Circuits and Systems, 2015, 6, 252-256
Published Online November 2015 in SciRes. http://www.scirp.org/journal/cs
http://dx.doi.org/10.4236/cs.2015.611025

CDDITA-Based Voltage-Mode First Order All Pass Filter Configuration

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Received 14 October 2015; accepted 15 November 2015; published 18 November 2015

Abstract

This realization of a voltage-mode first order voltage-mode all pass filter (VM-APF) employing single current differencing differential input transconductance amplifier (CDDITA) as active component is presented. The proposed configuration employs one CDDITA along with two resistors and one grounded capacitor. The pole frequency and phase shift of proposed VM-APF are electronically tunable by transconductance of CDDITA. The proposed circuit is verified by SPICE simulations.

Keywords

CDDITA, All Pass Filter, First Order

1. Introduction

An first order all-pass filter is one of the most important building block of many analog signal generation/processing applications. It is frequently used for phase shifting purpose while maintaining the amplitude of signal constant over the desired range of frequency. It finds applications in realizing high selectivity active bandpass filters, delay equalizers and quadrature oscillators [1] [2]. Several voltage mode voltage-mode first-order all-pass filter configurations employing different active building blocks (ABBs) such as, current conveyors (CCIIs) [3]-[9], Operational Transconductance Amplifiers (OTAs) [10] [11], current controlled current conveyors (CCCIIs) [12]-[14], differential voltage current conveyor (DVCC) [15]-[17], differential difference current conveyors (DDCCs) [18]-[20], current differencing buffered amplifier (CDBA) [21]-[23], operational transresis-

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How to cite this paper: Prasad, D., Panwar, K., Bhaskar, D.R. and Srivastava, M. (2015) CDDITA-Based Voltage-Mode First Order All Pass Filter Configuration. *Circuits and Systems*, **6**, 252-256. http://dx.doi.org/10.4236/cs.2015.611025

tance amplifiers (OTRAs) [24]-[26], current controlled current differencing transconductance amplifiers (CCCDTA) [27], universal voltage conveyor [28] and Fully Balanced Voltage Differencing Buffered Amplifier (FBVDBA) [29] have been reported in literature but unfortunately, these proposed configurations suffer from one or more of the following drawbacks: i) use of excessive (more than one) number of ABBs [6] [8] [10] [11] [12] [14]; ii) use of excessive (more than two) number of resistors [3] [7] [20] [22] [23] [26]; iii) use of excessive (more than one) number of capacitors [4] [5] [8] [12] [15] [23]; iv) use of floating capacitors [9] [11]-[14] [18] [22]-[25] [27] [28] and v) Non availability of electronic control [3]-[9] [15]-[20] [23]-[26] [28] [29].

Therefore, the aim of this paper is to propose a new voltage-mode all-pass with following advantageous features: i) Single ABB realization; ii) use of only two resistors; iii) use of only one capacitor; iv) use of grounded capacitor which is desirable from the viewpoint of monolithic integration and v) electronically tunable phase and pole frequency.

2. The Proposed New Configuration

The CDDITA is one of the recent active ABB which have been introduced in [30]. **Figure 1** shows the symbolic representation of CDDITA, where P and N are input ports, z is auxiliary port, X+ and X− are output ports and V is buffered port with all ports at high impedance level except P and N which are low impedance ports. The behavioural model of CDDITA given in **Figure 2**, shows that a CDDITA consist of a current differencing unit (CDU) followed by an operational transconductance amplifier. The CMOS implementation of CDDITA has been shown in **Figure 3** [31].

The proposed voltage-mode first order all-pass filter (VM-APF) is shown in **Figure 4**.

The routine circuit analysis of proposed VM-APS shown in **Figure 4**, yields the following voltage mode transfer function

$$\frac{V_0(s)}{V_{in}(s)} = \frac{(sC - g_m)}{(sC + g_m)} \tag{1}$$

for

$$\frac{1}{R_1} = \frac{1}{R_2} = g_m \tag{2}$$

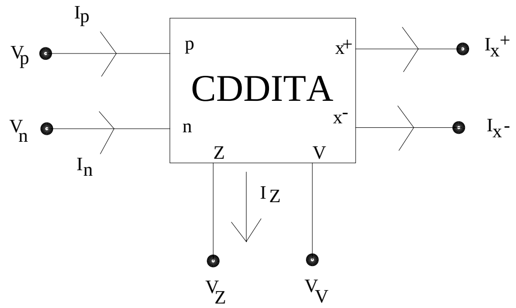

Figure 1. CDDITA symbolic representation.

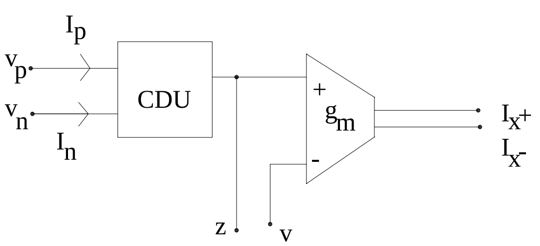

Figure 2. Behavioural model of CDDITA.

