Indian Streams Research Journal
Vol -1 , ISSUE –1, Feb - 2011
ISSN:- 2230-7850

Available online at www.lbp.world

HIGH PASS BAND GAIN THIRDORDER ACTIVE-R FILTER WITH POSITIVE FEEDBACK FOR DIFFERENT CENTER FREQUENCY f_0

P. R. Mirkute

Yeshwant Mahavidyalaya , Nanded (India)

Abstract:

A third order active-R filter with positive feedback introduced through resistance R and feed forward input signal to inverting input of third op. amp. Proposed circuit designed for center tapped positive feedback for various center frequencies F_0. The positive feedback resistor R is center taps to R_3 by keeping Q=10 and R=470Ω. The circuit gives two filter functions at distinct terminal; low pass and high pass.The response of the designed circuit shows that the high pass band gain. The circuit is useful for high value of Q. It is observed that better gain roll-off per octave for F_0=20 kHz. This circuit is suitable for 10 kHz $\leq F_0 \leq$ 70 kHz. The circuit gives better low pass and high pass response for Q=10.

Introduction:

In the literature number of filter circuits using the operational amplifier (op-amp) have been reported[1-14]. These circuits realize all-pass functions. Circuits uses a purely resistors and operational amplifiers andare called active-R filters. The advantage of active-R filter is that it operates at higher frequencies than those realized with operational amplifier assuming its gain to be infinite. Secondly it gives desired filter characteristics without external capacitors. This paper proposes design method for third order active-R filter with positive feedback and feed forward input signal configuration for different center frequencies. Proposed filter circuit gives two filter functions low pass and high pass at distinct terminals. The proposed circuit with positive feedback and feedforward input signal is studied for different center frequencies F_0 (F_0=10, 20, 50, 60 and 70, 80 100 and 200 kHz) with constant of Q=10, positive feedback resistor R=470 Ω and tapping ratio A= 0.5.

The proposed active-R filter circuit is realized using µA 741 IC and is represented by “Integrator model” [3-19]. The high frequency roll-off suggests that the op-amp can be represented by single pole model [13, 20-23].

CIRCUIT ANALYSIS AND DESIGN EQUATIONS:

The transfer function shows op. amp. as an ‘integrator’ model [8]. It is represented by single pole model and leads to complex gain.

$$A(S) = \frac{(A_0\omega_0)}{(S+\omega_0)} \qquad (1)$$

where,

A_0 = open loop d. c. gain

ω_0 =open loop 3dB bandwidth of the op. amp =2 π_{F0}

Indian Streams Research Journal
Vol -1 , ISSUE –1, Feb - 2011
ISSN:- 2230-7850

GB= $A_0\omega_0$ = gain bandwidth product of the op. amp

For S>> ω_0

$$A(S) = \frac{A_0\omega_0}{S} = \frac{GB}{S} \qquad (2)$$

The figure (1) shows the third order active-R filter circuit where the feedback resistance R_3 is tapped at the center and resistance R is connected with multiple feedback.

The transfer functions for various outputs are

$$T_{LP}(S) = \frac{-\left(\frac{1}{R_4}\right)\left(GB_1 GB_2 GB_3\right)}{S^3X_1 + S^2X_2 + SX_3 + X_4} \qquad (3)$$

$$T_{HP}(S) = \frac{\left(\frac{1}{R_4}\right)\left(S^3\right)}{S^3X_1 + S^2X_2 + SX_3 + X_4} \qquad (4)$$

where,

$$X_1 = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_4} + \frac{1}{AR_3} - \frac{(1\text{-}A)RN}{A}\right)$$

$$X_2 = \left(\frac{GB_1}{R_1}\right) + GB_3(RN) = \omega_0\left(\frac{1}{Q} + 1\right)$$

$$X_3 = \left(GB_1 GB_2\right)\left(\frac{1}{R_2} + \left[(1 - A)R_3N\right]\right) = \omega_0^2\left(\frac{1}{Q} + 1\right)$$

$$X_4 = GB_1 GB_2 GB_3(RN) = \omega_0^3$$

$$N = \frac{1}{RR_3 + (1 - A)R_3^2}$$

The circuit has been designed using coefficient-matching technique with general third order filter transfer functions [15]

$$T(S)=\frac{H_3S^3+H_2S^2+HS+H_0}{S^3+S^2\omega_0\left[\left(\frac{1}{Q}\right)+1\right]+S\omega_0^2\left[\left(\frac{1}{Q}\right)+1\right]+\omega_0^3} \quad (5)$$

