ANTONIOU GYRATOR WITH OVA AND OTA IN LC LADDER ACTIVE FILTER

Manjula V. Katageri[1] , M.M.Mutsaddi[2]

1 Government First Grade College , BAGALKOT , India

2 Basaveshwar Science College , BAGALKOT , India

ABSTRACT:

Antoniou Gyrator grounded inductance simulating circuit using OVA and OTA 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 by using different configuration .The filter response clearly indicates the ripple is decreases as we go for higher order LC filters , studies their by executing Butterworth ideal characteristics of the filter. The external resistance R_Q connected across the inductor at the output is very helpful in suppressing oscillations observed at the output. The studied structures have applications in multiplexer design.

I. INTRODUCTION

An electronic wave filter is often frequency selective circuit that passes a specific band of frequencies and attenuates singles of frequencies outside this band. In Analog passive filters the inductance simulation using active devices is necessary to synthesis of useful passive filter characteristics. The simulation of inductance reduces the physical size with high accuracy and low sensitivity with active device OVA and OTA. The gyrator design used by Antoniou is widely used in realization of active filters which may be taken as an analog method of developing active filters using Op-Amp. By connecting an Antoniou gyrator inductance simulator is used in developing multiple order filters which may be considered as analog from of passive filter of different order .An experimental test on this circuit is developed using a software Proteus Professional 7 . The method of determining the filter response at successive orders is most attractive which explains the performance of Op-Amp and OTA along with passive components. The general circuit which was given by Antoniou Gyrator for grounded inductance simulation applies to OVA and OTA are used to design the multiple order filter circuit . A symbol of gyrator is shown in fig. 1. The Antoniou and Bruton gyrator of grounded inductance simulation circuit is shown in Fig. 2.[6-8]

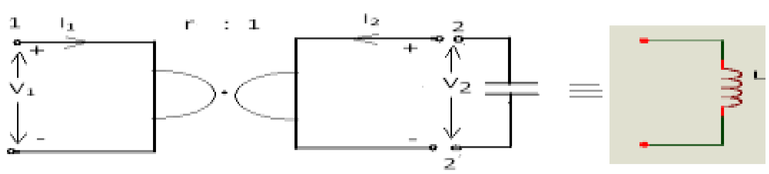


Fig. 1. A symbol of Gyrator

II CIRCUIT DISCRIPTION

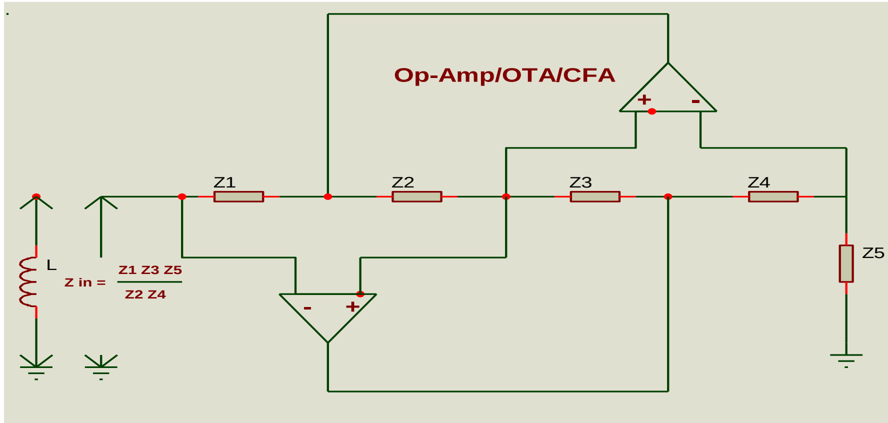


Fig.2 Antoniou Gyrator

Referring to the Fig.2, the analysis of gyrator gives the input impedance as

$$Z_{11} = \frac{V_1}{I_1} = \frac{Z_1 Z_3 Z_5}{Z_2 Z_4} \quad (1)$$

This acts as impedance converter with conversion factor K(s) defined as

$$Z_{11} = K(s)\ Z_5$$

Where $K(s) = \frac{Z_1(s) Z_3(s)}{Z_2(s) Z_4(s)}$ (2)

Since K(s) can be a desired function of S . Hence this circuit is generalized impedance converter. This is possible to realize four simulated elements when terminated in a resistive load. This is given in Table 1.

Table 1.

