International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 10, Issue 3 (March 2014), PP.48-54

Design of OTA-C Notch Filter in Mega Hertz frequency range

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Abstract: A review paper on OTA – C integrator circuit is consisting of a resistor simulation and OTA integrator. The structure functions as a best notch filter. A sharp rejection of the frequency in MHz region is observed with decreased gain. The rejection in the frequency is sensitive to bias current and capacitance values. The configuration has high value in Q which is useful in signal processing applications in high frequency region.

Keywords:- OTA-C Operational Transconductance Amplifier-Capacitor,

I. INTRODUCTION

Generally a notch filter is a special case of a band-stop filter and passes all frequencies except for a narrow range of frequency. .High Q band reject filters have important application in RF transceiver design .The continuous-time filters were broadly used in many high speed applications, such as wireline and wireless communications, digital video, RF/IF filter etc. High Q Notch filter is an integral part of the traditional RF transceiver design. The OTA-C filters with simplicity, modularity, open loop configuration ,and electronic tune ability would be the choice for high frequency filter design over Active-RC and MOSFET-C filter design. The integrator is the main building block in the OTA-C filter, which can be realized by a transconductor element loaded with a capacitor. The main function of the transconductor is to convert the input voltage into the output current maintaining accuracy and linearity at the same time.

Operational transconductances amplifier is widely used as an active element in analog signal processing. It is a differential input voltage controlled current source (DVVCS) device. The circuit symbol of OTA is shown in **Figure 1**.

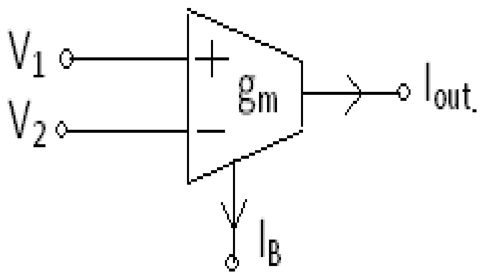

Fig 1. Circuit symbol of OTA

Io = $\mathbf{g_m}$ $(V1^+ - V2^-)$

Where $V1^+ - V2^-$ is a differential input voltage and Io is a OTA output current and g_m is the transconductance gain of OTA determined by the relation,

$\mathbf{g_m} = I_b / 2V_T$

Where I_b is the bias current of OTA and V_T is the volt equivalent temperature equal to 26mV at room temperature.OTA provides linear variation of transconductances gain g_m fairly over wide range due to dependence of g_m on bias current I_b of OTA. Circuit parameters such as Q- factor, cut off frequency of filter of OTA-C can be electronically tuned. Due to the presence of transconductance gain parameter g_m circuits realizing filters can be designed in such a way that they are free from passive resistors and inductors. Current source at the output of OTA gives better response of OTA-C active filter which is better than Op amp.

Filters that are designed using OTA-C or Gm-C are most popular in applications. Property of varying the bias current which leads to tuning of transconductance as a design parameter makes the filter flexible in frequency and Q-tuning , which makes OTA-C filters superior to passive filters and other active filters. In present study the advantages OTA are dealt, which gives better controlled sharp centre frequency and the tuning of Q of the Notch filter. [4-10]

II. CIRCUIT DESCRIPTION AND ANALASIS

Many of the basic OTA based structures use capacitors, which are attractive for integration. Component count of these structures is often very low. An OTA integrator is a OTA-C filter, which can be regarded as a first order low pass filter, as shown in Fig. 2. It consists of only an OTA and a capacitor. The transfer function for this integrator can be defined as,

$$\frac{V_o}{V1 - V2} = \frac{g_m}{sC}$$

This is an integration function in the Laplace domain and has a low pass property

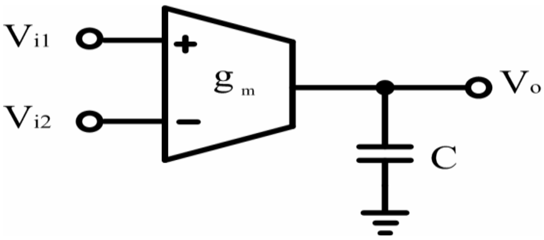

Fig 2. OTA integrator

Fig. 3 gives structure of second-order OTA-C Notch filter based on the OTA integrator structure which contains a global negative feedback. The transfer function of the filter is given below.

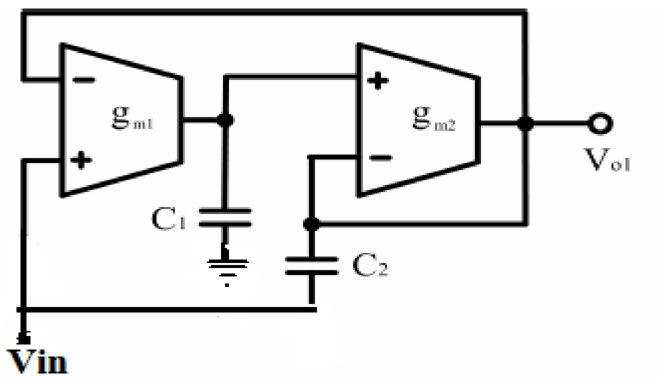

Fig. 3 Circuit diagram of second-order OTA-C Notch filter.

The transfer function of Notch filter is given by

$$H(s)_{bandstop} = \frac{s^2 C_1 C_2 + g_{m1} g_{m2}}{s^2 C_1 C_2 + s C_1 g_{m2} + g_{m1} g_{m2}}.$$

The centre frequency of a Notch filter can be electronically tuned by changing g_{m1} and g_{m2} and which is given by following expression.

The quality factor Q is given by the following expression which depends on g_{m1} and g_{m2} that is by tuning the transconductance of two OTAs

$$Q = \sqrt{\frac{C_2 g_{m1}}{C_1 g_{m2}}},$$

Quality factor can also be given by the relation, which can be obtained by keeping $g_{m1} = g_{m2} = g_m$.[1,2,3]

$$Q = \sqrt{\frac{C_2}{C_1}}$$

III. EXPERIMENTAL SETUP

The stated circuit of "Fig 4" is simulated using Proteus professional 7.5 software. Same circuit is arranged on bread board using an OTA LM13600 to verify the software results. The output of the filter is measured in respect of different values of C1 and C2, from the order of pF to nF. Readings are also analysed by varying the bias current from 100µA to 2mA. with the values of sharp rejection frequencies for the stated bias currents.

