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STUDIES ON ACTIVE FILTERS USING OTA-C AND OTHER CURRENT CONVEYORS

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ABSTRACT:

This paper presents the studies carried on active filters using operational transconductance amplifier-capacitor (OTA-C). The concept of linear transformation (LT) on active filters have the advantage of realizing every section of the original ladder with the prototype active elements using newly introduced chips such as MAX438 and also OPA606 of the OTA configurations. The relative bandwidth and gain of these filters are very much comparable with OTA-C structure. The OTA adds controllability in respect of bias current to the number of active filters, which are commonly selected for study. These filters have wide applications in high frequency region most suitable for mobile communication.

[I] INTRODUCTION

Several filter synthesis methods have been studied such as cascaded biquads, the element substitution method, signal-flow graph based method and linear transformation method etc[1] to [7]. In the present paper the application of linear transformation technique is used in the design of active band pass filter using
OTA-C.

At high frequencies the power consumption of Op amp/RC filters and switched capacitor filters tends to be high, in the design of portable equipment. As an alternative to this technique OTA-C filters have flexibility in over coming the above difficulty. These filters require tuning to compensate the variations of differential operational temperature and aging effect. The frequency characteristics which are accurate have the advantage of using these filters, specifically in mobile communications.

The tuning of the transconductance and the grounded capacitor realizes these filters in linearization technique. The linearization technique has the advantage of replacing original ladder using proto type by active elements such as OTA-C.The OTAs are suitable for linear transformation technique , because they have high input impedance and variable gain.. The proposed structure has the advantage of good integrability and a lower power consumption which is specially suited for mobile communication [1],[2],[3]. The application of OTA in active filter such as band pass is designed using linear transformation technique. The proposed design is used to compare the performance of the active filter using other current conveyor chips, where we can transform input/output voltage and current variable of a two port network into two new variables x_i and y_i, using linear transformation technique. The characteristic equation having the dimension of voltage can be expressed as [1], [2],[5],[9].

$$\begin{bmatrix} x_i \\ y_i \end{bmatrix} = \begin{bmatrix} a_i & b_i \\ c_i & d_i \end{bmatrix} \begin{bmatrix} V_i \\ I_i \end{bmatrix}$$

Where i=1,2

The input termination of a ladder filter connected to voltage source helps us to choose the transformation matrix as,

$$\begin{bmatrix} a_2 & b_2 \\ c_2 & d_2 \end{bmatrix} = \begin{bmatrix} 0 & -R \\ 1 & 0 \end{bmatrix}$$

We can obtain the output variables X_2, Y_2 and yield

$$Y_2 = \frac{-X_2 + E}{2RC + 1}, \text{ where}$$

$$-X_2 = (2RC+1)\,Y_2 - E$$

Therefore $X_2 = E-(2RC+1)Y_2$

The corresponding OTA-C circuit realized with a design equation

$$\frac{Cn}{gm} = RC$$

Cn is output capacitance; gm is transconductance which defines the product RC. Using this technique OTA-C band pass filter is assembled and the performance of the band pass structure is studied, its results are compared with experimental results obtained on the same active band pass structure using new conveyor, MAX438 / OPA606.[4],[5] and [6].

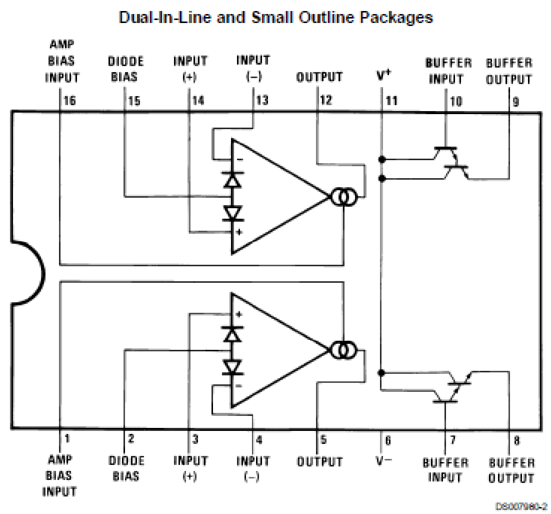
[II] MATERIALS AND METHODS

2.1 General description of LM13600

The LM13600 series consists of two current controlled transconductance amplifiers each with differential inputs and a push-pull output. The two amplifiers share common supplies but otherwise operate independently. Linearizing diodes are provided at the inputs to reduce distortion and allow higher input levels. The result is a 10dB signal-to-noise improvement referenced to 0.5 percent. Controlled impedance buffers which are especially designed to complement the dynamic range of the amplifiers are provided.

