IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 10, Issue 2, Ver. II (Mar - Apr.2015), PP 73-75
www.iosrjournals.org

Band Pass Filtering Technique using Sallenkey Filter

Nidhi[1]
[1]*Electronics Dept., Banasthali University (Raj.), India*

Abstract: *This paper contributes an understanding of pulse processing of nuclear detectors which is accomplished by analog pulse shaping analysis filter and common overview of the Sallenkey architecture succeeded by low pass and high pass filters.The interrogation encompasses holding quality factor, gain and mid frequency of filter self-sustaining each other and maintaining other critical condition of filter, keeping the filter stable.*
Keywords: *Band Pass Filter, Gain, Mid frequency, Quality factor, Stability.*

I. Introduction

Band pass filter design has yet been a challenge considering many interrelated vulnerabilities in parameters of the circuit.Quality factor, Q and Gain of the circuit are usually linked in band pass filter, and hence do not give the autonomous control. Narrowband pass filter stability demands different requirements. Conventionally, Quality factor, Q is increased to accomplish narrow band pass filtering but higher values of Q makes the circuit unstable and the circuit may probably oscillate due to the instability caused by increased value of Q.

There are a number of topologies for designing filters. Those filters which have low passand high pass stages cascaded performs the band pass function. These may be Chebyshev or Butterworth or Elliptical filters. Sallenkey filter is a semi-gaussian filter which is widely used nowadays.Sallenkey filter architecture followed by its operation is described in this paper.The main benefit of Sallenkey filter lies in the fact that the Quality factor, Q can be modified by adjusting gain without varying the mid frequency.[1,2]

II. Sallenkey Architecture

Sallenkey filter consists of a low pass filter followed by a high pass filter. The combination of low pass and high pass circuit will make the required band pass filter.This is unity gain configuration of Sallenkey filter.Sallenkey second order topology is used which requires single op-amp and four passive components to attain tuning. This filter works for non-inverting configuration only.[2]

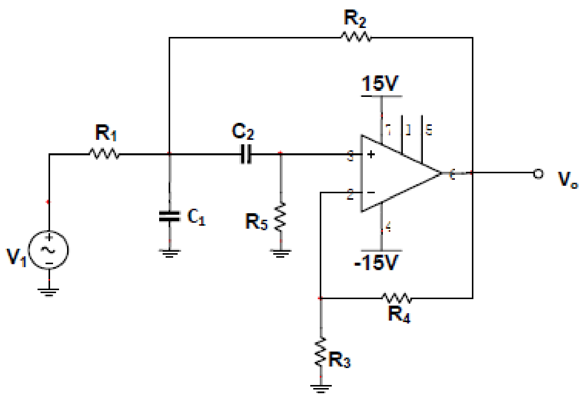

Figure 1. 2nd Order Sallenkey Architecture [1]

III. Low Pass Filter

A two stage RC filter network is shown in the figure 2. It forms a second order low pass filter. In most of the filters it is required to have quality factor greater than 0.5. Higher values of Q are reachable by applying positive feedback amplifier.[2]

$$H_{LP} = \frac{K}{-\left(\frac{f}{fc}\right)^2 + \frac{jf}{Qfc} + 1} \quad (1)$$

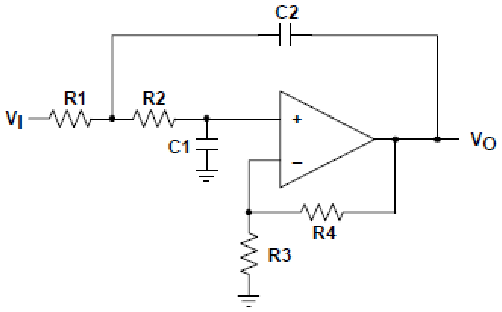

Figure 2. Low Pass Filter Circuit [2]

1. Operation

At low frequencies, C1 and C2 will be open circuited and the signal is buffered to output. At high frequencies C1 and C2 will be short circuited, due to which the signal will be shunted to the ground at the input of amplifier. The amplifier will then amplify the input to its output. Near cut-off frequency, impendence of C1 and C2 are of the same order of R1 and R2. Positive feedback by means of C2 contribute quality factor enhancement of the signal.[3]

2. Filter Component Ratios For Low Pass Filter

1. Suppose R1=mR, R2=R, C1=C and C2=nC [2]:

$$fc = \frac{1}{2\pi RC\sqrt{mn}} \tag{2}$$

$$Q = \frac{\sqrt{mn}}{m + 1 + mn(1 - K)} \tag{3}$$

With higher values of k, Q becomes negative which reflects that the poles move to the right half of the s plane and the circuit will oscillate.