We get design equations by comparing (3) and (4) with (5).

$$X_1=\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_4}+\frac{1}{AR_3}-\frac{(1-A)RN}{A}\right)=1 \quad (6)$$

$$X_2=\left(\frac{GB_1}{R_1}\right)+GB_3(RN)=\omega_0\left(\frac{1}{Q}+1\right) \quad (7)$$

$$X_3=(GB_1GB_2)\left(\frac{1}{R_2}+[(1-A)R_3N]\right)=\omega_0^2\left(\frac{1}{Q}+1\right) \quad (8)$$

$$X_4=GB_1GB_2GB_3(RN)=\omega_0^3 \quad (9)$$

Values of $R_{1,}$ R_2, R_3 and R_4; can be calculated using these equation for different values F_0 with Q = 10, R = 470Ω as shown in Table No. 1. For practical realization the value of resistance must be positive and are impedance scaled by 100.except feedback resistor R.

Experimental Observation:

The circuit was studied for different F_0 using operational amplifier μA741. The filter is designed using identical gain-bandwidth product GB of op-amp. (2), Q=10 and R= 470 Ω. The general range of these frequency responses for this active-R filter is from 10 Hz to 1 MHz as operating range of this op. amp. is 10 Hz to 1.2 MHz [22]. Following observation performed at three different terminals; low pass and high pass function for different F_0.

RESULT AND DISCUSSION:

(a) Low pass response:

Low pass responses for different values of F_0 is shown in figure (2). The observed center frequency is in good agreement with design values. For lower frequencies below 10 kHz, gain roll-off of the circuit is very high. The circuit does not studied for lower frequencies due to limitation of the op. amp. For practical realization, the resistances must be positive. Hence, there is a lower limit of F_0, if Q is assumed or vice versa.

Passband gain is high. There is decrease in passband gain as frequency is increased for F_0= 200 kHz; the passband gain is 31 dB. The response shows very large gain roll-off per octave for F_0=10, 20, 30, 50, 70, 80, 100 and 200 kHz. For F_0= 60 kHz the gain roll-off is 15 dB/octave. For F_0= 80 kHz; the gain roll-off per octave is 18.5 dB, for F_0=100 kHz the gain roll-off is 5 dB per octave. There is no overshoot anywhere in the response except for F_0=200 kHz; overshoot of 31 dB is observed at frequency 400 kHz. The circuit is suitable for 10 kHz $\le F_0 \le$ 70 kHz.

(b) High pass response:

The high pass response for different designed center frequencies F_0 is shown in figure (3). As center frequency increases, this may affects the transfer function as shown in transfer equation of high pass equation (4). The designed center frequency is disturbed and is shifted approximately by double. The passband gain is almost 0dB for the frequency F_0=10 and 20 kHz. The peak of the overshoots increases with increase in F_0. The gain roll-off per octave changes with the centre frequency. For instance F_0= 10 kHz the gain roll-off per octave is 19.5 dB, for F_0=50 kHz the gain roll-off per octave is 20 dB. For F_0= 60 kHz the gain roll-off per octave is 17.35 dB and for F_0=70 kHz the gain roll-off per octave is 9.65 dB.

The better high pass response of the circuit is for F_0= 20 kHz; with slight overshoot and gain roll-off per octave is 19.5 dB.

CONCLUSION:

A third order active-R filter with positive feedback introduced through resistance R and feed forward input signal to inverting input of third op. amp. is studied. Proposed circuit designed for center tapped positive feedback for various center frequencies F_0. The circuit gives two filter functions at distinct terminal; low pass and high pass. The response of the designed circuit shows that the high pass band gain. The circuit is useful for high value of Q. It is observed that better gain roll-off per octave for F_0=20 kHz. This circuit is suitable for10 kHz $\leq F_0 \leq$ 70 kHz. The circuit gives better low pass response for F_0=20, 50 and 60 kHz for Q=10.

The circuit may be used in instrumentation, communication, medical instruments, the digitations of telephone, entertainment electronics, etc.