Features

gm adjustable over 6 decades
Excellent gm linearity
Excellent matching between amplifiers
Linearizing diodes
Controlled impedance buffers
High output signal-to-noise ratio
Pin diagram of LM13600



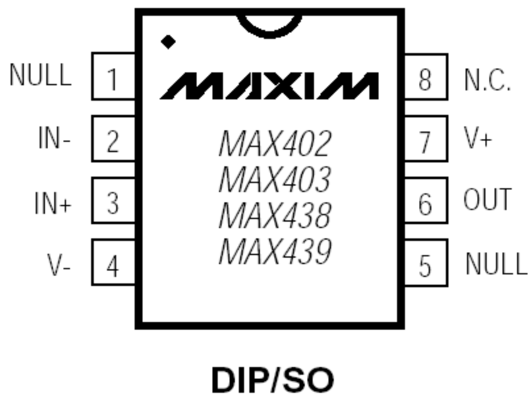
Order Number LM13600M, LM13600N or LM13600AN

2.2 General description of MAX438

The MAX438micropower op amps combine high-speed performance with low-power operation MAX438 are compensated for stability in applications with a closed-loop gain (AVCL) of 5V/V or greater. The MAX438 require less than 75µA of supply current while delivering 6MHz gain bandwidth with10V/µs slew rate.

Features

MAX438
© 6MHz Gain Bandwidth (AVCL ≥ 5V/V)
© 10V/µs Slew Rate
© 75µA Max Supply Current
Pin diagram of MAX438



[III] RESULTS AND DISCUSSION

OTA-C filter realized with minimum number of OTAs and capacitors is a powerful method of designing active filters using linear transformation and has flexibility in respect of the gain, pass band width compared to new conveyor active filters [2],[6],[7] and [8]. In MAX438 filter shown in Fig.1 has pass band from 50Hz to 20KHz with a gain -20 dB., where as in OTA-C filter shown in Fig.4 for a bias current of 50mA the pass band is 751KHz to 21.1GHz with a gain of -20dB. This is one of the merits of OTA-C filter over conventional conveyors. The flexibility of the studied circuit in terms of bias current which is used as tuning parameter to change the gain and the pass band range, can be used to study other types of basic filters, designed using OTA-C with linear transformation technique. This method is useful for realizing higher order filters. The transconductance of OTA-C has better compensation with good tracking which relaxes the band width requirement. The proposed design has good linearity over the dynamic range of its operation. [9],[10].

The OTA-2 of Fig. 4 can be replaced by register of 1000MΩ, which is shown in Fig. 7 with a bias current of 50mA. The gain of order -13.8dB, with a band pass range of 1.19MHz – 31.1GHz is obtained. Hence the linear transformation technique is most useful in active filter design.

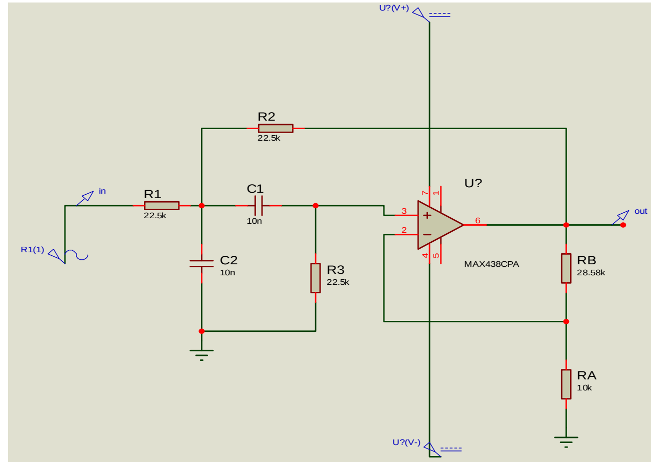


Fig. 1 Circuit diagram of conveyor chipMAX438/OPA606 Band pass filter.

