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Design of Biquad Universal Filter Using Operational Transconductance Amplifier

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Abstract This paper presents concept of universal filter using operational trans-conductance amplifier (OTA). The 0.18µm CMOS process is used for design and simulation. This OTA has basing current of 50µA with supply voltage ±1.25v. The design and simulation of this OTA is done using tanner tool 0.12µm technology file. This paper presents an electronically tunable voltage mode universal biquadratic filter with Three input and single output using two single ended OTA and two capacitors. The proposed filter provides low-pass, High-pass, Band-pass and Band-stop by appropriately connecting the input terminals. The natural frequency and the quality factor can be set orthogonally by adjusting the circuit components. Also, the natural frequency can be electronically tuned via the bias currents of OTAs.

Keyword- Biquad, universal filter, voltage mode, OTA, PMOSFET, NMOSFET, TANNER TOOL S-edit, L-edit, W-edit

Introduction

Active filter widely applied in the field of electrical engineering. They can be found in cross over network used in a three-way high fidelity loud speaker, portable ECG detection used in front end circuits and touch-tone telephone used for tone decoding. Several active devices were used to realize tunable active filters, i.e. OTA, OP-AMP, CDTA, Second generation current-controlled current conveyor. OTA is widely used to realize linear and non-linear Analog signal processing circuits. It is well known that an OTA provides an electronic tenability, a wide range of its transconductance gain and simple circuitry. Furthermore, OTA-based circuit require no resistors hence they are highly suitable for IC implementation. Considering The no of input and output terminals, these filter can simply be classified into two categories: (1) A single-input and multiple-output (SIMO) type and (2) a multiple-input type. Generally, the SIMO filter can simultaneously realize three basic filter functions., low-pass, band-pass, and high-pass at a time without altering the connection way of the circuits and without input signal matching. However, for the realization band-stop function additional addition and subtraction circuits are usually required. The multiple input filter can realize multifunction by altering the way in which the input signals are connected. Compared with the SIMO filter, the multiple-input filter provides a variety of circuit characteristics with different input voltage and usually does not require any parameter-matching conditions. In addition, multiple input filter may lead to reduction in the no of active elements used. The active filter using low active components are more suitable for IC implementation and also reduced the power consumption and area of chip when they build in the form of IC. In this paper, a new electronically tunable voltage mode universal biquadratic filter with three inputs and one output using two single ended OTAs and two capacitors is presented. The employment of single ended OTAs makes the circuit more suitable for IC implementation. By appropriately connecting the input terminals, the proposed circuit can provide low pass, band pass, high pass and band stop voltage response without changing the circuit topology. The natural frequency and quality factor can be controlled orthogonally and electronically. Cadence virtuoso simulation results are performed to conform the theoretical analysis.

II. Proposed circuit

The circuit symbol of OTA is shown in fig.1. The characteristic of ideal OTA can be described By Io=gm(V1 - V2) (1).

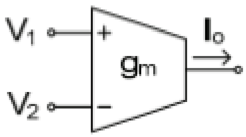
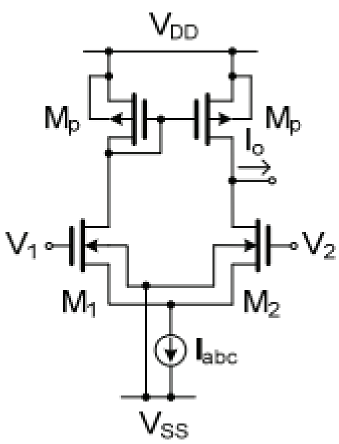


Figure 1: Circuit symbol of OTA



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Assume that M_1 and M_2 are matched and operated in saturation regions, the trans-conductance gain(gm) can be expressed by

$$G_m = \sqrt{\mu C_{ox}(W/L) I_{abc}}$$

Where I_{abc} is the bais current, μ is the carrier mobility, C_{ox} is the gate oxide capacitance per unit area, W and L are the channel width and length respectively. The aspect ratios of the transistors used are W/L = 5 μ/1μ for NMOS device and W/L =10μ/1μ for PMOS device.

III. SIMULATION RESULT

To show the performance of the proposed circuit tanner simulators are used. The power supplies are selected as V_{DD}= $-V_{ss}$=1.25 V. As an example, design, the parameters C1= C2= 10pF, I_{abc}=50μA (gm=181.97μS) are given. The simulated result for LP, HP, BP and BS filter characteristics are shown in fig.

