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A Novel Inverse Active High-Pass Filter Employing VDIBAs

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Abstract: The paper presents analog inverse high pass filter usingfour voltage differencing inverting buffered amplifiers (VDIBAs) and two grounded capacitors (GCs). To validate the functionality of the proposed active inverse filter design, PSPICE simulations of the proposed design is done with0.18μm TSMCtechnology.

Keywords: Voltage Differencing Inverting Buffered Amplifier (VDIBA), Inverse Analog Filters, Analog Signal Processing, Voltage Mode (VM).

1. Introduction

Analog circuit designs employing analog active building blocks have become much popular due to their high performance in various fields. The inverse filters designed from these analog active building blocks provide a number of applications in communication, control and instrumentation systems etc.During processing or transmission of an electrical signal, the signal may get distorted due to linear or non-linear transformation. To recover that input signal, an inverse filter scheme having inverse transfer characteristics of the original system is used [1].

An analog active building block VDIBA has been gaining the attention in the earlier literature [2]. The VDIBA configuration is simple in structure and adjustable electronically having wide range.

Going through this paper, it is necessary to lightena fastliteraturesurvey of previous work done on the realization of inverse analogactive filters. A universal inverse filter in [3] is proposed using CDBA (Current difference buffered amplifier) with appropriate admittance choices. In [4], a universal biquad using current feedback op-amps (CFOA) has been proposed.

In this paper, Minaei and Yuce proposed a voltage mode all pass filter using differential voltage current conveyor (DVCC) [5]. Here, current mode biquad universal active inverse filters have been presented using a single four terminal floating nullor (FTFN) [6]. This realization provides very high impedances at the both output terminals. Gupta, Bhaskar, Senani and Singh [7] presented a new configuration for the realization of inverse analog low pass, inverse analog band pass, inverse analog high pass and inverse analog band reject filters using current feedback operational amplifier (CFOA) which is available in marketsuch as AD844 with an accessible z terminal. Singh, Gupta and Senani[7] designed a new operational trans-resistance amplifier (OTRA) based universal analog inverse filter configuration.Here, the authors proposed a method for the systematic conversion of a voltage-mode RC filter using operational amplifier (op-amp) to a current mode activeinverse filter using FTFN [8]. The convertedinverse filter provideshigh output impedance which makesthat filter that canbeused in cascade form. In ref [9], the authors introduced inverse low pass, inverse high pass, inverse band pass active filters employing operational transconductance amplifiers (OTAs) and grounded capacitors.

The paper is organized as follows. Starting from the introduction, section II briefly describes the research method and the proposed design configuration. Section III discusses result and discussion. Section IV shows the conclusion of the paper.

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2. Proposed Configuration Circuit

VDIBA is an arrangement of two active devices such as operational transconductance amplifier (OTA) followed by unity gain inverting buffered amplifier (IBA). Hence, this device contains as output terminal (both current and voltage).A number of VDBA/VDIBAs configurations have been designed in [10]-[13]. The characteristics of VDIBA can be defined by the following matrix [14]

$$\begin{pmatrix} I_+ \\ I_- \\ I_z \\ V_w \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ g_m & -g_m & 0 & 0 \\ 0 & 0 & -\beta & 0 \end{pmatrix} \begin{pmatrix} V_+ \\ V_- \\ V_z \\ I_{w-} \end{pmatrix} \quad (1)$$

Here$g_m$is the trans-conductance and β is voltage gain (non-ideal) of the device VDIBA. β is unity for an ideal VDIBA. The symbolic representation and equivalent model of VDIBA are shown in Fig.1 [14].

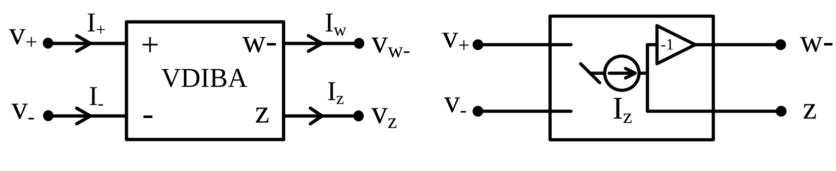

Fig.1. (a) Symbolic representation[14] (b) Equivalent model [14]

The proposed inverse active high pass filter circuit analysis yields the following expression for transfer function in fig. 2.

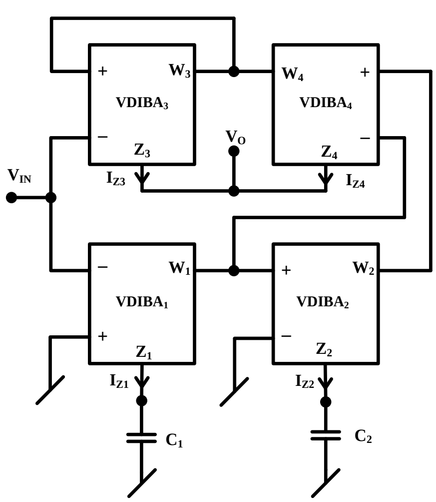

Fig.2 Proposed analog inverse high-pass filter.