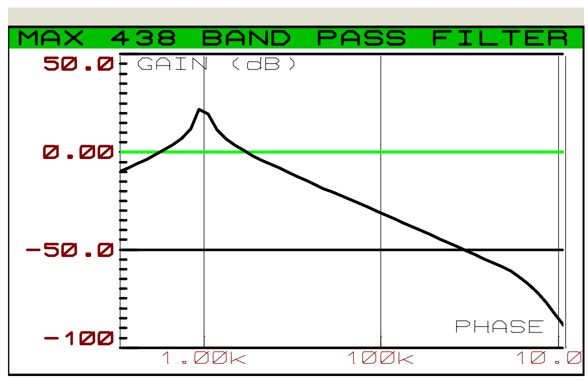


Fig. 2 Frequency response of Proteus professional 7 simulated conveyor chip MAX438/OPA606 Band pass filter circuit, with pass band from 50Hz to 20KHz. Maximum gain is 20.9dB at 1 KHz frequency.

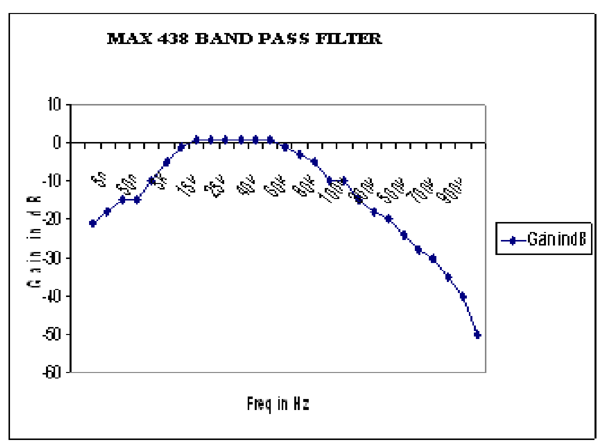


Fig. 3 Frequency response of practical Op amp Band passes filter circuit, with pass band from 50Hz to 30KHz.

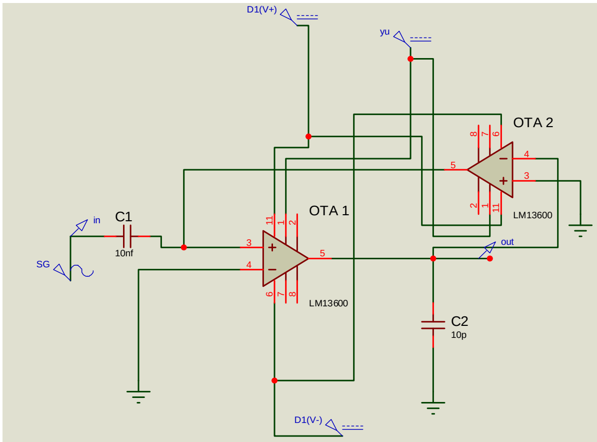


Fig. 4 Circuit diagram of OTA- C Band pass filter with bias current of order 50mA

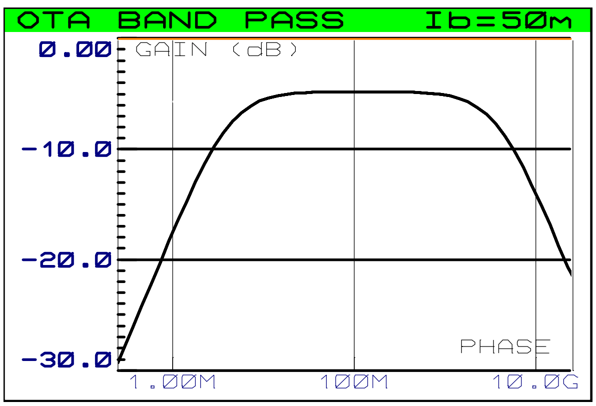


Fig. 5 Frequency response of Proteus professional 7 simulated OTA-C Band pass filter circuit, with pass band from 751KHz to21.1GHz at -20dB gain. Maximum gain is -4.81dB at 100MHz frequency. The bias current is 50mA.

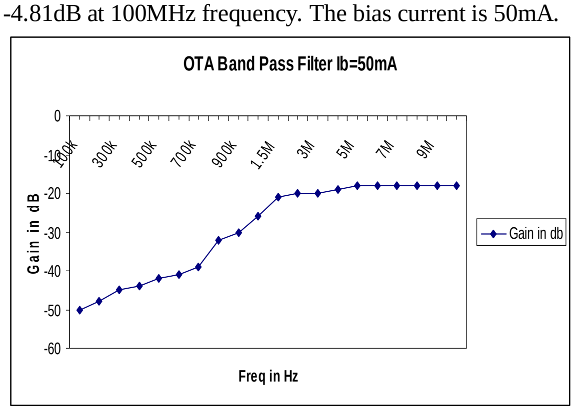


Fig. 6 Frequency response of practical OTA-C Band pass filter circuit, with pass band from 2MHz onwards at -20dB gain. Maximum gain is -18dB. The bias current is 50mA.

