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

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ABSTRACT
A realization of voltage mode transfer 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 \( f_0 = 20 \text{ KHz} \), \( R = 470 \Omega \) 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 (\( \mu A741 \)) 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(=470\( \Omega \)). The circuit gives a high pass function having center frequency \( f_0=20\text{KHz} \).

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

\[
A(S) = \frac{(A_0 \omega_0)}{(S + \omega_0)}
\]  

(1)
where,
\( A_0 \) = open loop d. c. gain
\( \omega_0 \) = open loop 3dB bandwidth of the op. amp = 2 \( \pi F_0 \)
\( GB = A_0 \omega_0 \) = gain bandwidth product of the op. amp

For \( S >> \omega_0 \)

\[ A(S) = \frac{A_0 \omega_0}{S + \omega_0} = \frac{GB}{S} \]  

(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

\[ T_{HP}(S) = \frac{(\frac{1}{R_3^2})(S^3)}{S^3X_1 + S^2X_2 + SX_3 + X_4} \]  

(3)

where,

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

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

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

\[ X_4 = GB_1GB_2GB_3(RN) = \omega_0^3 \]

\[ N = \frac{1}{RR_3(1-A)R_3} \]

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

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

(4)

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

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

(5)

\[ X_2 = \left( \frac{GB_1}{R_1} \right) + GB_3(RN) = \omega_0 \left( \frac{1}{Q} + 1 \right) X_3 = (GB_1GB_2) \left( \frac{1}{R_2} + [(1-A)R_3N] \right) = \omega_0^2 \left( \frac{1}{Q} + 1 \right) \]  

(6)

\[ X_4 = GB_1GB_2GB_3(RN) = \omega_0^3 \]  

(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 \( F_0 = 20 \text{ kHz} \) and \( R = 470 \Omega \) as shown in Table 1.
AN ACTIVE HIGH PASS REALIZATION USING THIRD ORDER ACTIVE-R FILTER WITH MULTIPLE

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

<table>
<thead>
<tr>
<th>Q</th>
<th>Designed value Ω</th>
<th>Experimental value Ω</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R₁</td>
<td>R₂</td>
</tr>
<tr>
<td>0.1</td>
<td>254</td>
<td>7.26k</td>
</tr>
<tr>
<td>1</td>
<td>1.40k</td>
<td>43.82k</td>
</tr>
<tr>
<td>5</td>
<td>2.33k</td>
<td>79.26k</td>
</tr>
<tr>
<td>10</td>
<td>2.54k</td>
<td>88.18k</td>
</tr>
<tr>
<td>50</td>
<td>2.74k</td>
<td>96.90k</td>
</tr>
<tr>
<td>100</td>
<td>2.75k</td>
<td>98.11k</td>
</tr>
</tbody>
</table>

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.

REFERENCES: