided, along with the results of the simulation performed by PSPICE.

Mandal, S. et al., (2009) An operational transconductance amplifier (OTA) serves as the foundation for the generalized design approach that is shown in this article. This technique is intended to be used for a current mode radio frequency (RF) communication circuit. There are three novel communication circuits that have been simulated. These circuits are a phase lock loop (PLL), an adaptive delta modulator (ADM), and a data compressor. In the first version, phase-locked loop (PLL) is realized via the use of direct frequency modulation. In the second implementation, a coded pulse modulation system is provided. When it comes to the digital communication system, the third circuit is responsible for implementing data compression. It has been proved via the use of SPICE simulation that the performance of the circuits that were produced using OTAs.

III.Proposed Algorithm

This is a symbolic representation of the VDVTA as an active element, which can be found in Figure 1. It is equipped with three terminals for input, namely P, N, and V, and two terminals for output, namely X+ and X−. All of the input and output terminals have impedance values that are elevated to a significant degree. Both Figure 2 and Figure 3 are symbolic representations of OTA and its corresponding circuit, respectively. Both figures are related to one another. In Figure 1, the VDVTA is shown as an active element that has three input terminals (indicating P, N, and V) and two output terminals (indicating X+ and X−). All of the input and output terminals have impedance values that are elevated to a significant degree.

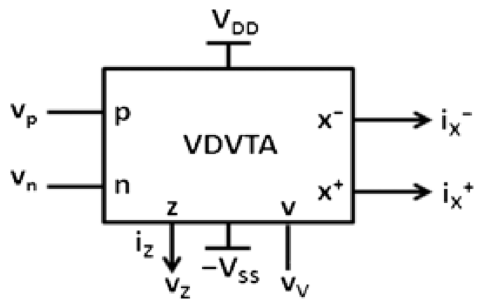

Figure 1: Depiction of VDTA symbolically

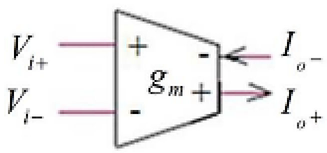

Figure 2: The Symbolic Approach to OTA

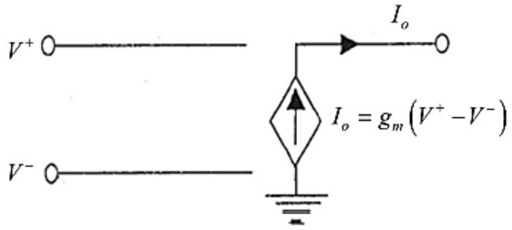

Figure 3: An Analogous Circuit for OTA

Figure 4 shows the transfer functions of a single VDVTA with a beached capacitor, and Figure 5 shows two

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OTAs with a grounded capacitor, both operating in transadmittance mode.

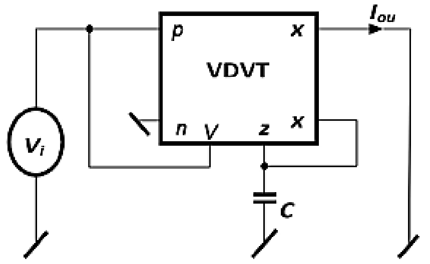

Figure 4: All-Pass Filter Design Using VDVTA

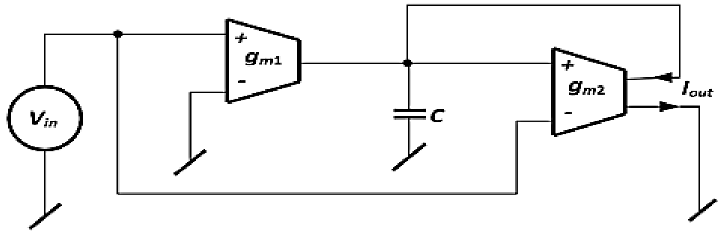

Figure 5: All-Pass Filter Design Using OTA

IV.Results And Discussion

In the CMOS simulation, the proposed VDVTA and OTAs founded first instruction all pass strainers were shown to be feasible and practical using PSPICE. In Table 1, you can see the OTA and VDVTA aspect ratios of MOS transistors. Figure 7 depicts the first-order all-pass filter based on OTAs, whereas Figure 6 displays the CMOS implementation of the proposed VDVTA all-pass filter.