Load	**K(s)**	**Simulated element**
R	KS	L
R	K/S	C
R	$K S^2$	FDNC
R	$-K^2$	FDNR

However the author concerned with **Simulation of Grounded Inductance.**

The Antoniou gyrator (AG) acts as inductance simulation circuit at Z_2 or $Z_4 = 1/SC$ and all other impedances are resistors, in which Z_5 acts as load resistor. Hence two port AG network is realized as Generalized Impedance Converter (GIC), when either of the port is loaded. I.e. if port 2 is loaded, port 1 is converted as impedance of inductance and vice-versa. The resultant magnitude will be same for both movements. Thus impedance converter is characterized by

$$Z_{11} = S\,L_0 \tag{3}$$

$$\text{at } R_i = \frac{1}{g_i} \quad , \quad L_0 = \frac{C g_2}{g_1 g_3 g_5} \text{ or } \frac{C g_4}{g_1 g_3 g_5} \tag{4}$$

$$\text{If} \quad g_1 = g_2 / g_4 = g_3 = g_5 = g_m$$

$$L_0 = \frac{C}{g_m^2} \tag{5}$$

This is an ideal simulated inductance for ideal operation of Op-amp. The simulated grounded inductance is verified through single stage high pass filter for designed value of cut off frequency. This high pass filter is again extended in LC ladder to see the performance of frequency response, which is useful in telecommunication appliances.

III. EXPERIMENTAL RESULTS AND DISCUSSION

By studying the circuit with Op-Amp IC 741,Operational transconductance amplifier (OTA) LM13600/LM13700 in multiple designing of high pass filter have given better frequency response curves. The familiar voltage feedback 741 Op-Amp has a slew rate 0.5v/us & gain bandwidth product of 1MHz. OTA LM13600 has one tuning parameter the biasing current. Which varies the transconductance over 6 decades helps to suppress the oscillations occur in high pass filter design as justified.

HIGH PASS FILTER

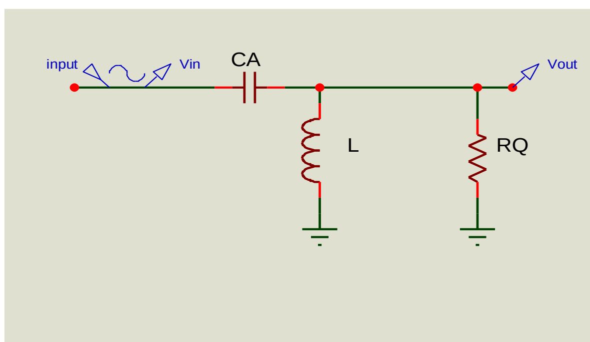


Fig.3 passive high pass filter

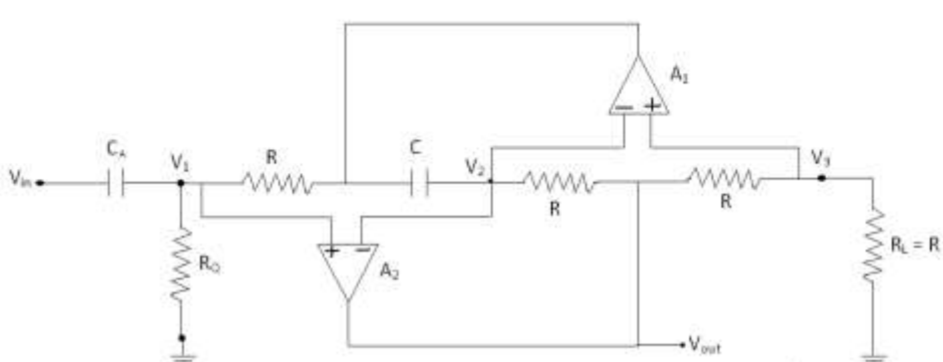


Fig. 4 Simulated High pass filter

The passive single stage high pass filter shown in Fig. 3. This is second order LC filter in which R_Q acts as Q determining resistor. This R_Q reduces the ripples at cutoff frequencies. The Fig. 4. shows second order active filter, with filter capacitor C_A, R_Q and then passive L is replaced by simulated Antoniou gyrator in which $L = C/g^2 = CR^2$, at $R_1 = R_3 = R_4 = R_5 = R$ and $Z_2 = 1/SC$.

