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COMPARATIVE STUDY OF LC LADDER ACTIVE FILTER USING OTA AND CURRENT CONVEYOR

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ABSTRACT:

A simulating circuit using Op-Amp, Operational Transconductance amplifier (OTA) and current conveyor Op-amp are used in the design of multiple order high pass active filters in respect of their superiority in passing the signal from low frequency to extremely high frequency in LC Ladder Active Filter. The filter response clearly indicates that the roll of rate decreases as we go for higher order studies their by executing Butterworth ideal characteristics of the filter. The OTA helps to avoid an external resistance RQ connected across the inductor at the output to suppress noisy oscillations observed at the response. The studied structures have applications in multiplexer design and video filters.

[I] INTRODUCTION

The current conveyor design used by Sedra & Smith[1],[2] is widely used in realization of active filters which may be taken as an analog method of developing active filters using Op-Amp. A current conveyor / OTA as inductance simulator is used in developing multiple order filters which may be considered as analog from of active filter of different order. An experimental test on all these studied circuits are developed using a software Proteus Professional 7.

The method of determining the filter response at successive orders is most attractive which explains comparative performances of Op-Amp, Current conveyor OTA and passive components.

The Antoniu Gyrator for grounded inductance simulation [3] is shown in fig 1, which is applied to simulate with current conveyor / OTA. These values of inductance are used in multiple order filter design, which is analogues to LC Ladder. [4],[5].

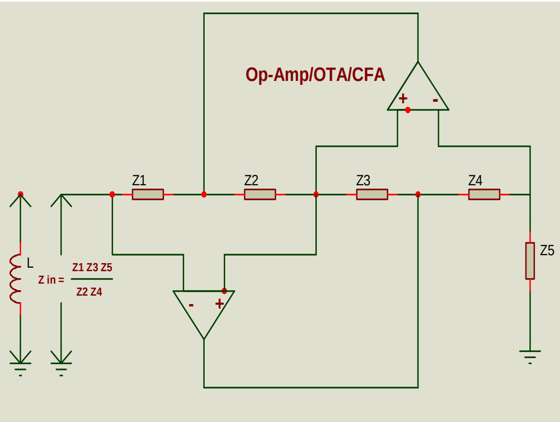

Fig 1.

The input impedance of the gyrator is

$$Zin = \frac{Z_1 Z_3 Z_5}{Z_2 Z_4}$$

to simulate L , select Z_2 or Z_4 as a capacitive impedance and all others are resistive impedances.

at Z_2 =SC

$$L = \frac{CR_1R_3R_5}{R_4}$$

at equal values of resistive impedances,

$L = C R^2$ for Op-Amp and Current conveyor and for OTA Gyrator [6] the simulated inductance is

at $g_{m1} = g_{m2} = g_m = 1 / (19.2 \text{ I bias})$

$L = C/g_m^2$

if $R^2 = 1/g_m^2$, the Gyrator (fig 1) has superior performance in pressing of noise using OTA in high frequency applications and gives good response of high pass filter So biasing current is one of advantage to suppress the oscillations in multiple order filter. The roll of rate in the response increases with respect to the order to execute the approximate Butterworth characteristics. [7].

[II] MATERIALS AND METHODS.

2.1 Comparative description of current conveyor LM 6181[8] and OTA LM 13600[9] with Op-Amp µA741.

The µA741 Voltage feedback Amplifier (OA) offers

*0.5 V/µs Slew rate
*1 MHz gain bandwidth product

The LM6181, high speed Current –feedback Amplifier (CFA) offers

*100 mA output current
*2000V /µs slew rate
*100 MHz Bandwidth
*50 ns setting time (0.1%)
*Characterized for supply ranges ±5V & ±15V

The LM13600 Operational Transconductance Amplifier (OTA) offers

*g_m adjustable over 6 decades
*Excellent g_m linearity
*High output signals-to -noise ratio
*Controlled impedance buffers
*Linear zing diodes
*Excellent matching between amplifiers

2.2. LC Ladder Simulation

LC Ladder simulation is taken from single stage (second order) passive LC high pass filter was designed at

$$f = \frac{1}{2\pi\sqrt{LC}}$$

and then it is extended for n stages. The passive LC Ladder high pass with 4 stage shown in fig 2, is studied at

$C_A=C_B=C_C=C_D=1nF$ & $L_A=L_B=L_C=L_D=100mH$.