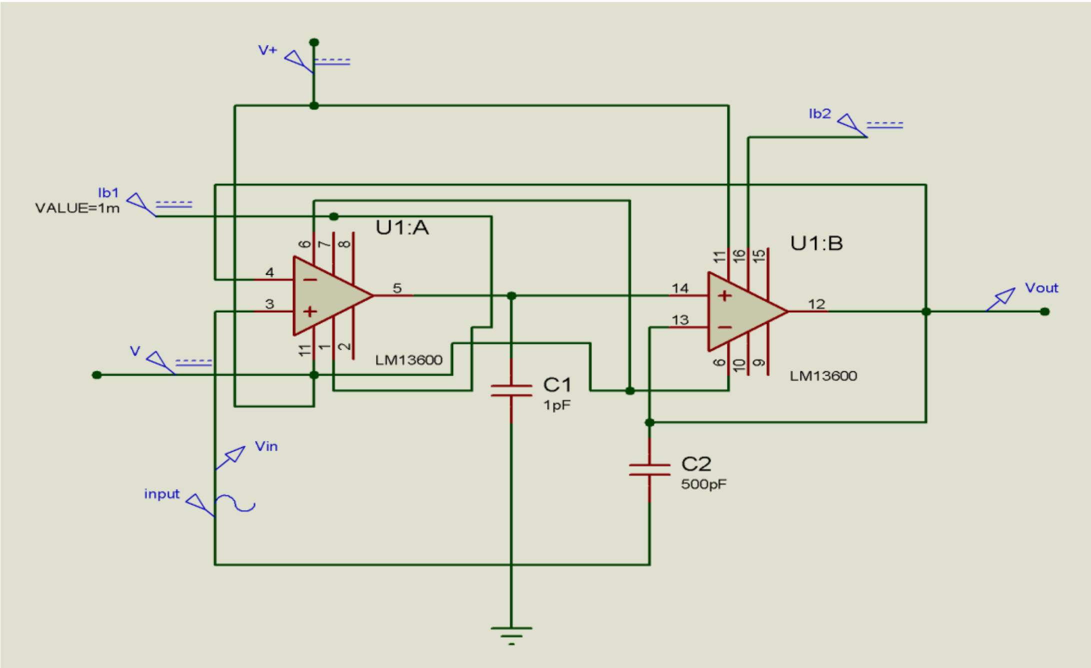

Fig. 4 Circuit diagram of second-order OTA-C Notch filter using Proteus professional 7.5 software

IV. RESULTS AND DISCUSSION

The studied circuit functions as a Notch filter of a sharp rejection frequency. The circuit is studied in two different cases.

Case 1: Variation of Q, which is independent of frequency variation.

Case 2: Variation of frequency

Case 1: By keeping bias current constant and by varying capacitances changing C_2 which gives the variation in Q

The table given below gives the variation in Q, which is obtained by varying C_2. and keeping C_1 constant. By keeping bias current constant, and by increasing C_2 from 500pF to 500nF the value of Q-factor varies from 22.36 to 707.As Q-factor increases rejection frequency decreases.

Table 1.1
$I_{b1} = I_{b2}$ = 1mA, C_1= 1pF

C_2	Quality factor Q	Frequency F
500pF	22.36	61.9MHz
1nF	31.62	25.6MHz
10nF	100	7.93 MHz
50nF	223	3.85MHz
100nF	316.22	2.54MHz
200nF	447.21	2.01MHz
300nF	547	1.59MHz
400nF	632	1.28MHz
500nF	707	1.28MHz