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$$\frac{V_o(s)}{V_{in}(s)} = -\frac{1}{\frac{s^2}{s^2 + s\frac{g_{m_1}g_{m_4}}{C_1 g_{m_3}} + \frac{g_{m_1}g_{m_2}g_{m_4}}{C_1 C_2 g_{m_3}}}} \quad (2)$$

$$\omega_0 = \sqrt{\frac{g_{m1}g_{m2}g_{m4}}{C_1 C_2 g_{m3}}} \quad (3)$$

From equation (2), an inverse analog high-pass filter can be realized. It is seen that in this filter, the trans-conductance of VDIBAs are electronically controllable by their bias currents.

3. Simulation Results

The testing of proposed inverse active high pass filter was done by PSPICE simulation tool using 0.18 µm TSMC technology. Firstly, the CMOS implementation of VDIBA [14] has been simulated by PSPICE tool using the same technology as shown in Fig. 3. The passive elements were selected as C1 = C2 = 1nF. The trans-conductances of VDIBAs were controlled by the bias currents Ib1=Ib2= Ib3=Ib4=200µA. The results approve the validity of the proposed design. Fig. 4 shows the frequency response of the proposed inverse high-pass filter configuration and its cut-off frequency is 12.24 MHz.

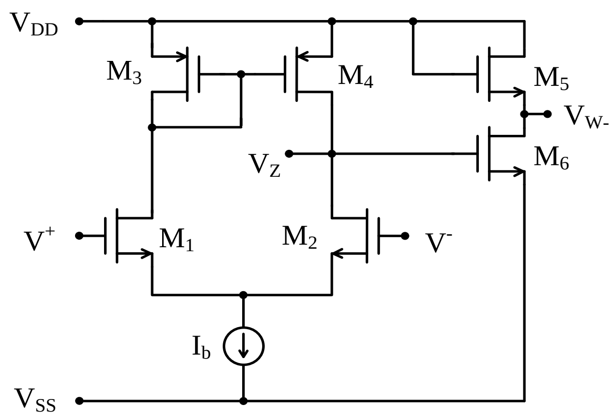

Fig.3 An exemplary CMOS implementation of VDIBA [14], $V_{DD} = V_{SS} = 0.9V$

In order to verify the proposed circuit, the PSPICE simulations of the inverse analog high-pass filter have been done using 0.18 µm TSMC CMOS technology. The typical frequency response of inverse analog high-pass filter is shown in figure 4. Table 1 shows comparison of proposed circuit with previously designed and simulated circuits.

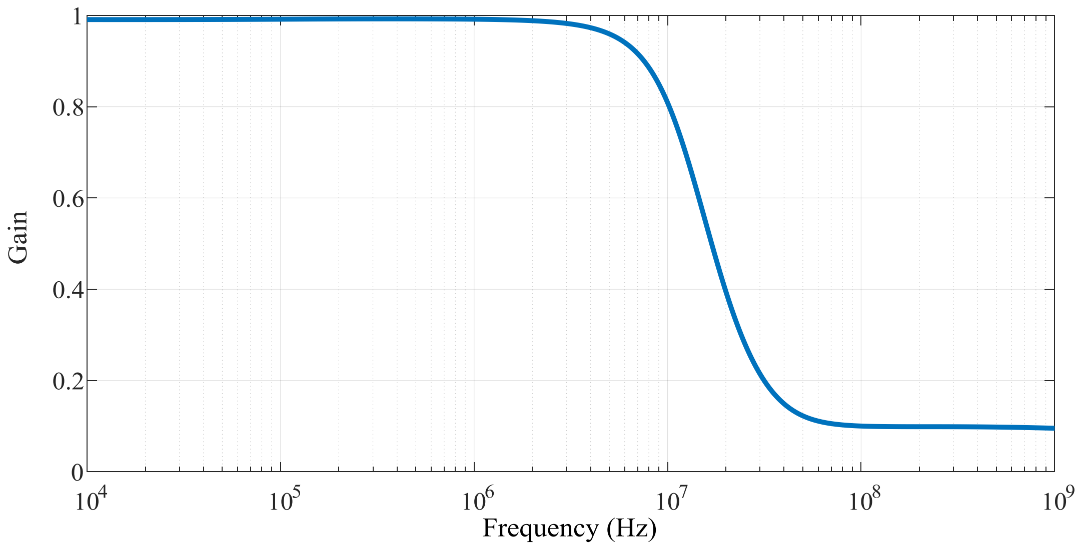

Fig.4 Frequency ResponseCharacteristics of Proposed InverseActive High-pass Filter

Table1. Comparison of Proposed Circuit with Previously Designed Circuits

	Proposed Circuits	Ref [3]	Ref [15]	Ref [16]
Mode of Operation	VM	VM	VM	VM
Number of Active Building Blocks used	4 VDIBA	2 CDBA	2 VDTA	3 CFOA
Number of Passive Components used	2GC only	2GC, 2C(Floating),2R	2GC only	3 GC, 2R
Values of the Passive Components used	$C_1=C_2=1nF$	$C_1=C_2=C_3=C_4=50pF$ $R_1=R_2=10K\Omega$	$C_1=C_2=10pF$	$C_1=C_2=C_3=1nF$ $R_1=R_2=40K\Omega$
Cut-off Frequency	12.24MHz	316.3KHz	10MHz	Approx.1KHz
DC Power Supply	±0.9V	±10V	±0.9V	±12V

4. Conclusion

A new inverse analog high-pass filter configuration is proposed with minimum number of passive components. The simulation has been done using 0.18µm TSMC CMOS technology. It approaches more suitable realization for inverse filter functions. Various inverse analog filters can be designed by minor modification in the proposed design.

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