The cutoff frequency in W_0 as,

$$W_0 = \frac{1}{\sqrt{LC}} \tag{6}$$

and the quality factor is $Q = R_Q \ (L/C)^{1/2}$

Thus for desired value of W_0 and using an appropriate value of C, one can determine the value of L. This L for Antoniou Gyrator with $Z_2 = 1/SC$ performs good simulation without loading a high frequency point. The output of amplifier A_2 directly proportional to the signal at GIC input. This simple observation allows the application of GIC circuit as a second order biquad circuit shown in Fig. 4. The transfer function of the circuit is

$$T(s) = \frac{V_o}{V_i} = \frac{2S^2}{S^2 + S(W_o/Q) + W_o^2} \tag{7}$$

Where $W_o = \frac{1}{CR}$ and $Q = \frac{R_Q}{R}$

As $V_1 = V_2 = V_3$

$V_{out} = 2\,V_3$ (if $R_4 = R_5$)

Hence the gain is doubled for any value of input and provides

*all low sensitivity parameter

*input impedance is infinite at resonant frequency

all resistors are equal , except for the Q determining factor being R_Q and the maximum value of Q is obtained if the capacitor C of the converter is chosen to be equal to that of capacitor of filter circuit .

The simulated value of inductance is,

$L = CR^2$ for Op-Amp at $R_1 = R_3 = R_4 = R_5 = R$

$L = \frac{C}{g_m^2}$ for OTA if $\frac{C}{g_m^2} = CR^2$ (8)

Where $g_m = \frac{I_B}{2V_T}$ called transconductance of OTA (9)

and I_B is the biasing current and $V_T = \frac{T}{11600}$ is the thermal voltage .

By the comparing of Op-amp and OTA devices through Antoniou Gyrator, the OTA grounded simulated inductance is the best to tune the inductance electronically through only one parameter i.e. biasing current in $\frac{C}{g_m^2} = CR^2$ is to be obeyed. In this condition, it has superior performance in pressing of noise using OTA in high frequency applications and gives good response of high pass filter, where Op-amp simulation depends only on passive elements. Thus the biasing current is one of the best advantages to suppress the oscillations in application of multiple order LC ladder network. [3-4]