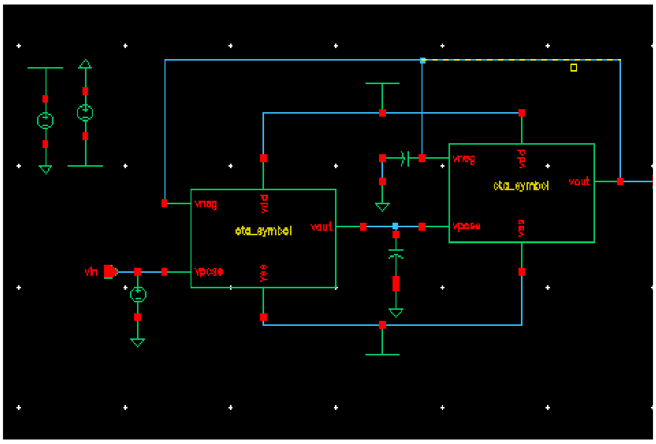

Fig.2. proposed schematic of low pass filter.

Above figure shows the schematic of low pass filter and its response shown in figure 3. The transfer function of low pass filter is given as

$$\frac{W_O^2}{S^2 + (W_O/Q) + W_O^2}$$

The response of this low pass filter is shown below

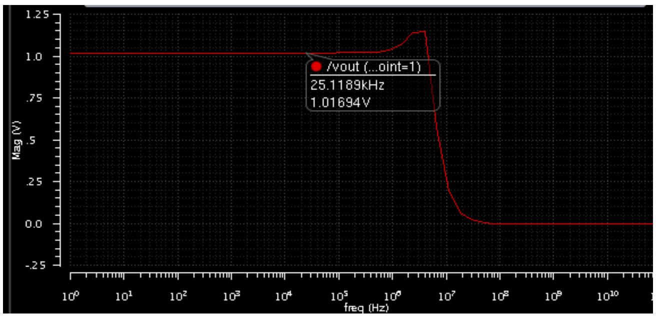

Fig.3. response of low pass filter

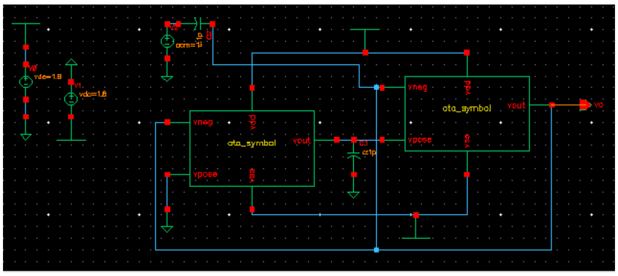

Fig.4 proposed schematic of high pass filter

The transfer function of high-pass filter is given as

$$\frac{S^2}{S^2 + (W_O/Q) + W_O^2}$$

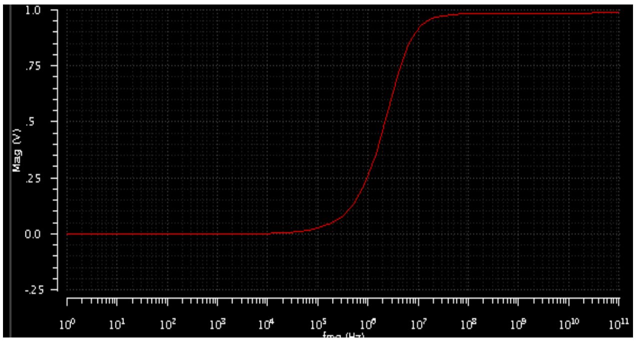

Fig.5. response of high pass filter.

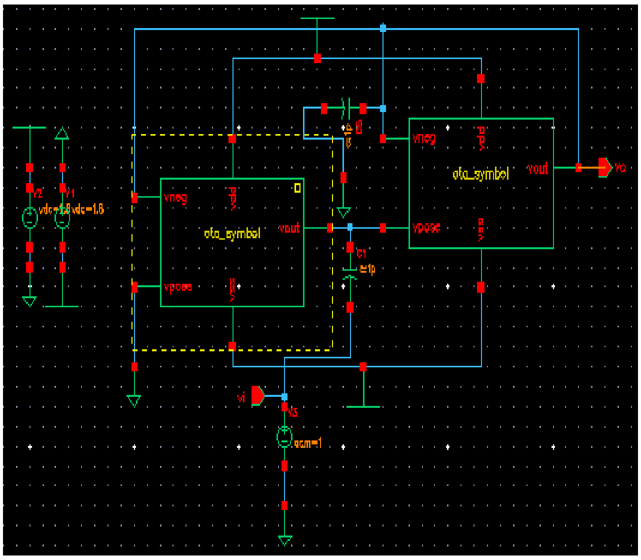

fig.6.proposed schematic of band pass filter.