2. Suppose R1=R2=R and C1=C2=C[2]:

$$fc = \frac{1}{2\pi RC} \tag{4}$$

$$Q = \frac{1}{3 - K} \tag{5}$$

f and Q does not depend on each other which leads to the simplification of the design. But, the major problem is that the gain controls the quality factor, Q of circuit. Further, gain may be required to attain preferable signal gain in pass band, when K=3, Q will become infinity and with larger values of resistances Q will become negative and again the poles will move to the right hand side of the s plane which will make the circuit oscillatory.

IV. High Pass Filter

High pass filter configuration is showed in the Fig 3. Signals are attenuated by the square of the frequency ratio at low frequencies particularly below cut off frequencies f=fc, HLP= -jKQ and the signals are improved by factor of Q. When f>>fc, the signals will be multiplied by the gain factor of k. Second order high pass filter is described by increase of attenuation by a power of 2 at low frequencies[2-5].

$$H_{HP} = \frac{-K\left(\frac{f}{fc}\right)^2}{-\left(\frac{f}{fc}\right)^2 + \frac{jf}{Qfc} + 1} \tag{6}$$

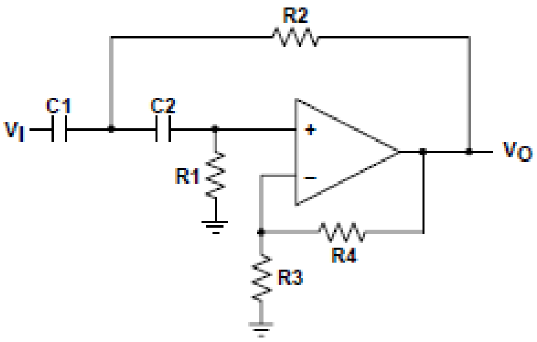

Figure 3.high pass filter circuit [2]

V. Filter Component Ratios For High Pass Filter

1. Suppose R1=nr, R2= R, C1=C and C2=mC [2]:

$$fc = \frac{1}{2\pi RC\sqrt{mn}} \tag{7}$$

$$Q = \frac{\sqrt{mn}}{n + 1 + mn(1 - K)} \tag{8}$$

Having higher values of K, Q will become negative and due to which poles will be moving to the right half of the s plane which will make the circuit oscillatory.

2. Suppose R1=R2=R and C1=C2=C [2]:

$$fc = \frac{1}{2\pi RC} \tag{9}$$

$$Q = \frac{1}{3 - K} \tag{10}$$

With this configuration fc and Q are not depending on each other and thus design has been simplified upto some extent but still Quality factor of the circuit is determined by Gain.

Resistor values having K=3 will lead to the Quality factor equal to infinity and with larger values of resistor,Q will become negative which will make the circuit unstable.[6]

VI. Conclusion

As the quality factor is raised the selectivity of the filter will be enhanced and due to which the bandwidth will be reduced. Values of R and C are inversely proportional to each other. Gain of the circuit should be fixed at first and then Q based on ‘m’ and ‘n’. Then after selecting the value of C,R is calculated to set cut-off frequency, f_c. Q should not be negative as it will make the circuit oscillatory.[1-3][8]

References

[1]. TreyimaD.Kurvev, JhonsonA.Mise,Benard A. Atsuwe.“Implementation of an active filter AC Band-Pass filter at varying Quality factors using MATLAB”, International Journal Of Scientific and Technology research volume -3, ISSUE-5, May 2014.
[2]. James Karki."Analysis of the Sallen-Key Architecture",Application Report for Texas Instrument, July 1990,sloa024.
[3]. Thomas Kugelstadt. "Active Filter Design Techniques", Fundamentals of Low Pass Filters, Texas Instrument.
[4]. Mark Sauerwald, "Designing Active High Speed Filters",National Semiconductor Corporation, February 2005.
[5]. Raman K. Attri. "Practical Design Evaluation of Extremely Narrow Band-Pass Filter Topologies",R. Attri Instrumentation Design Series (Electronics), Paper No.7, September, 2005.
[6]. Thomas Kugelstadt. “Active Filter Design Technique: Op-amps for everyone”,Texas Instrument Design reference SLOD006B, Aug 2002.
[7]. Kerry Lacanette.“A Basic Introduction to filter- Active, Passive and Switched Capacto”, National Semiconductor, Application note 779,1991.

Books:

[8]. Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits, Fifth Edition, 1998.