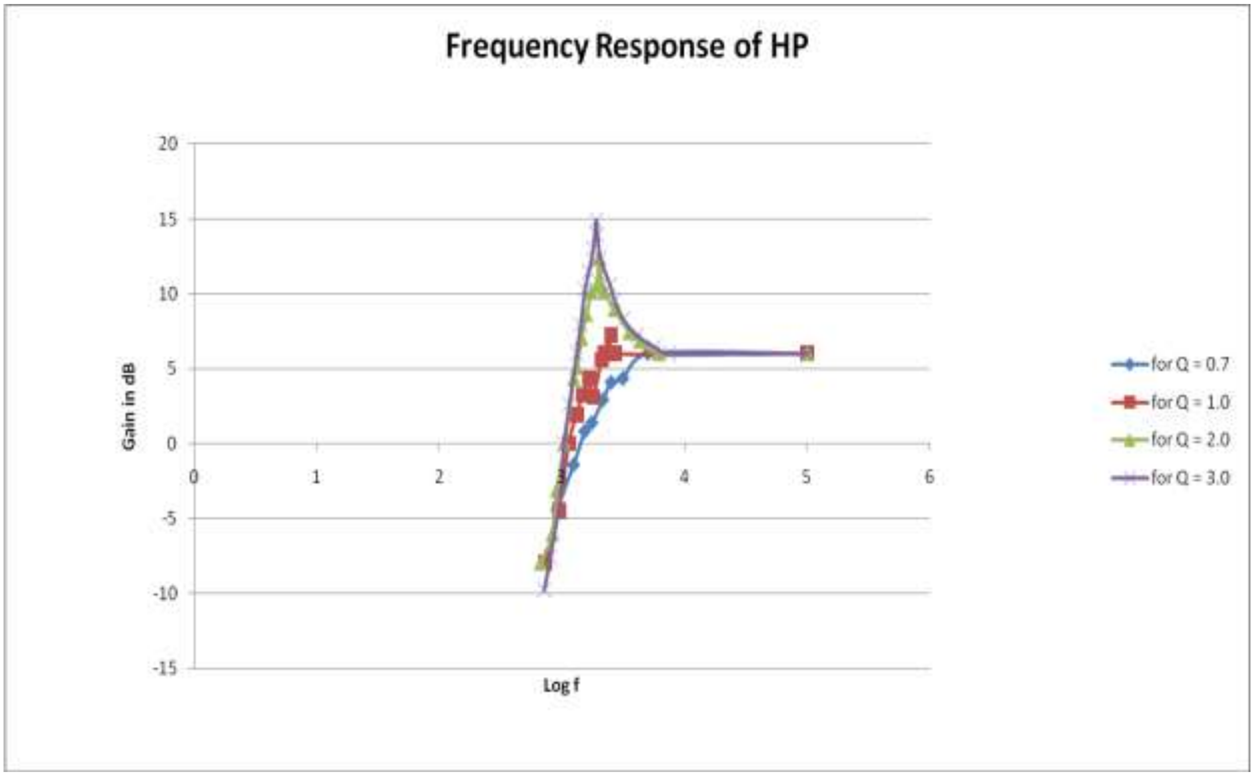
Table 2

Freq. (Hz)	**C(F)**	**L =** $\frac{1}{(2\pi f_0)^2 C}$ **(H)**	**R_1 = R_3 (Ω)**
16	1.0 µ	98.9	9.947 K
200	0.65 µ	974.4 m	1.224 K
2 K	0.07 µ	90.4 m	1.136 K
16K	0.1 µ	987.4 µ	99.4

Table 2. indicates the design of high pass filter with respective inductance and resistance of R_1 and R_3 As R_Q depends on Q, Table 3. gives the value of R_Q with respect to chosen value of Q, where Q = 3, 2, 1 and 0.7.

Table 3

Q	**R_Q = R X Q**	
	at R = 10.2 KΩ	**at R = 1.22 KΩ**
3	30.6 KΩ	3.6 KΩ
2	20.4 KΩ	2.4 KΩ
1	10.2 KΩ	1.2 KΩ
0.7	7.2 KΩ	860 Ω



Graph 1. At L = 103 mH and cut-off freq f_0 = 1.82 K Hz(Log f_0 =3.26)

LC Ladder Simulation

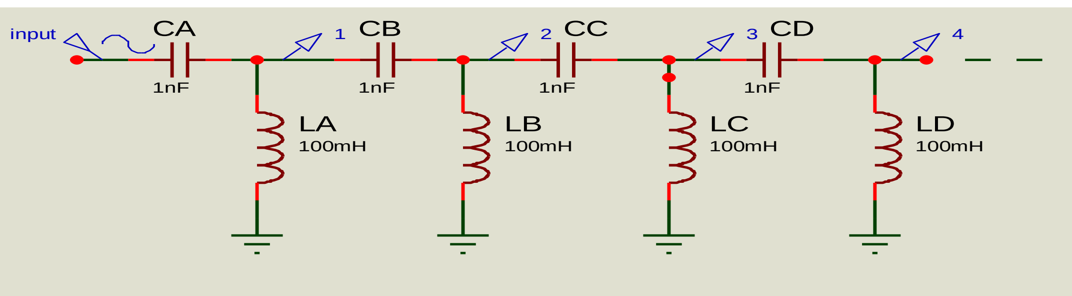


Fig. 5 Passive LC ladder filter

The passive LC ladder filter with 4 stages in Fig 5 is considered at C_A=C_B=---=1nF & L_A=L_B=---=100mH to comparative study of active LC ladder for 4 stage are given in Fig 6 & Fig 7. The frequency responses of passive and active filters are shown in graph 1.[1-2]

At $R_A = R_B = R_C = R_D = 1.2k\Omega$

C1 = C2 = C3 = C4 =70nF gives LA = LB = LC = LD = 100mH is connected to CA = CB = CC = CD = 1nf passes all frequencies above 15 KHz as W = 1/LC. The passing frequencies can be selecting for differernt combination. The oscillations at higher order cut off regions are minimized to tune RQ. In OTA HP the oscillations are minimised by tuning the biasing current .At 2mA, nearly matches with gyrator condition gives a very good response. The roll of rate is increases from -40db/decade from second order of I stage to of 4^{th} stage is -40dB /decade to -170db/decade.It can execute Butterworth response for further higher stages. [1-9]

