A high quality factor obtained by a second order band pass filter using CDTA

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Abstract

Band Pass Filters are devices that pass a particular band and reject other frequencies. An example of an analogue electronic band-pass filter is an RLC circuit (a resistor–inductor–capacitor circuit). These filters can also be created by combining a low-pass filter with a high-pass filter.Bandpass is an adjective that describes a type of filter or filtering process; it is to be distinguished from passband, which refers to the actual portion of affected spectrum. Hence, one might say "A dual bandpass filter has two passbands." A bandpass signal is a signal containing a band of frequencies not adjacent to zero frequency, such as a signal that comes out of a bandpass filter. To obtain Band pass filters with high quality factors, various studies have been done, and various methods are adopted. CDTA (Current Differencing Transconductance Amplifiers) are the circuits which can be employed to make band pass filters at high frequencies to achieve high quality factors without involving extra parasitic. This paper presents a review of the method which are been adopted to make a band pass filter to achieve a high quality factor using CDTA's. Using the proposed method this paper is based on providing high quality factor by employing a feedback circuit to a second order filter. The used second order filter is improved in such a way that we can obtain a high impedance output. Thus, it cancels a requirement of any extra active element to obtain filter outputs. The whole circuit is deeply studied to understand the influence of parasitics and non idealities. Various other references on design of band pass is studied with use of CDTA and the proposed circuit is favourable in improving quality factor to much better extent without having parasitic developed and any effect on stability of circuits.

Points: *Second Order Filter, CDTA (Current Differencing Transconductance Amplifier), CA (Current Amplifier), Quality Factor.*

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1. Introduction

In today's era, all the modern communication system, be it TV, mobile phones or anything, all these are made up using different type of filters, especially the band pass filters. Various techniques are available to make a band pass filter with high quality factors, for achieving high quality factors, without change in pole frequency, one of the method that can be adopted is to change passive element ratio, but these will lead to certain demerits, one of it being using large chip area. In literature presented such as new agile filters, the pole frequency are altered to obtain a high quality factor, but the main aim of our method is to obtain a filter with high quality factor without altering pole frequency such that no parasitics are developed at higher frequencies. The filter's quality factor can be enhanced as independent filter elements with proper filter outputs and feedback circuits. Furthermore, the quality factor can be adjusted with feedback gain. Sensitivity of the quality factor with respect to feedback gain is less than unity.

The modified filter is based on CDTA and current amplifier is utilized. Thanks to modified CDTA, all filter outputs are directly received from high impedance port Z instead of their outputs through capacitor. Also, input signal and output of feedback circuit is easily interconnected in order to apply into input terminal of filter because of having terminals with current input and output. Thus, there is no need the extra element to obtain filter outputs. Also, the Transconductance stage of CDTA has only X_ terminals instead of X+ and X_ terminals. By this way, the CMOS
Implementation of CDTA becomes simpler. Besides, current amplifier
consists of only four transistors. The overall filter structure consists of two CDTAs, single current amplifier and two grounded capacitors as passive components.

2. Literature Review

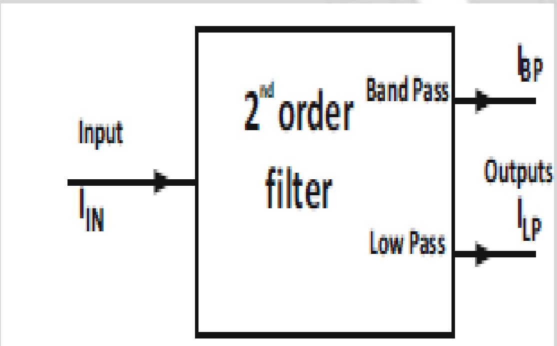
Now a days, various techniques have been adopted to improve communications in a more efficient way. To improve the quality factor of band pass filters various techniques are employed. Work in design of new agile filters for high quality factor requires a change in pole frequency, work in designs of electronically controllable band pass filter are requires feedback mechanism, and certain others works are carried out for the implementation of band pass filters. Some of the methods employed are discussed here as follows.

