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AN ACTIVE HIGH PASS REALIZATION USING THIRD ORDER ACTIVE-R FILTER WITH MULTIPLE FEEDBACK AND FEEDFORWARD INPUT SIGNAL FOR DIFFERENT CIRCUIT MERIT FACTOR Q

P. R. Mirkute
Department of Physics , Yeshwant Mahavidyalaya,Nanded.

ABSTRACT

A realization of voltage mode trasnfer function for single output signals that is a high pass third order active-R filter with positive feedback and feed forward input signal proposed for different moderate Q. The positive feedback resistor R taps to R_3 at center. The circuit response is studied for different values of circuit merit factor Q (Q=0.1, 1, 5, 10, 50, 100, 500) with F_0 = 20 KHz, R = 470 Ω and tapping ratio A=0.5. The proposed circuit realizes a high pass filter function. In the high pass response the designed center frequency is disturbed.The proposed circuit works better response for Q=10

KEYWORDS: *Active-R circuits, Highpass filters.*

1. INTRODUCTION:

It is well known that active-R filter designs based on operational amplifiers and resistors. The filter is a device is designed to separate, pass or suppress a group of signals. These are frequency selective networks. The circuit is realized using single pole (as "integrator") behavior of an internally compensated operational amplifiers (Soderstand, 1976; Mohan & Patil, n.d.; Sun, 1983; Shinde, Achole, & Mirkute, 2003; Shinde, Mirkute, & Patil, 2003). This circuit realizing a high value of Q high pass filter is reported which is controllable through a single element.

2. PROPOSED CIRCUIT:

The proposed circuit (Fig.1) is constructed with single input, three op-amp (µA741) with identical band width product as an active element and four resistances. The negative feedback resistances R_1; R_2 and R_3 from the output of three op-amps to inverting input of the first op-amp.the resistance R_3 is tapped at center by positive feedback resistor R(=470Ω). The circuit gives a high pass function having center frequency f_0=20KHz.

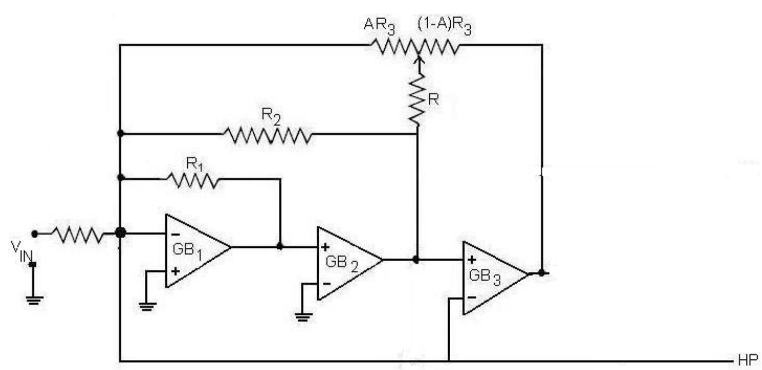

Fig.1 Third order active-R filter with multiple feedback and feedforward input signal for different circuit merit factor Q.

3. DESIGN EQUATIONS:

The transfer function shows op. amp. as an 'integrator' model [3]. It is represented by single pole model and leads to complex gain

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

where,
A_0= open loop d. c. gain
ω_0=open loop 3dB bandwidth of the op. amp =2 πF_0
GB= $A_0\omega_0$= gain bandwidth product of the op. amp
For S>>ω_0

$$A(S) = \frac{A_0\omega_0}{S+\omega_0} = \frac{\mathrm{GB}}{S} \quad (2)$$

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 feedbacks.

Transfer function for high pass filter is

$$T_{\mathrm{HP}}(S) = \frac{\left(\frac{1}{R_4}\right)(S^3)}{S^3X_1+S^2X_2+\mathrm{S}X_3+X_4} \quad (3)$$

where,

$$X_1 = \left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_4}+\frac{1}{\mathrm{AR}_3}-\frac{\text{(1-A) RN}}{A}\right)$$

$$X_2 = \left(\frac{\mathrm{GB}_1}{R_1}\right)+\mathrm{GB}_3(\mathrm{RN}) = \omega_0\left(\frac{1}{Q}+1\right)$$

$$X_3 = (\mathrm{GB}_1\mathrm{GB}_2)\left(\frac{1}{R_2}+[(1-A)R_3N]\right) = \omega_0^2\left(\frac{1}{Q}+1\right)$$

$$X_4 = \mathrm{GB}_1\mathrm{GB}_2\mathrm{GB}_3(\mathrm{RN}) = \omega_0^3$$

$$N = \frac{1}{\mathrm{RR}_3+(1-A)\,\mathrm{R}_3^2}$$

The circuit has been designed using coefficient-matching technique with general third order filter transfer functions [6].

