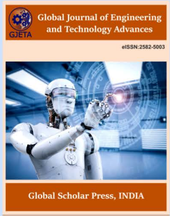
Global Journal of Engineering and Technology Advances

eISSN: 2582-5003

Cross Ref DOI: 10.30574/gjeta

Journal homepage: https://gjeta.com/



(RESEARCH ARTICLE)

Check for updates

New Z copy- current differencing transconductance amplifier active filter using FinFET transistor based current Mode Universal Filter

Arsen Ahmed Mohammed [1, *], Zaidoon Khalaf Mahmood [2] and Hüseyin Demirel [3]

[1] *Electrical department college of engineering, University of Kirkuk, Iraq.*

[2] *University of Kirkuk, Iraq*

[3] *Yıldırım Beyazıt University, Business School, Dept. of Management Information Systems 06760 - Ankara, Türkiye*

Global Journal of Engineering and Technology Advances, 2024, 18(02), 001–005

Publication history: Received on 16 December 2023; revised on 28 January 2024; accepted on 31 January 2024

Article DOI: https://doi.org/10.30574/gjeta.2024.18.2.0019

Abstract

This research paper presents the design of an active current mode device named Z-copy- Current Differencing Transconductance Amplifier (ZC-CDTA) in conjunction with FinFET (Fin Field-Effect Transistor) transistors. An input bias current can be used to adjust its parasitic resistances at its two current input ports. It is ideal for use in current-mode signal processing, which is steadily more common than voltage-style signal processing, because it operates in current mode on all terminals. The suggested component was implemented using Finfet technology, and its performances were assessed using simulations using cadence tools and linear technology SPICE. They demonstrate the new active element's usage, with a maximum bandwidth of 300MHz. The highest power consumption is 1.01 mW, and the supply voltages can be as low as ±0.1 V. The low-power consumption and wide current range tuning of the suggested Zc-CDTA are achieved.

Keywords: ZC-CDTA; Locust beans; FinFET (Fin Field-Effect Transistor); Cadence tools; Low-power.

1. Introduction

The past in the design of electronic circuits often used passive devices combined with active devices, with active devices in the popular voltage mode. Dive op amps can be seen with multiple holes, narrow bandwidths, low consumption rates. Over the last decade, Penton has been trying to reduce the supply voltage in electronic circuits due to the need to use portable devices or wired communication devices that run on batteries. Therefore, the technique of working in the current mode has been applied. With several advantages, Daikai has the dynamic range of deer, has a deer bandwidth and low energy consumption. The current mode devices are popular DAIKE, OTA, current belt circuit and Current Differencing Buffered Amplifier (CDBA). However, this device does not operate in all current modes because the VA OTA and the current belt have a voltage mode input, the CDBA park, which has proven to be faulty. OTA deer frequency response and current belt circuit[1-3]. The output is still in the form of voltage. Therefore, when performing signal processing tasks in the current mode, the current switching circuit, alternating current circuit, total voltage circuit, or modified and additional circuits are used, thus making the overall circuit more complex. Recently, a new current-mode active device called the Current Differencing Transconductance Amplifier (CDTA) was introduced. Ideal for use in analog signal processing circuits, the CDTA is a device that operates in full current mode, i.e. input and output current. It is also possible to adjust the amplitude of the output current. CDTA also has a CDBA bandpass. However, this outdated CDTA is not able to adjust the frequency at both input pins, making it difficult to operate. This is because when working in the processing circuit, the signal will cause the passive device to be jammed, making the circuit subsonic and unable to control the power output[4-7]. It is not suitable for the development of integrated circuits, as well as the use of many external passive devices, which leads to high power consumption.

* Corresponding author: Arsen Ahmed Mohammed.