2.1A new frequency agile filter structure employing CDTA for positioning systems and secure communications.[R1]

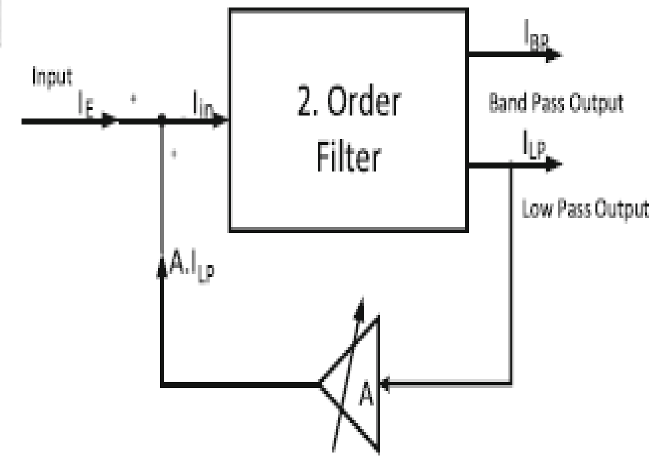
Frequency agile filter is one of the basic element of multi-standard transceivers and some encryption techniques as frequency hopping spread spectrum (FHSS), DHSS.

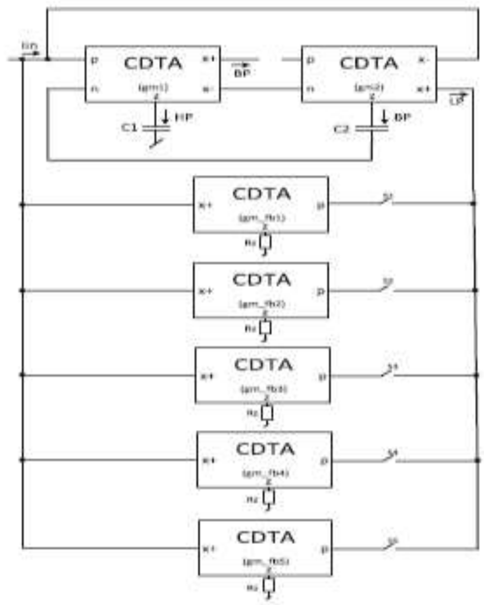
Frequency agile filter allows to sense different protocols with only one circuit.. There are several methods to design frequency agile filters. Current differencing trans-conductance amplifier (CDTA) can be used for frequency agile filter design. Current differencing trans-conductance amplifier (CDTA) can be considerable alternative building block of current mode operational amplifiers. The circuit description of CDTA is very suitable to design analog filters by using only capacitors. The filter structure consists of CDTAs as active element and only two capacitors as passive element.

The second order filter has at least two outputs. One of the outputs is low pass and the other is band pass. The low pass output can be directly applied to the input by passing through a gain stage.



In this condition, band pass gain does not change in contrast to the centre frequency of the band pass filter and quality factor. The method is shown through the figures.





Reconfigurable filter structure

2.2 Electronically controllable band pass filters with high quality factor and reduced capacitor value [R2].
The high quality factor value can be obtained and tuned electronically by changing the gain of the feedback circuit. In fact, the proposed method decreases the values of the capacitor up to approximately square root of the feedback gain. The new method employs a feedback circuit and a second order filter which has two outputs, bandpass and highpass responses. The gain of the bandpass filter remains constant while the centre frequency can be adjusted by electronically changing of the feedback gain.
The proposed method depicted here is built using second order filter structure and feedback circuit. Here a second order filter structure called Class-0 has two filter outputs, bandpass and highpass responses. Highpass response of Class-0 is applied to the input of the feedback circuit. Then, output of the feedback circuit is added into the input signal of the system. The whole structure is called Class-1. This is an interesting idea for the bandpass filter output of the Class-1

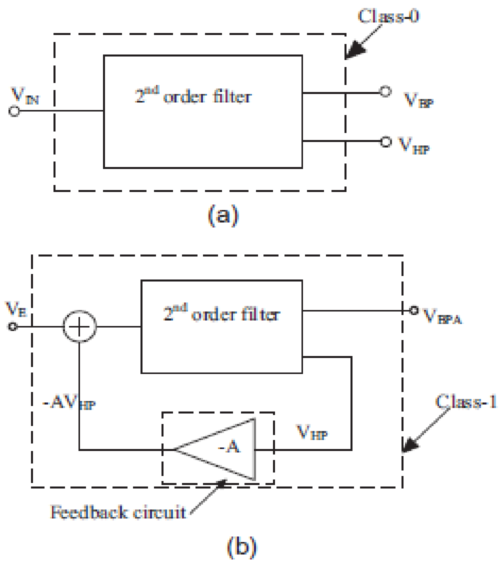
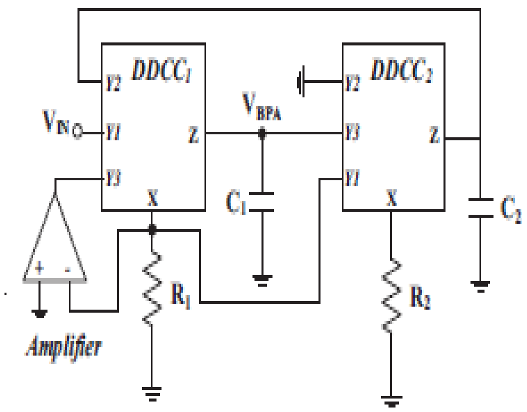