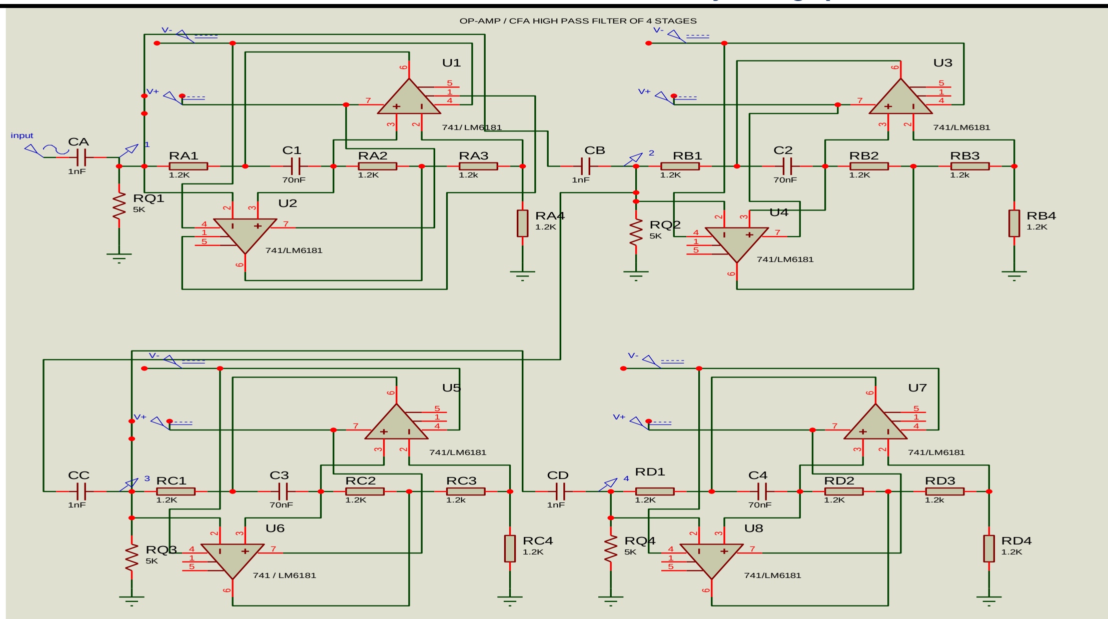
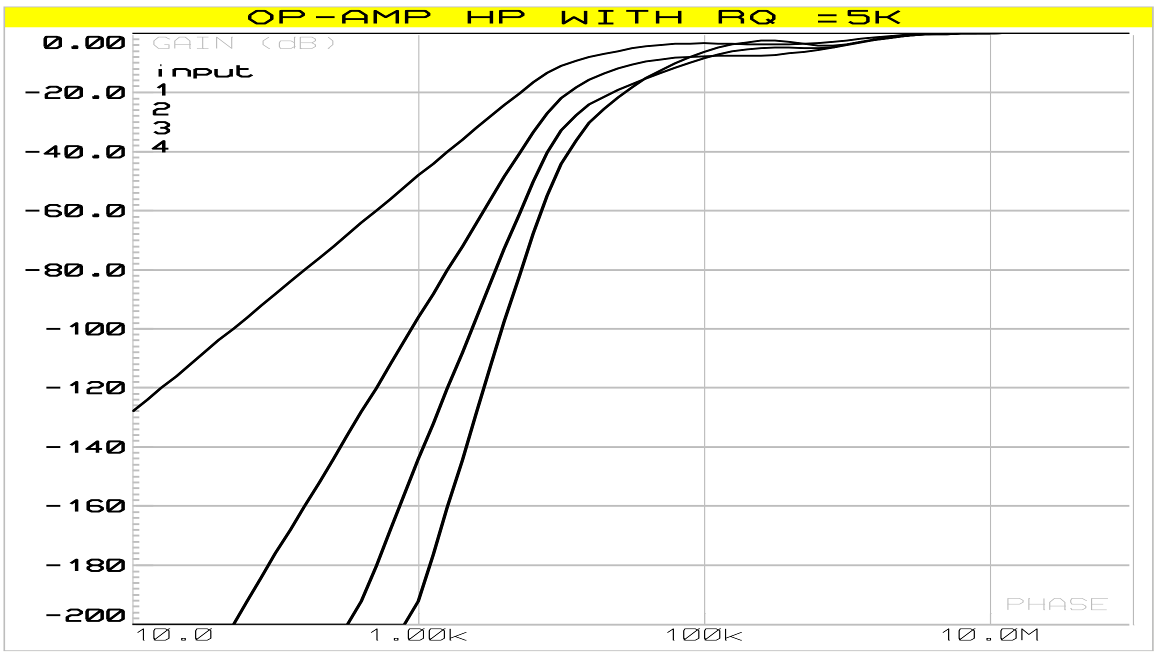


Fig.6. 4 stage Op –Amp active LC HP



Graph 2.