The objective of this research is to propose a ZC-CDTA design with a CMOS structure, which can adjust the frequency at both input legs of the CDTA. The results of the simulation of the PSPICE program show that the proposed ZC-CDTA has a consumption rate. 1.01 mW peak power at ±0.1V the latency rate can be adjusted at the biased input terminals in the deer. It has a deer bandwidth of up to several megahertz, making it ideal for the development of integrated circuits. It has also demonstrated the application of multi-layer frequency filtering circuits and circuits [8].

2. Materials and methods

2.1. Materials

Design and analysis novel active filter used FinFET transistor 7nm parameter by cadence virtuoso and Linear technology SPICE program were used in the work.

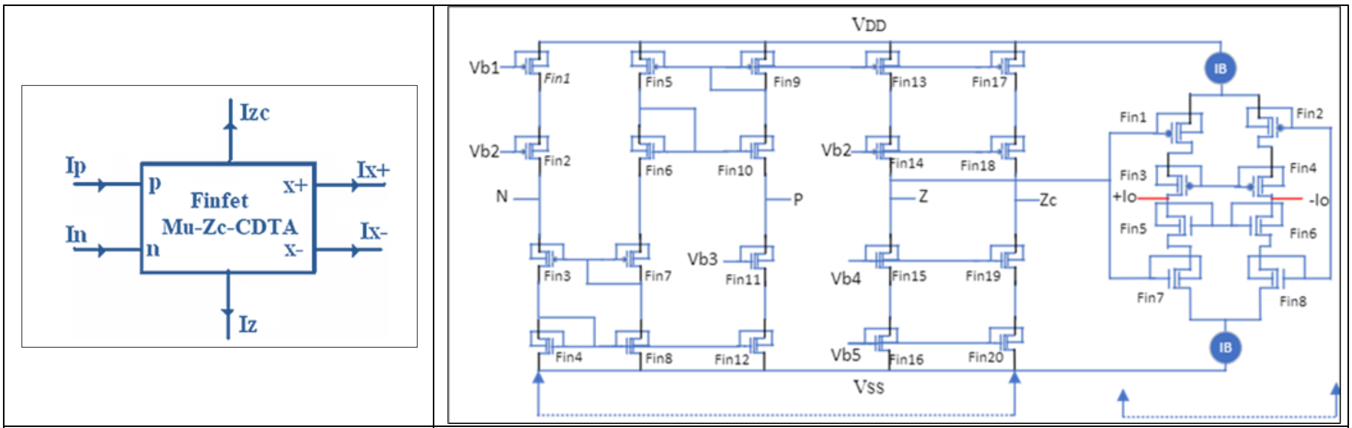
2.2. Proposed Active Circuit using FinFET transistor.

The most recent active component of current mode is the Z-copy current differencing Transconductance amplifier (ZC-CDTA). It was developed from CDTA and came into being more recently. Its applications are ubiquitous. This is the CDTA in its updated form. The Z_C-CDTA sign is seen in Fig. 1(a). Fig. 1(b) shows how Zc-CDTA is implemented in space. With four high impedance output terminals and two low impedance output terminals, the ZC-CDTA dual output transconductance amplifier is its initial stage. A unit for splitting current makes up its second stage. Applications involving current mode input and current mode output signals are better suited for the inner structure of ZC-CDTA. Matrix (1) may be used to understand the relationship between ZD-CDTA's I/O terminals in more depth. It is shown as follows:

$$\begin{bmatrix} V_p \\ V_n \\ I_z \\ I_{zc} \\ I_{x+} \\ I_{x-} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & g_m & 0 & 0 & 0 \\ 0 & 0 & -g_m & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} I_p \\ I_n \\ V_z \\ V_{zc} \\ V_{x+} \\ V_{x-} \end{bmatrix} \tag{1}$$

where gm is the ZC-CDTA's transconductance. The above equation (1) ideal ZC-CDTA criteria can be expressed as

$$\left.\begin{aligned} V_p = V_n = 0 \\ I_z = I_x = I_p - I_n \\ I_{xz} = I_{x-} = g_m V_z \end{aligned}\right\} \tag{2}$$