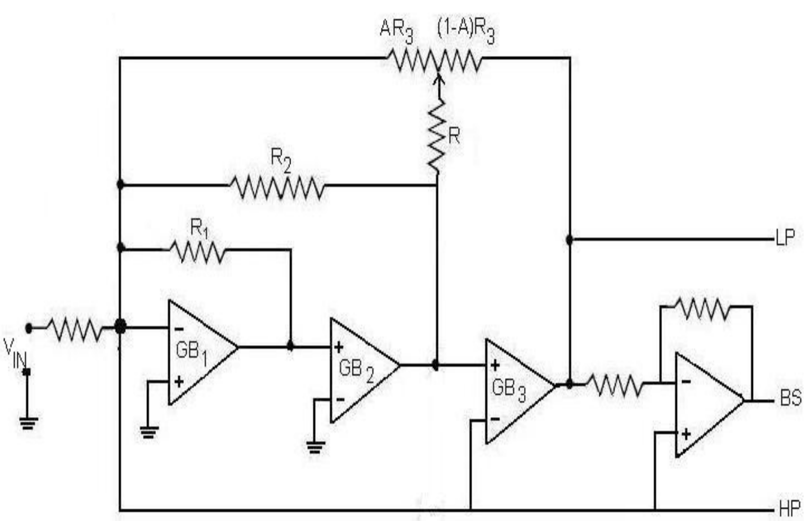

Figure 1 High pass band gain third order active-R filter with positive feedback and Feedforward input signal for different center frequency F_0.

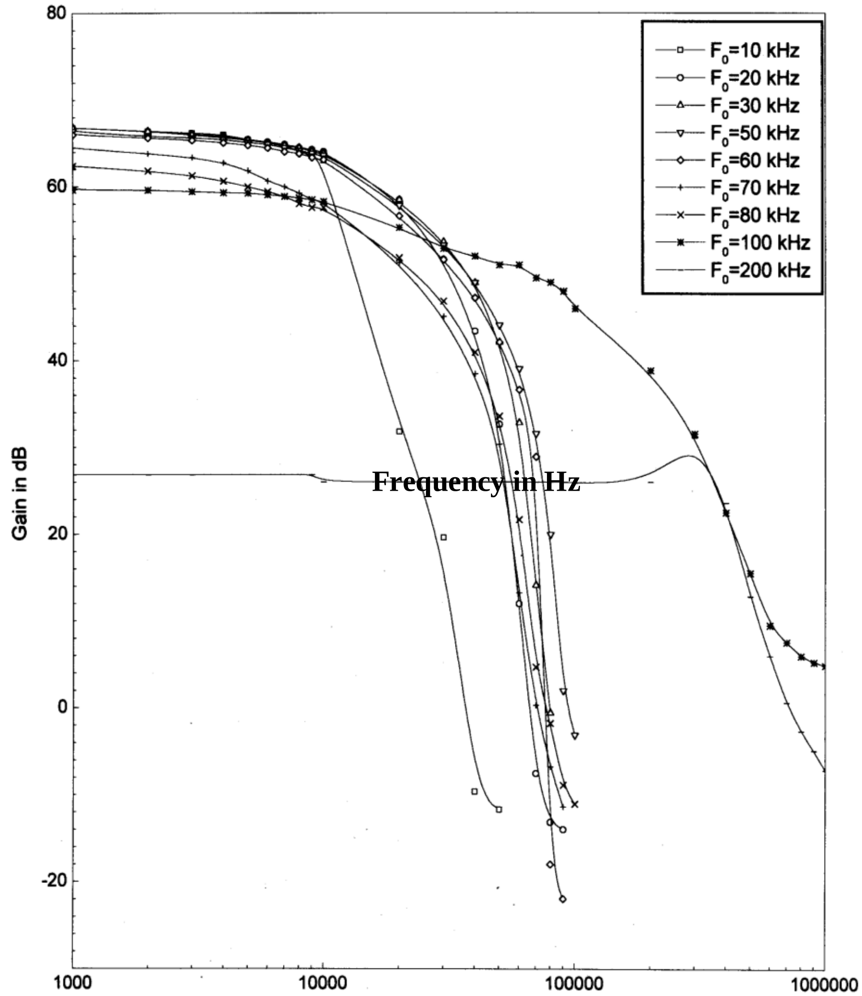

Figure 2 Third order active-R filter low pass response with positive feedback and feedforward input signal for different center frequency F_0.