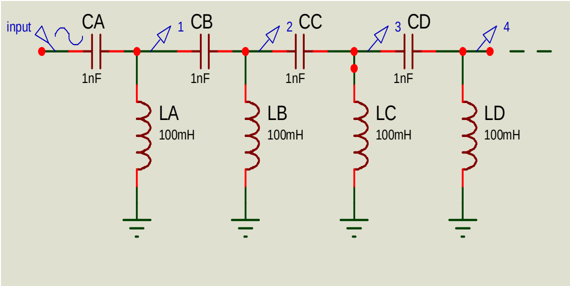

Fig. 2 Passive LC ladder filter

The passive L is then replaced with simulated L, at $R_A = R_B = R_C = R_D = 1.2K\Omega$ & $C_1 = C_2 = C_3 = C_4 = 70nF$ using OA, CFA & OTA as shown in the fig. 3 & 4.

This high pass filter passes all frequencies above 15 KHz. The passing frequencies can be selected for differernt combination of L & C.

[III] RESULTS AND DISCUSSION.

The Simulated LC ladder high pass filter was realised with OA, CFA & OTA in four stages through software Protuse Professional 7, shown in figures 5,6 & 7. The OA has 0.5V/µs slew rate & 1MHz bandwidth, gives noisy response at higher frequencies. Where by using high speed CFA LM6181 as its slew rate is 2000V/µs , noise can be minimised with high speed. This is one advantage over OA. But even 100MHz bandwidth of CFA the oscillations at higher order cut off regions are noisy like passive as well as OA filter. This is minimized by using RQ at output. which is shown in fig. 3. It determines the quality factor. [3],[6] At RQ = R, Q = RQ/R =1. Where by using OTA, the noisy oscillations at high pass filter response are minimised by tuning the biasing current only. These oscillations are smoothened at Ibias=2mA, where the gyrator condition is nearly matches at R = 1.2kΩ that gives a very good response.

For each LC stage roll of rate incrases from -40db/decade,-80db/decade, -120db /decade & -170 db/decade for 4th stage and it may gives Butterworth response after few stages. The studied frequency responces of passive, active OA/CFA high pass filter are shown in Fig 5&6 without RQ and with RQ = 5KΩ & 1,2,3,4 outputs of respective four stages are taken from upper curve in each response & Fig 7. of OTA oscillations are smoothened at Ibias=2mA. It clearly indicates that OTA filter is advantageous in high frequency video applications.[4]-[10].