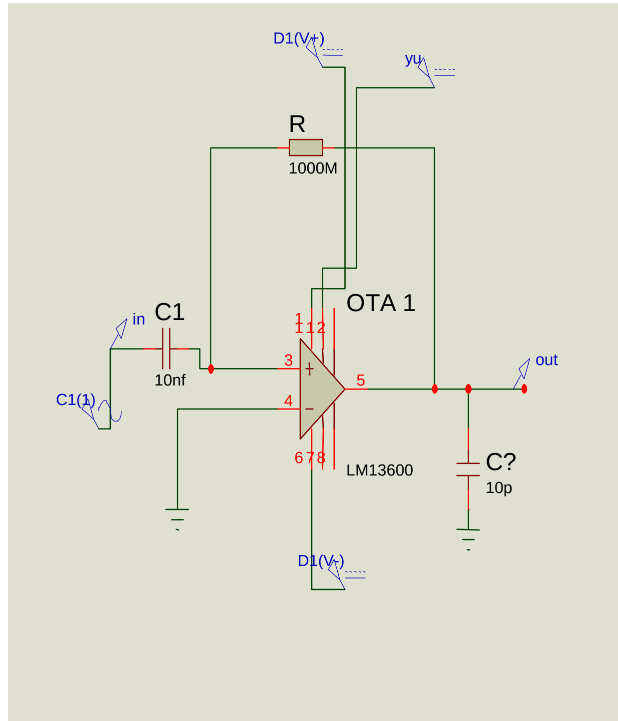


Fig. 7 Circuit diagram of OTA- C Band pass filter using feed back resistor of order R=1000MΩ(Replacement of OTA 2)

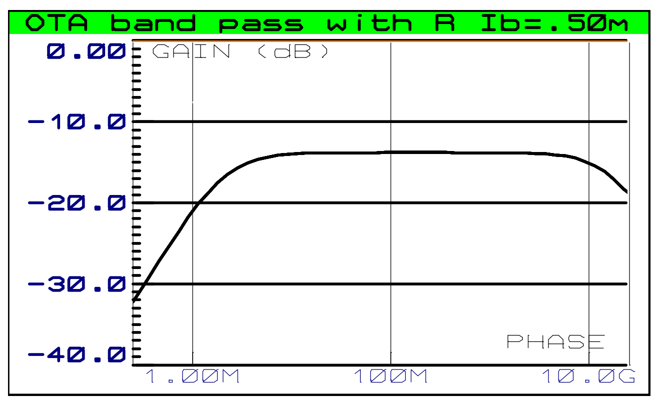


Fig. 8 Frequency response of Proteus professional 7 simulated OTA-C Band pass filter circuit, with resister of 1000MΩ, with pass band from 1.19MHz to 31.1GHz at -20dB gain. Maximum gain is -13.8dB at 100MHz frequency. The bias current is 50mA.

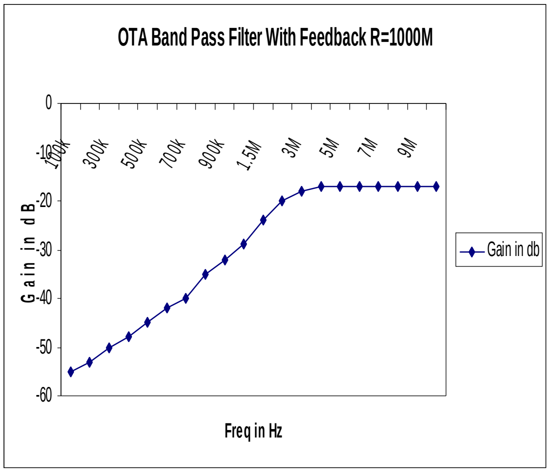


Fig. 9 Frequency response of practical OTA-C Band pass filter circuit with feed back resistor, with pass band from 2MHz onwards at -20dB gain. Maximum gain is -17dB . The bias current is 50mA.

[IV] CONCLUSION

The comparative studies on active filters using new conveyor chips and OTA-C band pass filter structure reveals the extensive application of OTA-C over wide range of operating frequencies [1] to [11]. The studied experimental results support the observation and the conclusions drawn on comparative studies. The linear transformation technique is one of the suitable methods in studying the other types of filters in high frequency region with flexible gain bandwidth product.

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