A | B

Figure 1 (a) Symbol for the active filter device Zc-CDTA(b) Circuit schematic by FinFET transistor

The Zc-CDTA's transconductance is denoted by gm, and its low-impedance input terminals are p and n, high-impedance output terminals are X, and Z is an auxiliary terminal. It has an extra terminal Z, referred to as the Z-copy, as suggested in the Z_C-CDTA. The low impedance input currents that vary in direction but have identical magnitudes make up the Z-copy's outgoing current. The magnitudes of these currents are revealed by the product of a transconductance (g_m) and the voltage at terminal Z. Therefore, matrix equation (1) gives the optimal conditions for ZC-CDTA. The circuit designer's freedom is provided by this duplicate of the Z terminal current [9].

2.3. The Proposed Circuit's Configuration

Figure 2 depicts the suggested current-mode universal active filter based on Zc-CDTA. One Zc-CDTA and two grounded capacitors make up the suggested filter's circuit. The fact that every capacitor is grounded makes filters appealing for use in integrated circuits (ICs). The suggested filter's current transfer function may be obtained by applying characteristic equation (1) to the circuit analysis.

$$\frac{I_{HP}}{I_{in}} = \frac{S^2}{S^2+S\frac{1}{C_1R_n}+\frac{g_m}{C_1C_2R_n}} \qquad (3)$$

$$\frac{I_{BP}}{I_{in}} = \frac{S/C_1R_n}{S^2+S\frac{1}{C_1R_n}+\frac{g_m}{C_1C_2R_n}} \qquad (4)$$

$$\frac{I_{LP}}{I_{in}} = \frac{g_m/C_1C_2R_n}{S^2+S\frac{1}{C_1R_n}+\frac{g_m}{C_1C_2R_n}} \qquad (5)$$

$$\frac{I_{BR}}{I_{in}} = \frac{S^2+g_m/C_1C_2R_n}{S^2+S\frac{1}{C_1R_n}+\frac{g_m}{C_1C_2R_n}} \qquad (6)$$

$$\frac{I_{AP}}{I_{in}} = \frac{S^2-S/C_1R_n+{}^{g_m}/_{C_1C_2R_n}}{S^2+S\frac{1}{C_1R_n}+\frac{g_m}{C_1C_2R_n}} \qquad (7)$$

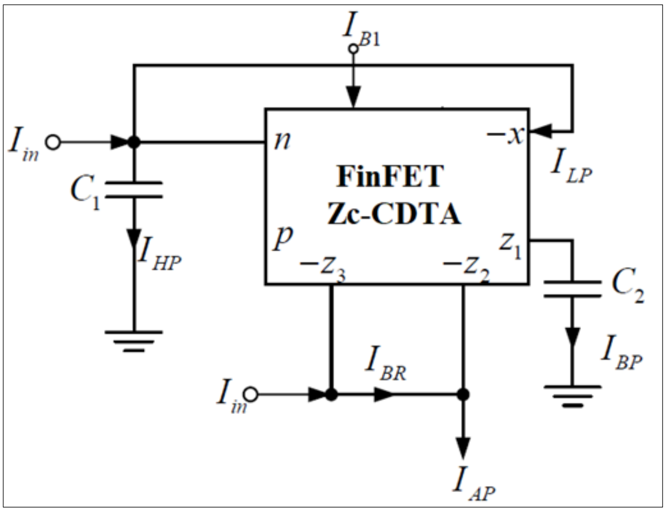


Figure 2 Proposed Current-Mode Universal Filter

From equation (3) - (7), the cutoff frequency value (ω0) and the quality factor value (Qo) can be obtained from

$$\omega_0 = \sqrt{\frac{g_m}{C_1C_2R_n}} \qquad (8)$$

CDTA design that can be controlled by current through Finfet technology and applications.