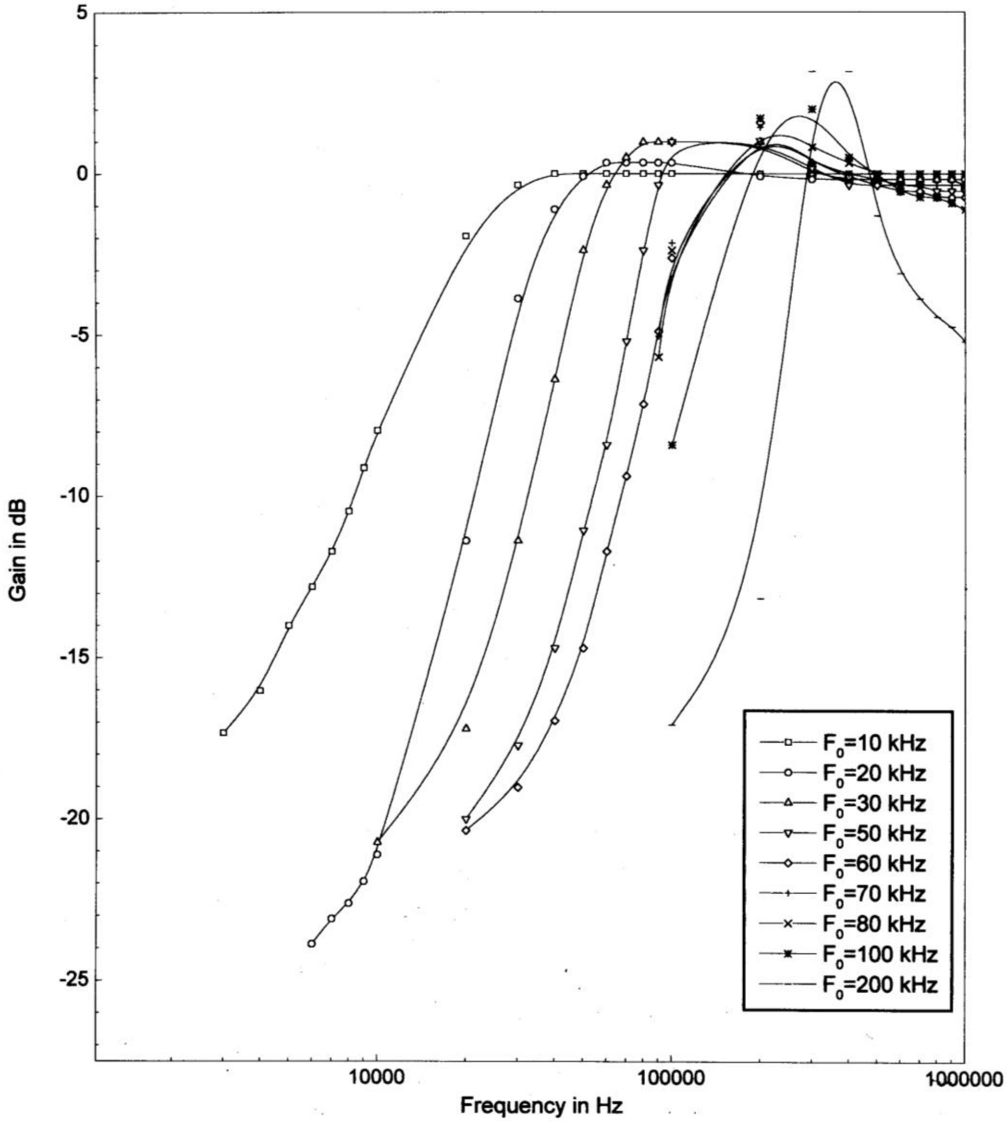

Figure 3 Third order active-R filter high pass response with positive feedback and feedforward input signal for different center frequency F_0.