Frequency response

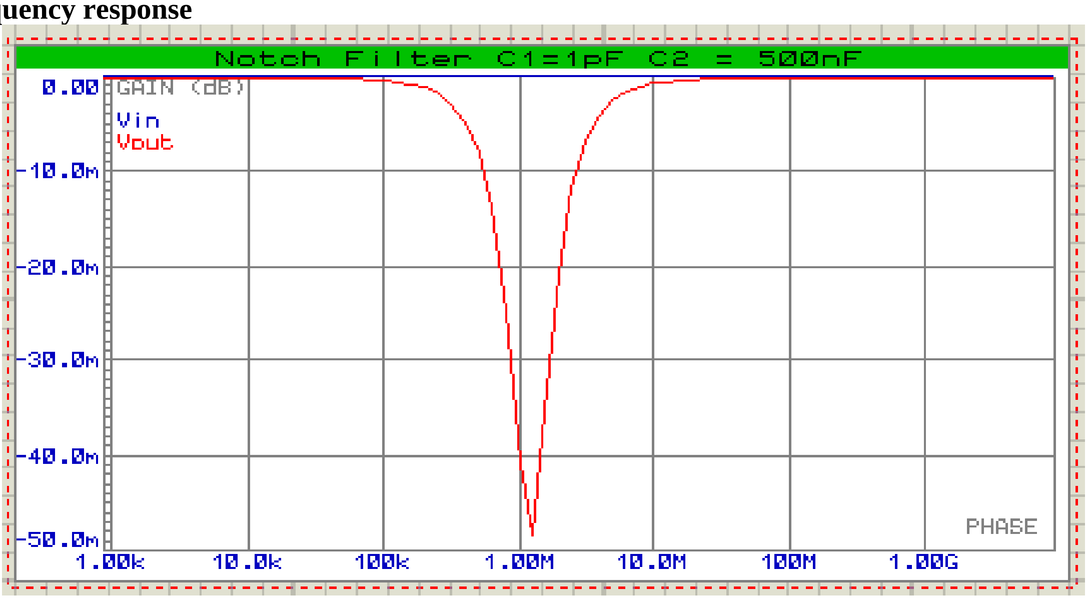

Fig.5 Frequency response of Proteus professional simulated OTA-C notch filter circuit, with Ib1 = 1mA= Ib2= 1mA i,e gm1= gm2= 0.0192Siemens with C1 = 1pF and C2= 500nF with sharp rejection frequency of 1.28 MHz .

Case 2:By keeping C1 and C2 constant and by varying bias current variation in sharp rejection frequency can be obtained.

By varying the bias current of OTA1 and OTA2 and by keeping capacitance constant, variation in sharp rejection frequency is observed from **12.7MHz** to **50.9MHz** for bias current from 100µA to 2mA.The sharp rejection frequency goes on increasing with increase in bias current for a fixed C1 and C2. However the Q factor of the notch filter goes on decreasing or increasing which depends on the combination of C1, C2, g_{m1} and g_{m2}.. These observations are given in table 1.2 and table 1.3.

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Table 1.2
C_1 =1pF C_2= 500pF
and I_{b1} = 1mA

I_{b2}	Frequency F	Q-factor
100µA	12.7MHz	70.71
500µA	31.2MHz	31.62
1mA	40.1MHz	22.6
1.5mA	49.9MHz	18.25
2mA	50.9MHz	15.81

Table 1.3
C_1 =1pF C_2= 500pF
and I_{b2} = 1mA

I_{b1}	Frequency F	Q-factor
100µA	12.7MHz	7.07
500µA	25.1MHz	15.81
1mA	39.4 MHz	22.6
1.5mA	50.9 MHz	27.38