Transfer function of band pass filter is given as

$$\frac{S(W_O/Q)}{S^2 + (W_O/Q) + W_O^2}$$

Response of band pass filter is shown in fig.7.

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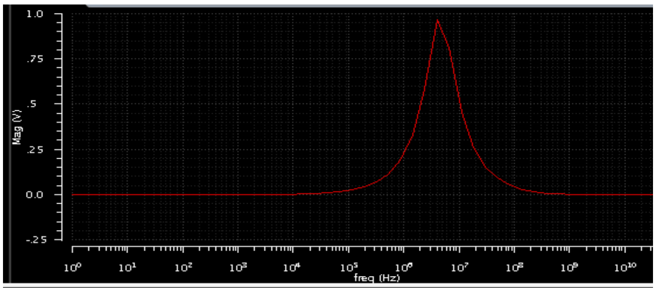

fig7. Response of band pass filter

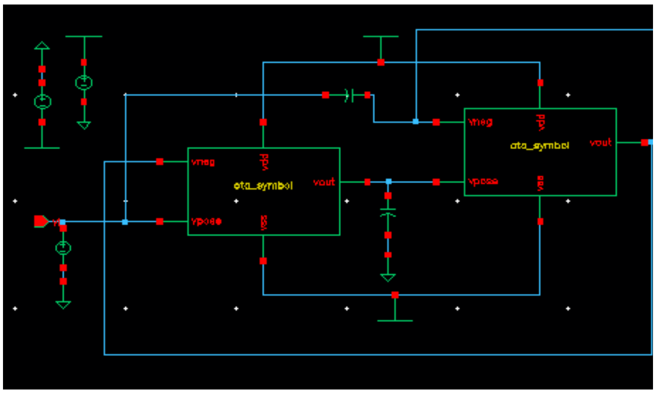

fig.8. proposed schematic of band reject filter

The transfer function of band reject filter is given as

$$\frac{S^2 + W_O^2}{S^2 + (W_O/Q) + W_O^2}$$

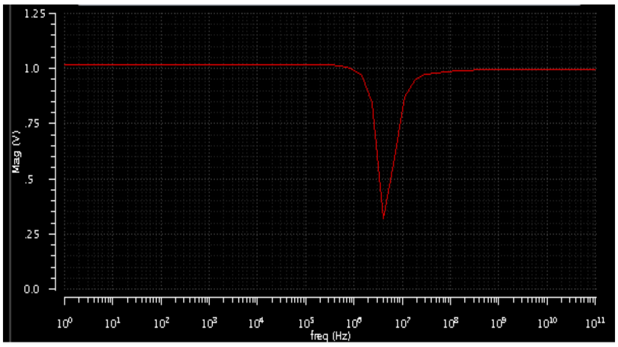

Fig.9 response of band reject filter.

The all performance of universal filter is performed separately in above fig. The combined proposed voltage mode universal filter is shown in fig.10. It should be noted that the circuit employ only two OTA and two capacitors.here v1,v2 and v3 are the three input and vout is the out-put. the all filter performance can be obtained by applying different combination of input on universal filter.

- For low-pass filter v1=Vin, v2=v3=0.
- For High-pass filter v3=Vin,v1=v2=0.
- For Band-pass filter v2=Vin,v1=v3=0
- For Band-reject filter v3=v1=Vin,v2=0.

IV. Conclusions

In this paper, an electronically tunable voltage mode universal filter using two single ended OTAs and two capacitor is presented. By appropriately connecting the input terminals the proposed filter can realize low-pass, high-pass, band-pass and band-stop voltage responses. The parameter Wo and Q can be controlled electronically by adjusting the baising current of OTAs. The use of minimum no of active devices makes the proposed circuit suitable for IC implementation. The performance of proposed filter can be confirmed by TSPICE simulation.

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