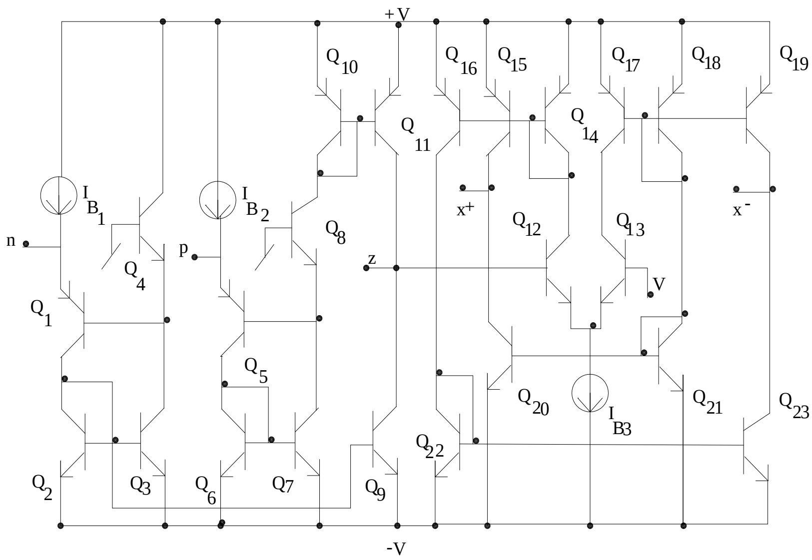

Figure 3. CMOS implementation of CDDITA [31].

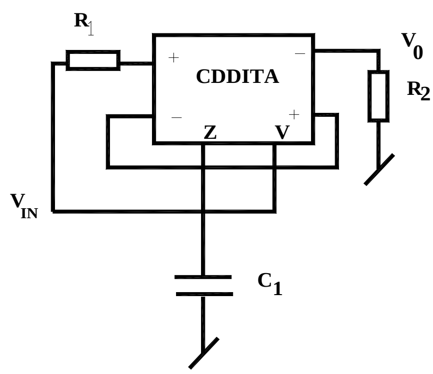

Figure 4. Proposed VM-APF.

From Equation (1) it is clear that voltage gain is unity. The pole frequency and phase response obtained from Equation (1) are

$$\omega_0 = \frac{g_m}{C} \tag{3}$$

and

$$\angle \frac{V_0(s)}{V_{in}(s)} = \phi(\omega_p) = \pi - 2\tan^{-1}\left(\frac{\omega_p C}{g_m}\right) \tag{4}$$

So, proposed circuit provides phase shift from 0 to 180˚. The pole frequency is electronically tunable by transconductance g_m.

3. Simulation Results

The circuit illustrated in **Figure 4** is tested by SPICE simulations (OrCAD 9.1 Version). The simulations were performed employing Bipolar-based CDDITA (shown in **Figure 3**) with supply voltages ±3V DC, with biasing currents $IB_1 = IB_2 = IB_3 = 100$ µA and with the transistor model parameters of PR100 N(PNP) and NR100 N(NPN) of the bipolar arrays ALA400 from AT&T [32]. The component values used were $C = 100$ nF, $R_1 = R_2 = 500\ \Omega$. The frequency and phase responses of proposed VM-APF are shown in **Figure 5**.

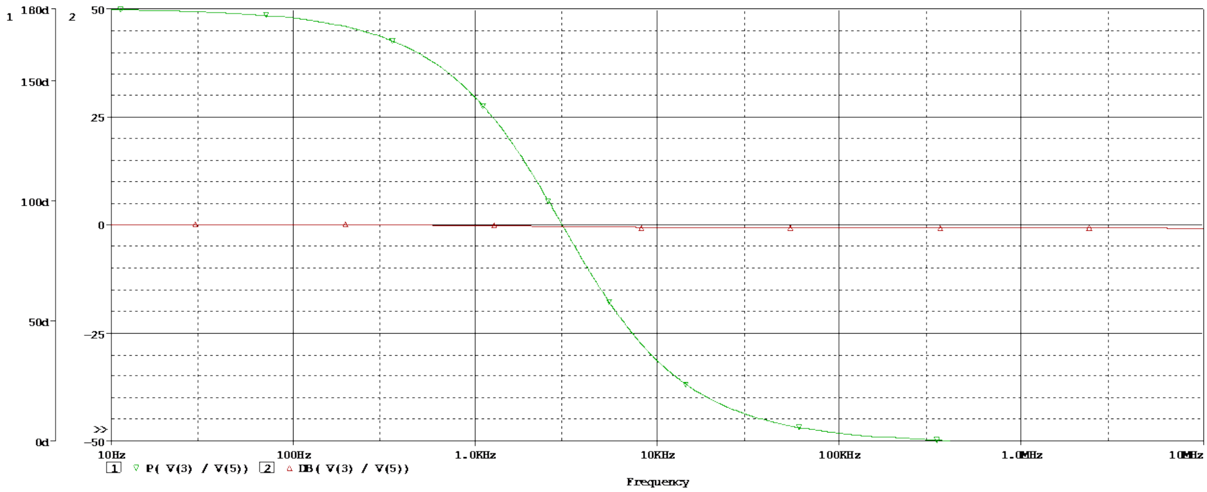

Figure 5. Frequency and phase responses of proposed VM-APF.

4. Conclusion

A new voltage-mode first-order all-pass filter employing single CDDITA, two resistors and one grounded capacitor is presented. The positive features of proposed circuit are use of single ABB, use of grounded capacitor and availability of electronic tuning feature. The theoretical analysis is verified by SPICE simulations.

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