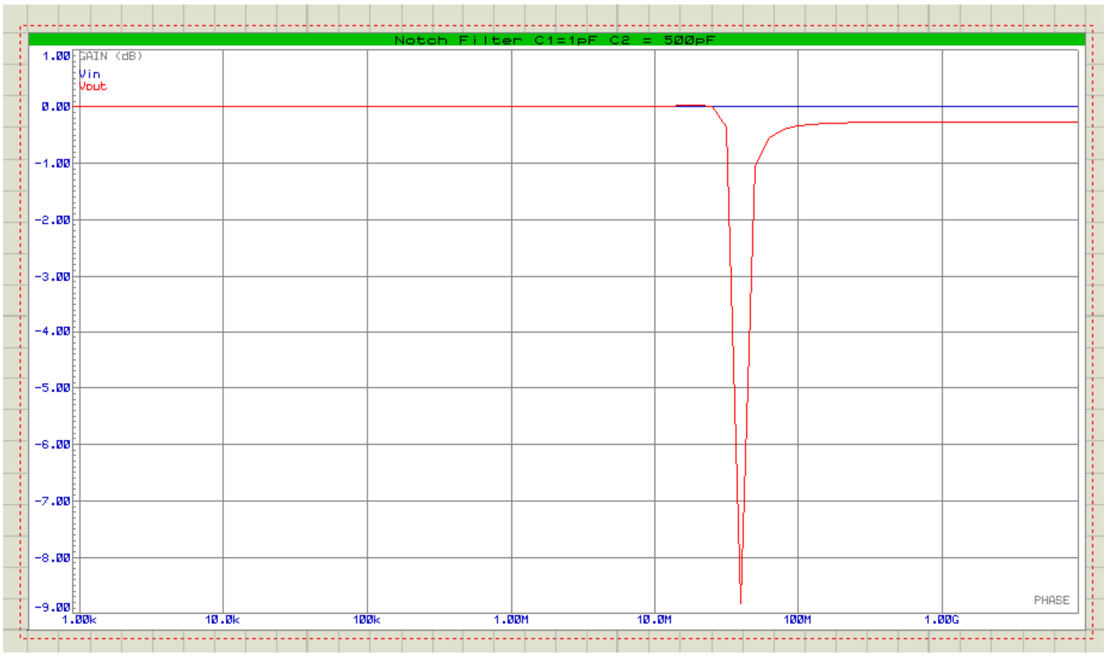

Fig.6 Frequency response of Proteus professional simulated OTA-C notch filter circuit, with I_{b1} = 1mA, I_{b2}= 2mA i,e $g_{m1=}$0.0192Siemens , $g_{m2=}$ 0.038Siemens with C1 = 1pF and C2= 500nF with sharp rejection frequency of 50.9 MHz .

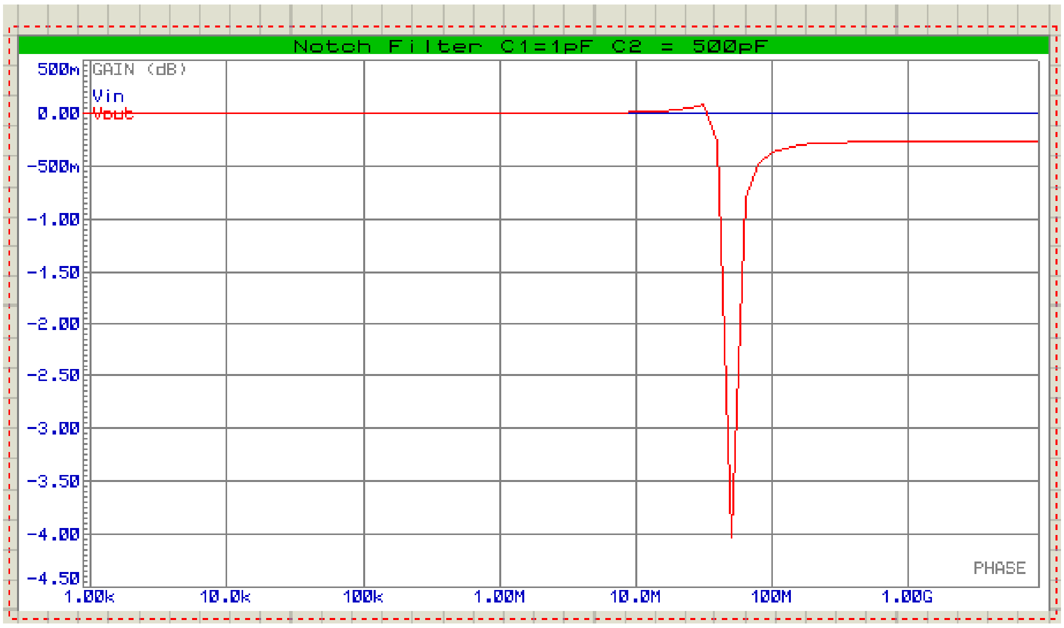

Fig.7 Frequency response of Proteus professional simulated OTA-C notch filter circuit, with I_{b1} = 1.5mA, I_{b2}= 2mA i,e $g_{m1=}$,0.0288 Siemens $g_{m2=}$ 0.0192Siemens with C1 = 1pF and C2= 500nF with sharp rejection frequency of 50.9 MHz.

From the above observations it is clear that, the Q factor is sensitive to the values of C1 and C2 , which can be varied from 1pF to 500nF, along with tune able transconductances g_{m1} and $g_{m2.}$ Sharp rejection frequency of a notch filter increases with increase in bias currents of OTA1 and OTA2 from 100uA to 2mA.