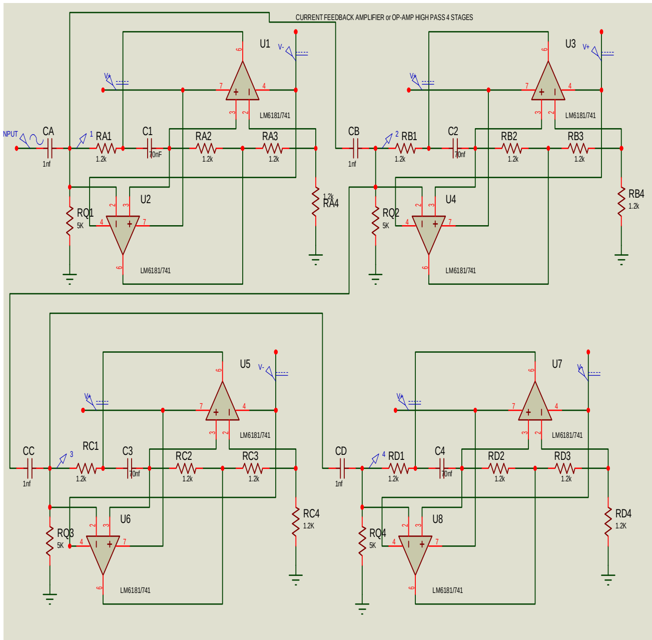

Fig.3 4 stage Op –Amp / CFA Active HP

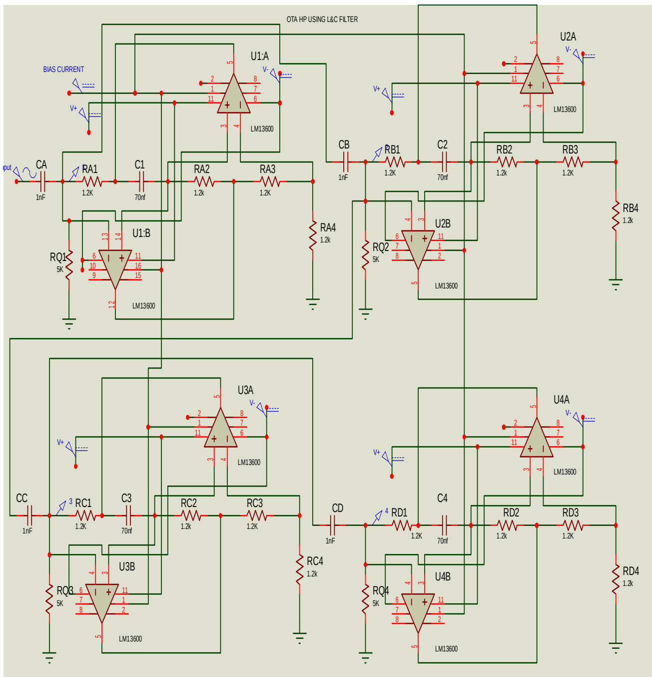

Fig.4. 4 Stage OTA Active LC HP

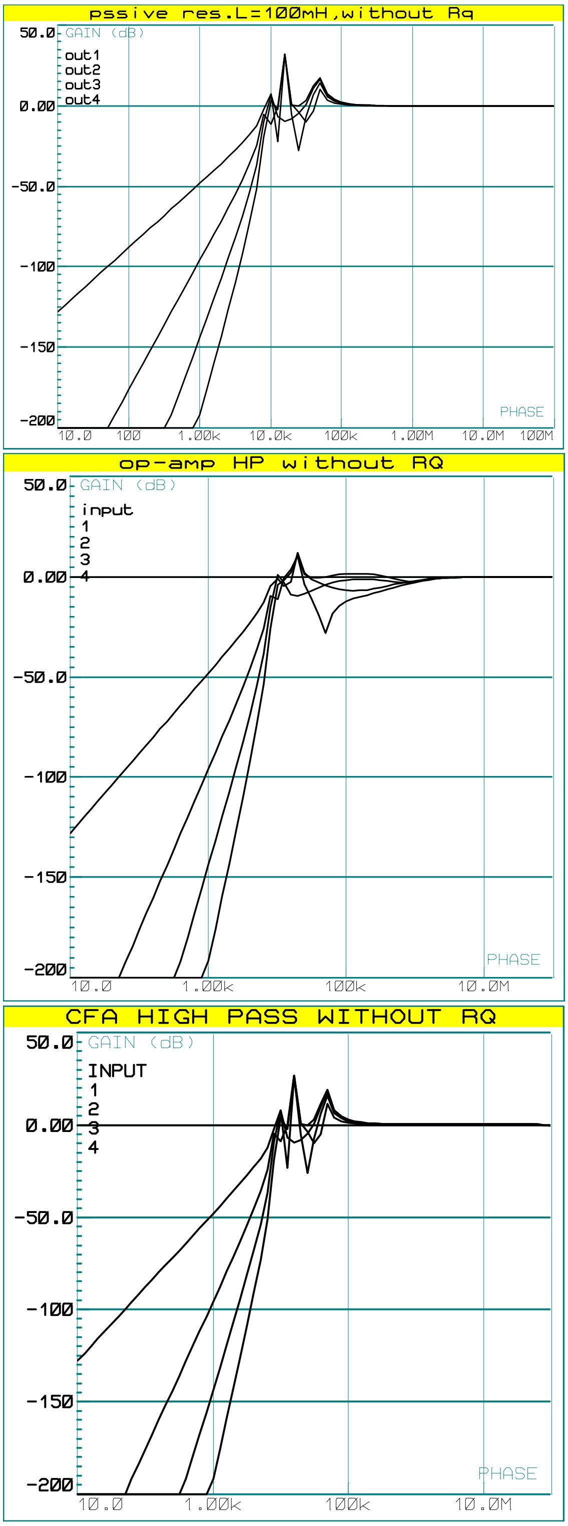

Fig 5. Freq. Res. of passive, Simulated active OA and CFA LC filter without RQ.