Fig. 1. (a) Class-0 and (b) Class-1 structure.

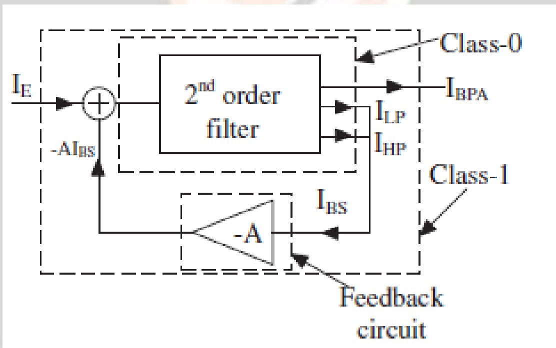
The CDTA is employed here and the circuit is made to acheieve the required Class-1 for acheievinga high quality factor.
In the proposed circuitry the quality factor improves by a facrtor of sqrt(1+A).



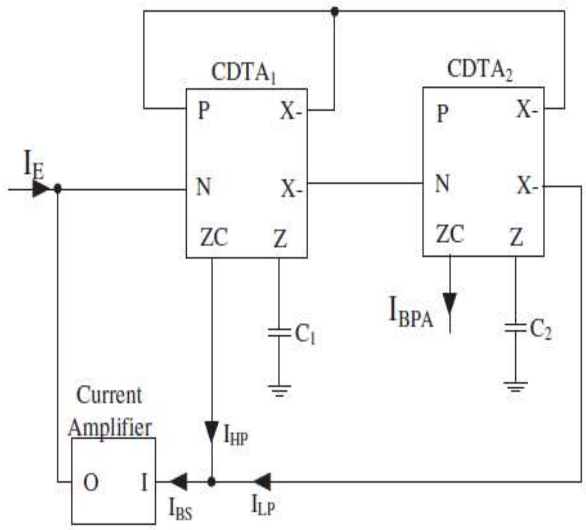
DDCC and amplifier based realization of the Class-1.

2.3 Proposed Method

The proposed method that we used is based on improving quality factor without change in pole frequency. Here we have employed a second order filter which will help us in designing the filter. The second-order filter includes at least a single input and three outputs, a low-pass filter (LPF), a BPF and a high-pass filter (HPF). Note that the interconnection of LPF and HPF output is obtained to band-stop filter (BSF). Figure a depicts second order filter structure called as Class-0. It is necessary to take into account the input and output of Class-0 when selecting the feedback circuit. The combination of Class-0 and the feedback circuit is called Class-1as shown

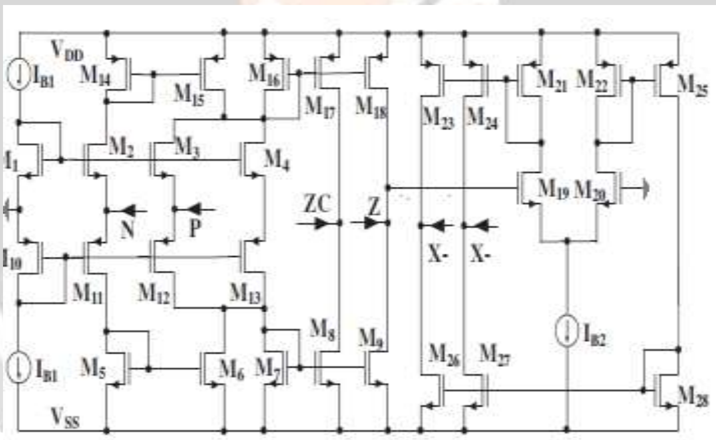


To obtain high quality factor at second order active filter using CDTA element, the filter in figure is a modified version of an existing filter employing two CDTAs and two grounded capacitors realizing LPF, BPF and HPF output. However, it is necessary to obtain BPF and HPF output using extra active elements. Therefore, filter structure and the CMOS implementation of CDTA are modified in order that HPF and BPF outputs are directly received high impedance, output at Z-copy terminal. Thereby, BPF and HPF outputs through capacitor can be easily obtained to high impedance output without using extra element. Furthermore, to simplify the Realization CMOS of CDTA on the second order filter, terminal connections is reorganized as given in figure. It is observed that Transconductance stage of CDTA based filter has only X_ terminals Instead of X+ and X_ terminals according to previous reported in references [3].In this way, numbers of transistor is reduced in the CMOS realization of CDTA. Note that current convention is such that all Currents flow into the CDTA.



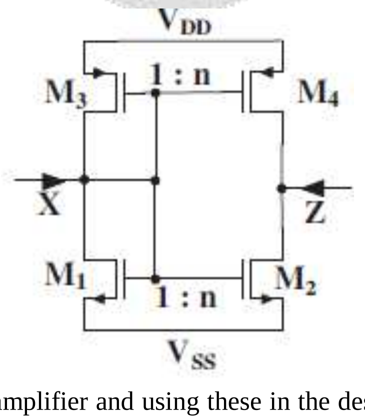
The employed Class-1 structure wit
Class-0 and current amplifier

This gives that here by the feedback structure the gain is increased by a factor of (1+A). Now, using this, the pole frequency of the structure is not altered and thus the parasitics are not developed at higher frequencies .The CDTA used here is as follows:



The implementation of the CDTA

Also the current amplifier employed in Class-1 modified structure is as follows:



Thus by design Of CDTA and current amplifier and using these in the design of filters, the output of Band pass can be obtained and through feedback mechanism of current amplifier the quality factor is increased to much higher level.

4. Results

A performance analysis of the works done or the method discussed is done to gather up the differences which can be analysed so that a comparison can be done with works in the past and our method. Our method gives a centre frequency of 1 MHz along with a quality factor of 14.4.The performance analysis table is represented as under:

	[R1]	[R2]	This Work
Supply voltage	**+-0.8V**	**+-1.27V**	**+-0.9V**
Technology	**0.18 Micrometer**	**0.18 Micrometer**	**0.18 Micrometer**
Operating Frequency	**90 MHz**	**461 Khz**	**1 Mhz**
Quality Factor	**9.64**	**18.67**	**14.5**
Agility	**Yes**	**No**	**No**
Parasitics Involved	**Yes (Due to Change in Pole frequency)**	**No**	**No**

Circuit performance comparison with conventional works

5. Conclusion

With the advancement in technologies, it is a great topic of importance for design of such devices which gives us a high efficiency along with least errors. Leading to the world of communications, In the devices employed for it, filters play a major role, thus there comes a point where the quality factor of these filters need to be employed. For high quality factors and for filters to work at higher frequencies, parasitics shouldn't be developed and thus the proposed methods are helpful in attaining such results. Using the proposed method of modified CDTA, the outputs of high impedance are easily achieved without using extra active elements.
Also, the pole frequency does not change when the quality factor increases. Furthermore, the quality factor is tuned by feedback gain and sensitivity of the quality factor with respect to feedback gain is less than unity. The performance of the time domain of Class-1 structure improves while gain of current amplifier increases with n factor. In addition, the overall structure is analyzed so as to examine effects of parasitic elements, non-ideal and sensitivity. Thus the methods employed give us an overview of how the filters can be designed in an efficient manner with much high quality factor and without any alteration in pole frequencies.

6. References

[1] T Li, B Mitra, EECS, 2003, eecs.umich.edu, L Jin, H Xing, D Chen, IEEE International Smposium on,2006, see.ed.ac.uk, Biolková V. Current-mode KHN filter Employing current differencing Transconductance amplifiers. AEU Int J Electron Commun 2006; 60:443–6.

[2] J Oehm, Analog integrated circuits and signal, 2001, Geiger RL. Amplifier design considerations for high frequency monolithic filters. Proc Eur Conf Circuit Theory Des 1987:321–6.

[3] O Mitrea, C Popa, AM Manolescu, Analog Integral Circuits Signal Process 2009; 61:247–57.
http://dx.doi.org/10.1007/s10470-009-9313-y

[4] TC Lu, HW Zan, MD Ker, WM Huang, KC Lin,2008, ics.ee.nctu.edu.tw

[5] CJB Fayomi, GI Wirth, HF Achigui, Electronically controllable bandpass filters with high quality factor and reduced capacitor value: An additional approach. Regular Paper 2015.