Indian Streams Research Journal
Vol -1 , ISSUE –1, Feb - 2011
ISSN:- 2230-7850 Available online at www.lbp.world

F_0	Design value Ω				Experimental value Ω			
	R_1	R_2	R_3	R_4	R_1	R_2	R_3	R_4
10	5.02k	406.10k	1.725k	102	5.02k	406.10k	1.725k	102
20	2.54k	88.18 k	555.26k	104	2.54k	88.18 k	555.26k	104
30	1.701k	36.786k	134.05k	106	1.701k	36.786k	134.05k	106
50	1.02k	12.40k	93.74k	111	1.02k	12.40k	93.74k	111
60	857	8.456k	61.30k	115	857	8.4k	61.30k	115
70	737	6.128k	41.87k	118	736	6.1k	41.87k	118
80	648	4.644k	29.63k	121	648	4.6k	29.63k	120
100	524	2.932	16.17k	130	524	2.932	16.17k	130
200	214	718	2.17k	214	214	718	2.17k	214

Table No. 1 Resistance value: Design value and Experimental value.

REFERENCES:

1) M. A. Soderstand "Design of active-R filter using only resistance and operational amplifier", International Journal of Electronics. Vol. 40 (No. 5); p.417-432, 1976.
2) A. B. Kadam and A. M. Mahajan "Effect of positive feedback on the response of active-R filter", J. Instrumentation Society of India, 25 (1 and 2); 48-45, 1995.
3) N. Mohan and R. L. Patil "An analytical method for determentating Q-values of an static variable active-R filter", Indian Journal of Pure and Applied Physics, 27:824-826.
4) Radhakrishnarao K. and S. Srinivasan "Low sensitivity active filtering the operational amplifier pole", IEEE Trans. on Circuits and system, OAS-21, 2,260-262. 19:322-328, 1972.
5) G.N. Shinde, P.B Patil, A. B. Kadam and P. R. Mirkute "Active-R biquadratic filter with positive feedback and feedforward signal", BRI'S JAST 5 (I and II), p.7-15. June, Dec., 2002.
6) G.N. Shinde, P. R. Mirkute and P.D. Achole "A third order active-R filter with feedforward input signal for different center frequency F_0", Bulletin of Pure and Applied Sciences, Vol. 21 D (No.2); p.77-83, 2002.
7) Masami- Higashimra " Active-R realization of current mode high pass filter" Int. J. of Electronics (1992), Vol 73, No.6, 1279-1283.
8) S. Srinivasan "A universal compensation scheme for active filter", International Journal of Electronics. Vol. 42 (No.2); p.141-151, 1977.
9) M. A. Soderstand and S. K. Mitra "Sensitivity analyses of third order filter", International Journal of Electronics. Vol. 30 (No. 3); p.265-273, 1971.
10) G.N. Shinde, P.D. Achole and P. R. Mirkute "Second order active-R filter with multiple feedback for different Q", Indian Journal of Physics, Vol.77B (2); p.237-239, 2003.
11) S. Srinivasan "Synthesis of transfer function using the operation amplifier pole, International Journal of Electronics. Vol. 54 (No. 4); p.523-530, 1983.
12) Srinivasan S. "A universal compensation scheme for active filter", International Journal of Electronics. Vol. 42 (No.2); p.141-151, 1977.

13) R. Schumann "A note on state variable type R active", IEEE Trans. Circuits Theory, Vol-22, p39, 1975.
14) G.N. Shinde, P. B. Patil and P. R. Mirkute "A third order active-R filter with feedforward input signal", Sadhana, Vol. 28, Part 6, pp.1019-1026, December 2003.
15) Wai-Kai- Chen "Passive and Active Filters: Theory and Implementations", John Wiley and Son's, New Delhi, Second Edition.1986.
16) DaryaniGobind "Principles of Active networks Synthesis and Design", John Wiley and Son's, New Delhi, Second Edition.1976.
17) G. B. Clayton " Operational amplifiers", E. L. B. S. Publications, London, Second Edition, 1986.
18) Shinde G.N. Ph.D. Thesis entitled "Investigation of some active-R filters"; Dr. B.A. M University, Aurangabad, June, 1998.
19) A.B. William "Electronic Filter Design Handbook" Mc-Graw Hill book Compony-1981.
20) Sergio Franco "Design with op-amp and Analog Integrated Circuits" Third Edition.
21) L. P. Huelsman "Theory and Design of Active RC Circuits" Tata Mc-Graw Hill book New Delhi. 1968.
22) Budak and D.M. Petrela "Frequency limitations of active filter using operational amplifiers", IEEE Trans. Circuits Theory, 19:322-328, 1972.
23) Sun-Zhi-Xiao "Active-R filter: a new biquadratic with four terminals", International Journal of Electronics, 54 (4): 523-530 1983.