V. CONCLUSIONS

The studied circuit of OTA-C Notch filter exhibits a sharp rejection frequency. This frequency increases with increase in bias current in MHz frequency range. The circuit is sensitive to the values of C1 and C2 shifting the rejected frequency with a power approximated to 0dB. From over all study of observations the Q factor is sensitive to the values of C1 and C2 along with tune able transconductances g_{m1} and g_{m2}. From this structure any desired signal of MHz range frequency can be effectively rejected. The increase in the value of sharp rejection frequency can be obtained by varying the bias current. As bias current increases the value of rejection frequency increases. This frequency decreases with increase in value of C1 and C2. This has applications in rejecting the noise present along with the signal in MHz range. The value of Q is greater than 1 exhibit the selectivity of the Notch filter in the range from 1 to 700 . [1,2,10]

ACKNOWLEDGMENT

The authors acknowledge the help rendered by VGST by giving level 1 assistance for the precurement of softwares , deviceses and instruments which have been used. The authors also acknowledge the work of transfer function presented in the thesis “Operational transconductance amplifier for Giga Hertz Applications” submitted to the, Department of Electrical and Computer Engineering, Queen’s University Kingston, Ontario, Canada (September, 2008) by You Zheng .

REFERENCES

[1]. You Zheng “Operational transconductance amplifier for Giga Hertz Applications” A thesis submitted to the, Department of Electrical and Computer Engineering, Queen’s University Kingston, Ontario, Canada (September, 2008)

[2]. R. L. Geiger and E. Sanchez-Sinencio, “Active filter design using operational transconductance amplifiers: A tutorial,” *IEEE Circuit and Device Magazine*, vol.1, pp. 20-32, Mar. 1985.

[3]. Anisur Rehman Nasir1 and S. Naseem Ahmad “Current-Mode Multifunction Filters Using Current-Feedback Amplifiers and Grounded Capacitors” Proceedings of the 5th National Conference; INDIACom-2011 Computing For Nation Development, March 10 – 11, 2011 Bharati Vidyapeeth’s Institute of Computer Applications and Management, James Moritz Yichuang Sun “100MHz, 6th

Order, Leap-Frog gm-C High Q Bandpass Filter and On-Chip Tuning Scheme" 0-7803-9390-2/06/$20.00 ©)2006 IEEE New Delhi

[4]. Ms. Shivani Gupta, Ms. Suman, Ms. Sonal Aggarwal "LOW POWER CONSUMPTION CMOS DESIGN" International Journal of Research in Advent Technology (IJRAT) Vol. 1, Issue 3, October 2013, ISSN: 2321–9637

[5]. James Moritz Yichuang Sun "100MHz, 6th Order, Leap-Frog gm-C High Q Bandpass Filter and On-Chip Tuning Scheme" 0-7803-9390-2/06/$20.00 ©)2006 IEEE

[6]. S Naseem Ahamed , M R Khan,operational transconductances amplifier based voltage mode Universal filter. Operational transconductances amplifier Indian Journal of pure and applied Physics Vol 43 September 2005 pp 714-719

[7]. Hai-xi. Li, Jin-yong. Zhang, Lei Wang "A Fully Integrated Continuous-Time 50-Hz Notch Filter with Center Frequency Tunability" Bulitean of advance technology research Vol. 5 No.7/ Jul. 2011

[8]. Riyas T M, Anusooya S "Design of Low Power Linear Multi-band CMOS Gm-C Filter" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 3, Issue 2, February 2014

[9]. Deliyannis, Theodore L. et al "Two Integrator Loop OTA-C Filters" *Continuous-Time Active Filter Design* Boca Raton: CRC Press LLC,1999

[10]. Gao Zhiqiang "Design of CMOS Integrated Q-enhanced RF Filters for Multi-Band/Mode Wireless Applications" Advanced Trends in Wireless Communications ISBN 978-953-307-183-1 February, 2011 99-02, 1999.