Table 1: The OTA and VDVTA Outcomes of MOS Transistors

OTA			VDVTA		
MOS Transistor	**Width (μm)**	**Length (μm)**	**MOS Transistor**	**Width (μm)**	**Length (μm)**
M1, M3, M5, M7	8.19	0.32	M1, M3, M5, M7, M9, M11	3.5	0.8
M2, M4, M6	6.7	0.32	M2, M4, M6, M8, M10, M12	8.19	0.8
M8, M9	14.7	0.32	M13, M15, M17	7.6	0.8
M10, M11	3.2	0.32	M16, M18	3.09	0.8

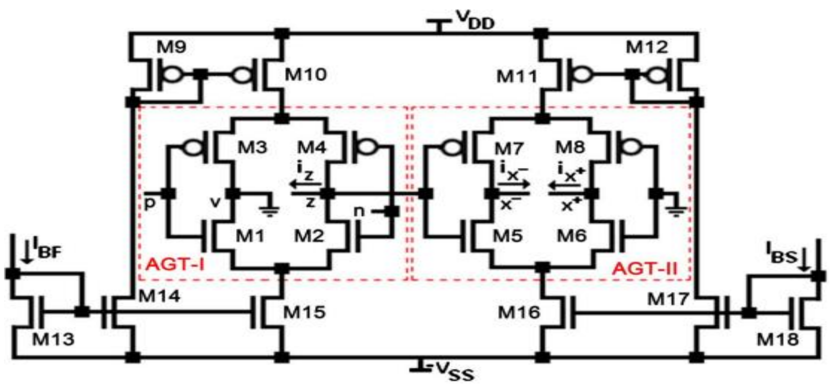

Figure 6: A VDVTA-Based All Pass Filter Implemented on CMOS Technology

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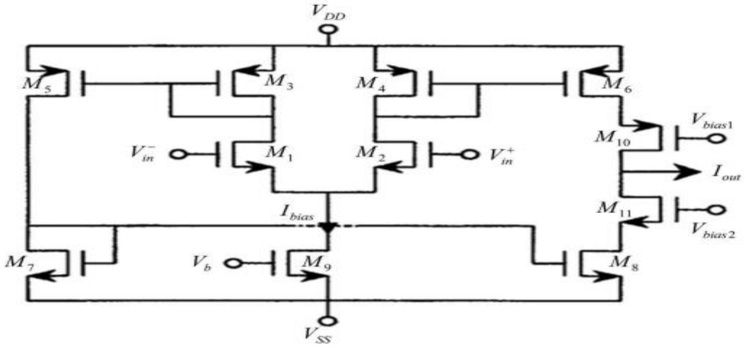

Figure 7: First-Order All-Pass Filter Design using CMOS Implementation of OTA

Figure 8 shows the simulated gain magnitude response of an OTAs-based first-order all-pass filter from 24 dB to 35.13 dB, and Figure 9 shows the set-up of input and output transient responses from 0 to 60 mV for first-order all-pass filters. The simulated phase margin of the first-order all-pass filter based on VDVTA ranges from about 0 to 180 degrees, or 360 degrees in the opposite direction, as seen in Figure 10. In the range of 1.53 kHz to 10.498 MHz, the pole frequency exhibits a right angle fluctuation. The frequency response of the proposed all pass filter configuration is seen in Figure 11. Utilizing an input noise spectral density of 3.8 nV and a cutoff frequency range of 1.53 KHz - 10.498 MHz, it generates an open loop gain between 5.045 and 6.020 dB, with average values ranging from 30 dB to 71 dB. The theoretical frequency, denoted as Fin, is around 1.499 kHz, and the power supply voltage is within ±0.85 V, with a bias value of ±0.5 V.

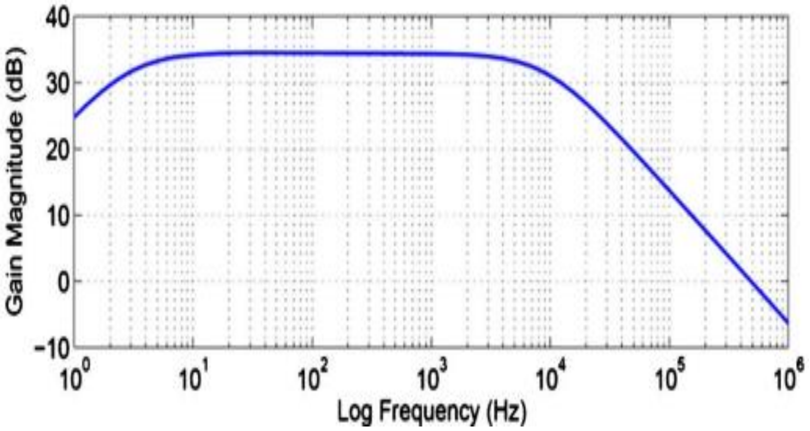

Figure 8: Response of the Suggested OTA-Based All-Pass Filter to Simulated Gain Magnitude

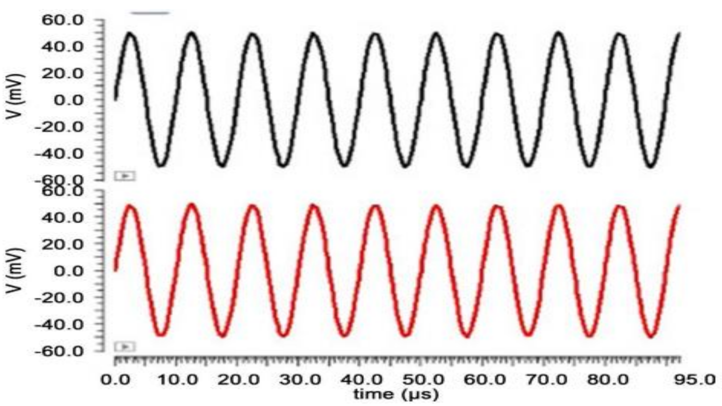

Figure 9: Input-Output Transient Response Analysis of Suggested VDVTA and OTA-Based All-Pass Filters

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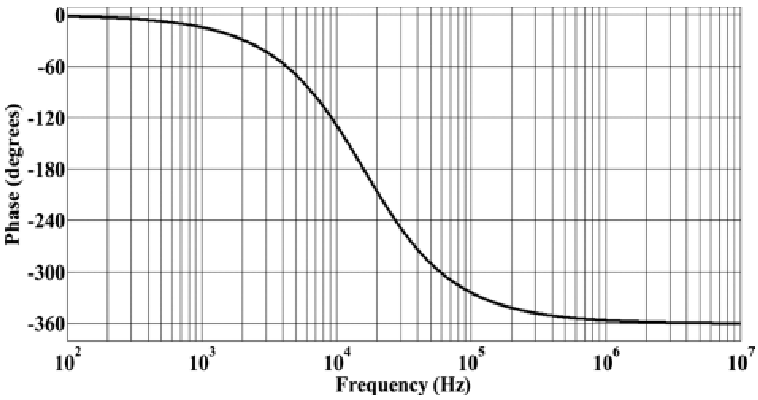

Figure 10: Analyzing the Proposed All Pass Filter Configurations via Simulated Phase Margin

With a supply voltage variation of ±0.5 V and different bias currents, the device model parameters were obtained from TSMC 0.18 µm and modeled in PSPICE with good linearity. Table 2 displays the first-order all-pass filters' simulated parameters, which are based on the proposed VDVTA and OTAs. The proposed first-or-all pass filters provide exceptional linearity and are derived from OTAs and TMSC 0.18 µm CMOS technology. Their parameters are 639.7 µA/V and 734 µA/V, respectively. The parameters are determined by supply voltages within a range of ±0.5 V.

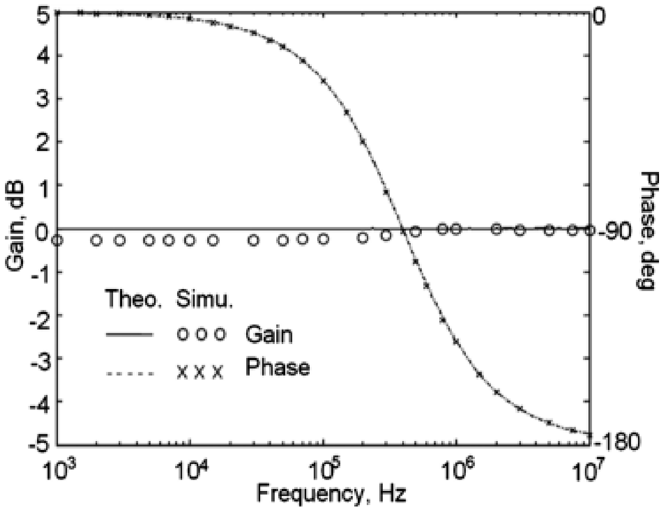

Figure 11: Simulated Frequency Response and Phase Analysis of Proposed All-Pass Filter

Table 2: Simulated Performance of Proposed VDVTA and OTA-Based All-Pass Filters across Varied Bias Currents: IBias = 10 µA to 300 µA

S. No	Specifications	Simulated
1	CMOS Technology	0.18 µm
2	Transconductances (µA/V)	68.16 µA/V - 789 µA/V at 10 µA - 300 µA
3	Bias current (µA)	10 µA - 300 µA
4	% Total Harmonic Distortion	1.21% - 2.83%
5	Power dissipation (mW)	1.6 mW - 4.76 mW
6	Maximum Input noise (nV)	33 nV- 42 nV
7	Maximum output noise (nV)	24 nV

8	Maximum Supply Voltage (V)	±0.85 V
9	Bias Voltage (V)	±0.50 V
10	Phase Margin	23- 45
11	Input output Voltage Swing (mV)	0 - 60 mV
12	Open loop Gain (dB)	5.045 - 6.020 dB with typical values 30 dB – 71dB
13	Frequency (KHz)	1.53 KHz and 10.498 MHz
14	Noise Spectral Density	4.10 nV/$\sqrt{Hz}$ at the input and 3.8 nV/$\sqrt{Hz}$

V.Conclusion

An exciting new direction for the development of analog circuitry is the construction of all-pass filters that include Operational Transconductance Amplifiers (OTAs) and Voltage Differencing Voltage Transconductance Amplifiers (VDVTAs). The specifications of the TMSC 0.18μm CMOS technology are used to determine the performance of the first-order all-pass filters that are based on OTAs and the proposed VDVTA. At the target range of pole frequencies, both design options provide very stable signals with little noise. The bias current has a direct correlation with the transconductance gain.

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