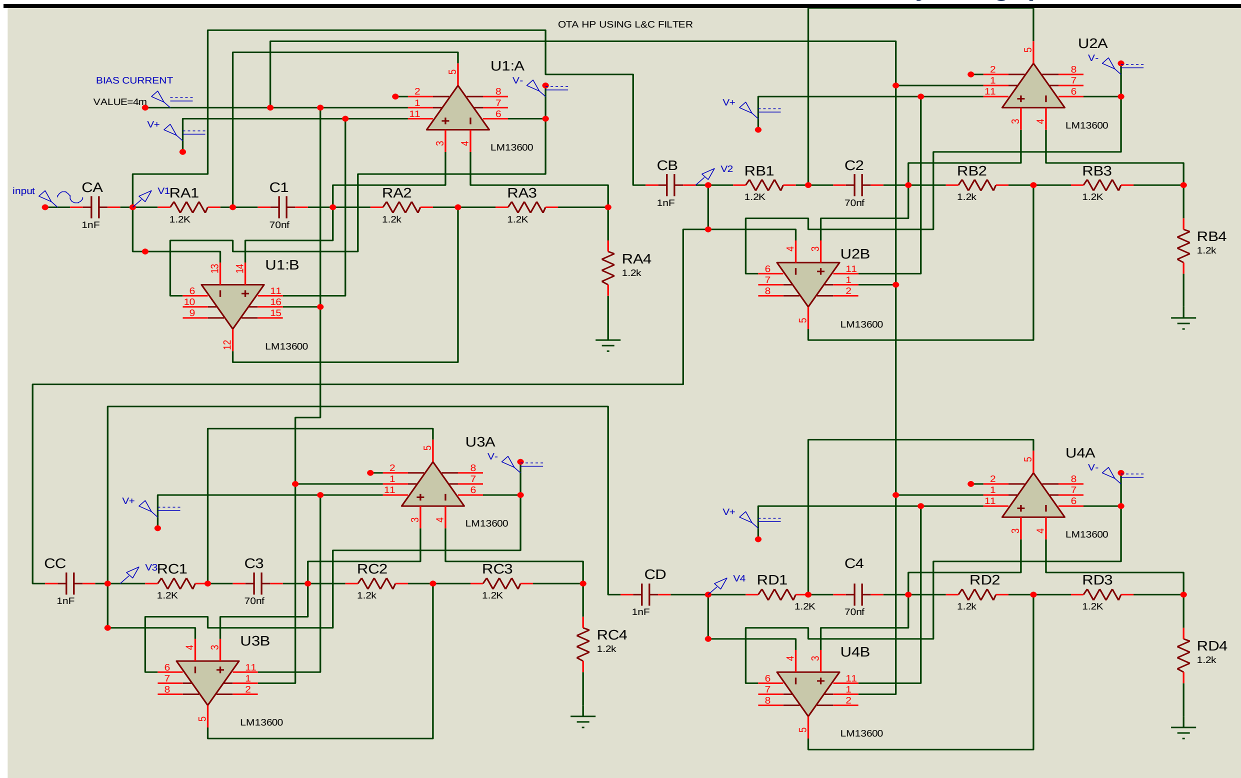
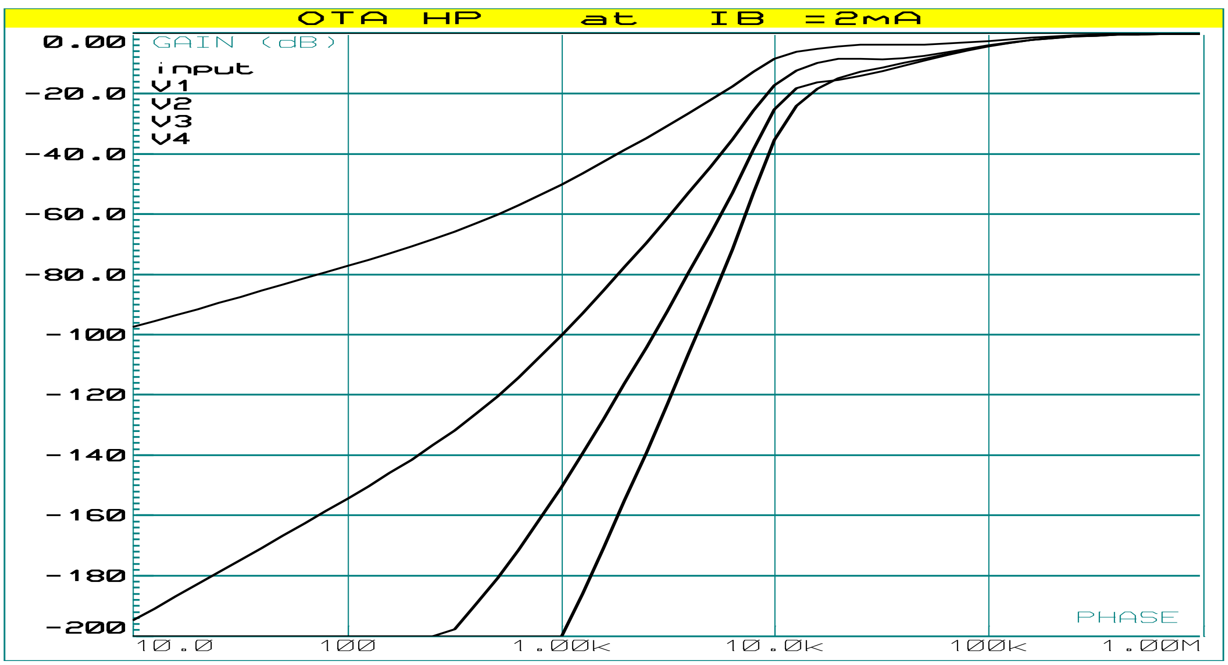