$$Q_0 = \omega_0 C_1 R_n \qquad (9)$$

When $g_m = \sqrt{\beta_n I_{B2}}$ let $R_n = 1/\sqrt{8\beta_n I_{B1}}$ From equations (8) and (9), it can be rewritten as follows:

$$\omega_0 = \left(\frac{\beta_n\sqrt{8I_{B1}I_{B2}}}{C_1C_2}\right)^{1/2} \tag{10}$$

$$Q_0 = \frac{C_1\sqrt{I_{B2}}}{C_2\sqrt{8I_{B1}}} \tag{11}$$

The bandwidth (BW) of the circuit is obtained from.

$$BW = \frac{\omega_0}{Q_0} = \left(\frac{16C_2\beta_n\sqrt{I_{B1}^3}}{C_1^3\sqrt{2I_{B2}}}\right)^{1/2} \tag{12}$$

2.4. Circuit Sensitivity

The sensitivity of the cut-off frequency of the presented circuit is obtained from.

$$S_{\beta_n}^{\omega_0} = \frac{1}{2}\ ;\ S_{I_{B1}}^{\omega_0} = \frac{1}{4}\ ;\ S_{I_{B2}}^{\omega_0} = \frac{1}{4}\ ;\ S_{C_1}^{\omega_0} = -\frac{1}{2}\ ;\ S_{C_2}^{\omega_0} = -\frac{1}{2} \tag{13}$$

While the sensitivity of the quality factor is

$$S_{\beta_n}^{Q_0} = 0\ ;\ S_{I_{B1}}^{Q_0} = -\frac{1}{4}\ ;\ S_{I_{B2}}^{Q_0} = \frac{1}{4}\ ;\ S_{C_1}^{Q_0} = 1\ ;\ S_{C_2}^{Q_0} = -1 \tag{14}$$

From equations (13) and (14), it is found that the sensitivity value caused by the device value is not more than 1. The simulation result of the frequency filter circuit is shown as Figure 3 as the magnitude response of the various functions when adjusted. C1=C2=1pF and IB=172nA.

3. Results of simulation

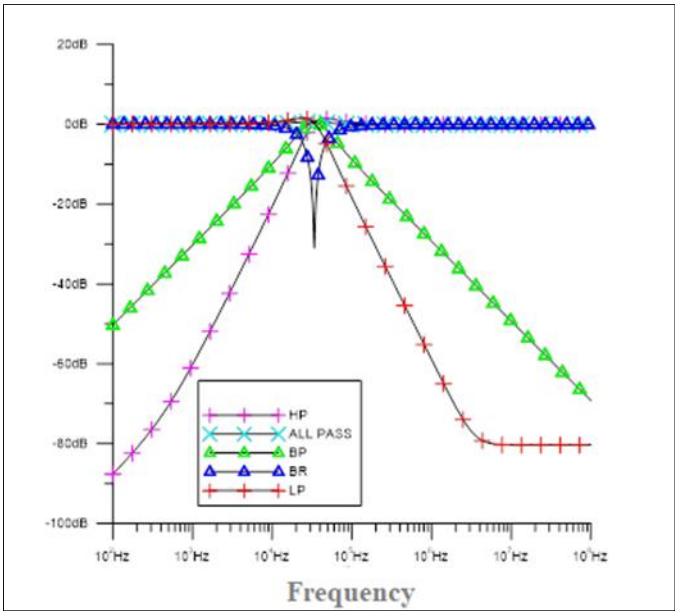


Figure 3 The magnitude response effect of the various functions of the frequency filter circuit in Fig.2

The Cadence tool and the linear technology SPICE simulation program have been used to model the proposed Zc-CDTA based current mode universal filter. As seen in Figure 2, the Zc-CDTA active element was created utilizing commercially available ICs, specifically OTA LM-13700 and CFAAD844. ±0.1V is the power supply voltage, and IBIAS=170nA is the bias current. The simulation result for the suggested universal filter is displayed in Figure 3. The results of the simulation match the theoretical analysis.