$$T(S) = \frac{H_3S^3+H_2S^2+\mathrm{HS}+H_0}{S^3+S^2\omega_0\left[\left(\frac{1}{Q}\right)+1\right]+\mathrm{S}\omega_0^2\left[\left(\frac{1}{Q}\right)+1\right]+\omega_0^3} \quad (4)$$

we get design equation by comparing (3) and (4)

$$X_1 = \left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_4}+\frac{1}{\mathrm{AR}_3}-\frac{\text{(1-A) RN}}{A}\right) = 1 \quad (5)$$

$$X_2 = \left(\frac{\mathrm{GB}_1}{R_1}\right)+\mathrm{GB}_3(\mathrm{RN}) = \omega_0\left(\frac{1}{Q}+1\right)X_3 = (\mathrm{GB}_1\mathrm{GB}_2)\left(\frac{1}{R_2}+[(1-A)R_3N]\right) = \omega_0^2\left(\frac{1}{Q}+1\right) \quad (6)$$

$$X_4 = \mathrm{GB}_1\mathrm{GB}_2\mathrm{GB}_3(\mathrm{RN}) = \omega_0^3 \quad (7)$$

Values of R_1, R_2, R_3 and R_4 can be calculated using these equation for different values of circuit merit factor Q with F_0 =20 kHz and R= 470Ω as shown in Table 1.

Q	Designed value Ω					Experimental value Ω				
	R_1	R_2	AR_3	$(1\text{-}A)AR_3$	R_4	R_1	R_2	AR_3	$(1\text{-}A)AR_3$	R_4
0.1	254	7.26k	555.2k	555.2k	168	254	7.26k	555.2k	555.2k	168
1	1.40k	43.82k	555.2k	555.2k	107	1.40k	43.82k	555.2k	555.2k	107
5	2.33k	79.26k	555.2k	555.2k	104	2.33k	79.26k	555.2k	555.2k	104
10	2.54k	88.18k	555.2k	555.2k	104	2.54k	88.18k	555.2k	555.2k	104
50	2.74k	96.90k	555.2k	555.2k	103	2.74k	96.90k	555.2k	555.2k	103
100	2.75k	98.11k	555.2k	555.2k	103	2.75k	98.11k	555.2k	555.2k	103

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

4. RESULTS AND DISCUSSION:-

The high pass response for different circuit merit factor Q is shown in figure (2). The designed center frequency is disturbed. For Q=0.1, the gain roll-off per octave is about 5.20 dB for octave 50 kHz to 100 kHz. For octave 20 kHz to 40 kHz; the gain roll-off per octave is about 11.21 dB per octave for Q=1. For octave 60 kHz to 120 kHz; the gain roll-off per octave is about 6.25 dB per octave for Q=5. For octave 65 kHz to 130 kHz; the gain roll-off per octave is about 19.5 dB per octave for Q=10.For octave 50 kHz to 100 kHz; the gain roll-off per octave is about 10 dB per octave for Q=100. This response shows slight overshoot with better passband gain (0 dB) which is independent of Q. the overshoot is observed for Q= 5, 10, 100 and 500. For Q= 50, the ideal high pass response is observed.

The circuit shows better high pass response for Q=10.

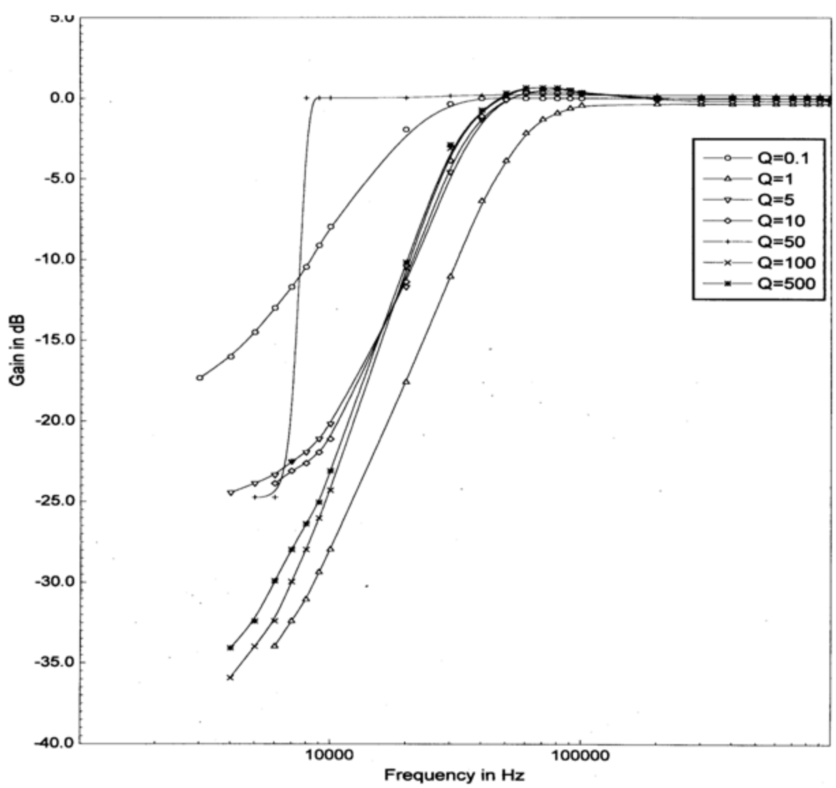

Fig.2 High pass response for different circuit merit factor Q

5. CONCLUSION:

A circuit of high pass filter having simple design. The response of the designed circuit shows that the high passband gain. Circuit designed for center tapped positive feedback for various moderate Q values. In the high pass response the designed center frequency is disturbed. The overall better circuits response shows for Q=10, as response shows better gain-roll-off and passband gain without shifting of center frequency.

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