Fig. 7. 4Stage OTA Active LC HP



Graph 3.

IV CONCLUSION

The simulation of grounded inductance with Antoniou gyrator with OVA is a schematic approach for realizing active voltage mode ladder filter.The current mode ladder filter discussed orders are illustrative how OTA is helpful in tuning the current transfer function by controlled transconductance in the application of video filters with requirements of group delay.A comparative study on the filter clearly indicates that the oscillatory response of simple LC Ladder and Op-Amp can be controlled by the resistance RQ of different values are used to suppress the oscillatory current generated before the high frequency response. The OTA design has an advantage in overcoming this osciliatory variation just by tuning the transconductance of OTA. The studied characteristics of 4 stages of passive LC ladder filters are OVA and OTA are illustrated in the Graph 2 and 3 advantageous in high frequency video applications.

V. References

1. .D.prasad, D.R.Bhaskar, A.K.Singh, April 2010,"New Grounded and Floating simulted inductance Circuits using Current Differencing Transconductance Amplifiers" Radioengineering, VOL.19, NO.1
2.Alexander J. casson and Esther RodrigueZ –villegas , 2011 , "A review and Modern Approach to LC ladder synthesis" J.Low Power Electron ,Appl.,1,20-44
3. Datasheet- National semiconductor Corporation, " LM13600/LM13700 Dual Operational Transconductance Amplifiers With linearing Dioded and Buffers. 2004
4. Worapong Tangsrira, Teerasilapa Dumawipata, Sumalee Unhavanich, 2003, " Realisation of Lowpass and Bandpass Leapfrog Filters Using OAs and OTAs" , SICE Annual Conference In FuKUi, August 4-6,FuKui University, Japan.
5.Hulsemann. " A text Book on Active filter designing"
6. Vasudev K. Aatre , june 1997, " A text Book on Network Theory and Filter Design"
7. Bhaba Priyo Das, Neville WatSon and Yonghe Liu, 2010, "Simulation of Voltage controlled tunable All pass Filter using LM13600 OTA " International Journal of Electrical and Computer Engineering 5:6
8.Prashant K. Mahapatra, Manjeet Singh and Neelesh Kumar,1999, "Realisation of active filters using operational Transconductance Amplifier (OTA), Journal of Instrumentation Soc. Of India 35(1),1-9
9. S.Rana and K. Pal, 2007, "Current Conveyour Simulation Circuits Using Operational Amplifiers"