4. Conclusion

In this article, we present the design of a new active device called named Z-copy- Current Differencing Transconductance Amplifier (ZC-CDTA) structured as a Finfet by ZC-CDTA presented as an active device operating in all current modes. And the transfer conductivity and latent resistance values at both input terminals can be adjusted by bias current. The performance test results through the PSPICE program found that the offered ZC-CDTA can support operation at input reads from -100nA to 100nA at ±0.1 supply sources. The volt circuit has a maximum power consumption rate of 1.01mW and can operate in the high frequency band up to hundreds of MHz. It also offers ZC-CDTA applications in frequency filtering circuits, multi-function current modes and floating inductor imitation circuits. both circuits can be adjusted electronically for various parameters. Each circuit uses only one ZC-CDTA, which is a clear confirmation that with ZC-CDTA design, less equipment consumption is required. In the future, ZC-CDTA A can be applied in other circuits, such as signal generator circuits, signal multiplication and division circuits, rectifiers, etc. The presented circuits are therefore suitable to be developed into integrated circuits for use in applications where signals are processed in current mode.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] C. Acar and S. Ozoguz, “A new versatile building block: current differencing buffered amplifier suitable for analog signal processing filters,” Microelectronics Journal, vol. 30, no. 2, pp. 157–160, 1999.

[2] Mohammede, Arsen Ahmed, Zaidoon Khalaf Mahmood, and Hüseyin Demirel. "STUDY OF FINFET TRANSISTOR: CRITICAL AND LITERATURE REVIEW IN FINFET TRANSISTOR IN THE ACTIVE FILTER." 3C TIC 12.1 (2023): 65-81. https://doi.org/ 10.17993/3ctic.2023.121.65-81

[3] AHMED, A., & DEMİREL, H. (2023). DESIGN Third order Sinusoidal Oscillator Employing Current Differencing Cascaded Trans conductance Amplifiers. Gazi University Journal of Science Part C: Design and Technology, 11(3), 735-743. https://doi.org/10.29109/gujsc.1290137

[4] Chaujar R, Kaur R, Saxena M, Gupta M, Gupta RS (2008) TCAD assessment of gate electrode work function engineered recessed channel (GEWE-RC) MOSFET and its multilayered gate architecture—part I: hot-carrier-reliability evaluation. IEEE Trans Electron Devices 55:2602–2612. doi:10.1109/TED.2008.2003085

[5] DEMİREL, Huseyin, and Arsen AHMED. "New FinFet Transistor Implementation of Floating and Grounded Inductance Simulator Based on Active Elements." Gazi Mühendislik Bilimleri Dergisi 9, no. 3 (2024): 647-653.

[6] Ahmed Mohammed, A., Demirel, H. and Khalaf Mahmood, Z. 2023. Design analysis of fin field effect transistor with high dielectric constant insulators. Nexo Scientific Magazine. 36, 06 (Dec. 2023), 892–905. DOI: https://doi.org/10.5377/nexo.v36i06.17445.

[7] DEMİREL, Huseyin, and Arsen AHMED. "A Low-Power 30MHz, 6th Order Bandpass Differential Gm-C Filter on Chip Utilizing Floating Current Source." Kastamonu University Journal of Engineering and Sciences 9, no. 2 (2023): 96-103.

[8] Mohammed, Arsen Ahmed, and Hüseyin Demirel. "Integration of Quadrature Oscillator and Floating Inductor in FinFET Transistor Design: Innovations and Applications." Iranian Journal of Electrical & Electronic Engineering 19, no. 04 (2023): 1.

[9] Bhaskar D. R., Sharma V. K., Monis M. and Rizvi S. M. I..1999. New current-mode universal biquad filter. Microelectronics Journal. vol. 30: pp.837-839.