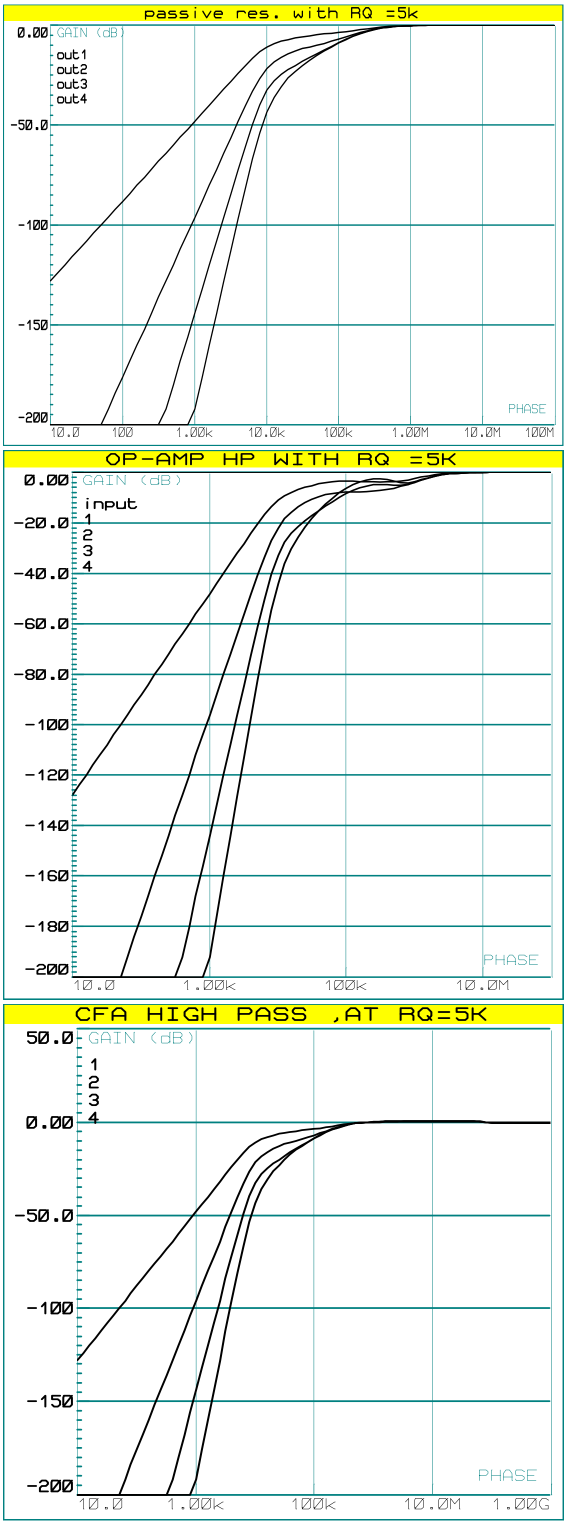

Fig. 6. Freq.res. of passive, Simulated active OA and CFA LC filter with RQ = 5 KΩ

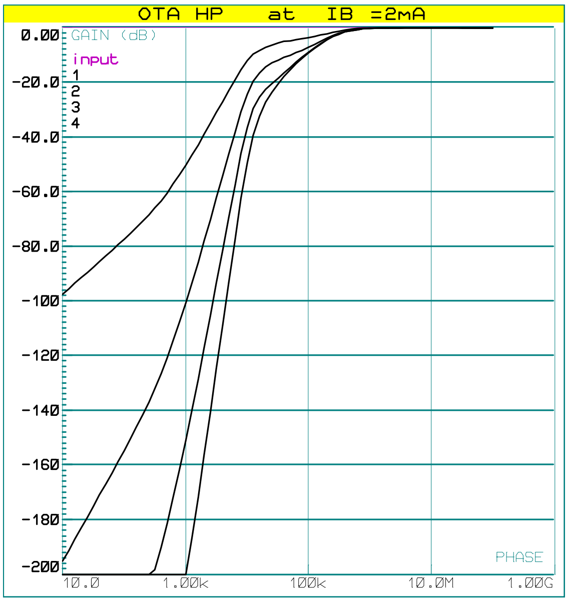

Fig 7 : Freq. Res. of OTA at Ib = 2mA

[IV] CONCLUSION

This paper is a schematic approach for realising active current mode ladder filter based on grounded inductance simulator & capacitance. The discussed orders are illustrative how OTA is helpful in tuning the current transfer function by controlled transconductance in the application of video filters with requrements of group delay.

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