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BAND -PASS RESPONSE OF SECOND ORDER CURRENT-MODE FILTER FOR Q =10

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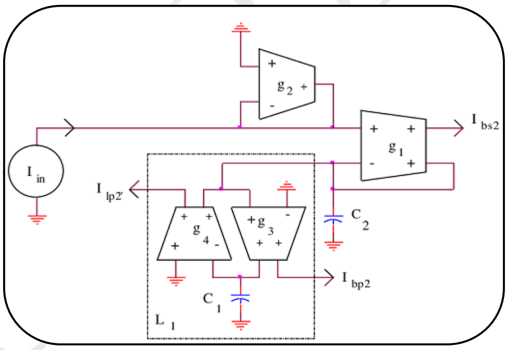
ABSTRACT

A new electronically tunable current-mode second order filter is proposed in this paper. OP-AMP is used as an active building block. With current input the transfer function derived for proposed filter circuit realizes low pass response. The other attractive features of the filter are 1) Employment of minimum active and passive elements 2) Responses are electronically tunable 3) Low active and passive sensitivities 4) Suitable for high frequency operation 5) Ideal for integrated circuit implementation 5) The circuit performance is close to ideal requirement for $5 \leq f_0 \leq 20$ *kHz.*



KEYWORDS: *Current mode filter, second order, band pass, center frequency, circuit merit factor.*

1.INTRODUCTION:

Current-mode active filters have received significant attention [1-8].They are becoming popular because of many advantages over voltage-mode filters. As compared to voltage-mode circuits, current-mode circuits can generally operate with low voltages and have higher bandwidth and slew rate[4,5].In current-mode circuits, output is controlled by input current.

The second order feed forward active-R filter is designed and realized using Operational Amplifiers. It is an internally compensated op-amp. An internally compensated Operational Amplifier is represented integrator model [6-8].The gain of such amplifier changes at the rate of 6 dB/octave (i.e.20 dB/decade). Active-R circuit contain only op-amps and resistors which makes them suitable for high frequency operation and integration with the bipolar monolithic technology [9-16].

2. PROPOSED CIRCUIT CONFIGURATION

In this circuit sinusoidal low current signal is applied at inverting terminal of first op-amp through first voltage divider arrangement (formed by g_{1a} and g_{1b}). Non-inverting terminal of first op-amp is grounded. The op-amps are coupled such that output of first op-amp is connected to non-inverting input of second op-amp through second voltage divider arrangement (formed by $g_{2a}$and g_{2b}).The feed forward is provided by connecting the input signal to the inverting terminal of second OA. The negative feedback is incorporated by by resistors g_1 and g_2 .Output of second op-amp gives band pass function.

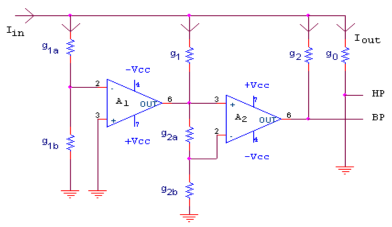


Fig 1: Circuit diagram of Second order current-mode filter

3. CIRCUIT ANALYSIS AND DESIGN EQUATIONS:

Transfer function of the circuit for band pass T_{BP} is calculated as,

$$T_{BP} = \frac{g_2\beta_1\beta_2k_1k_2S}{(g_0+g_1+g_2+g_{1b}k_1)S^2+(g_1\beta_1)k_1S+g_2\beta_1\beta_2(1-k_1)k_2} \quad (1)$$

Where,

$$k_1 = \frac{g_{1a}}{g_{1a}+g_{1b}}$$

$$k_2 = \frac{g_{2a}}{g_{2a}+g_{2b}}$$

The circuit was designed using coefficient matching technique i.e. by comparing these transfer functions with general second order transfer functions is given by,

$$T(S) = \frac{\alpha_2S^2+\alpha_1S+\alpha_0}{S^2+\frac{\omega_0}{Q}S+\omega_0^2} \quad (2)$$

Comparing equations (1) with (2), we get,

$$\frac{\omega_0}{Q} = (g_1\beta_1)k_1$$

$$\omega_0^2 = g_2\beta_1\beta_2(1-k_1)k_2$$

$$g_0 + g_1 + g_2 + g_{1b}k_1 = 1$$

But,

$$g_{1b}k_1 \ll 1$$

Therefore $g_0 + g_1 + g_2 = 1$

Using these equations, the values of g_0, g_1 and g_2 are calculated for different values of merit factor Q and frequency f_0.

4. BANDPASS RESPONSE FOR CIRCUIT MERIT FACTOR Q = 10

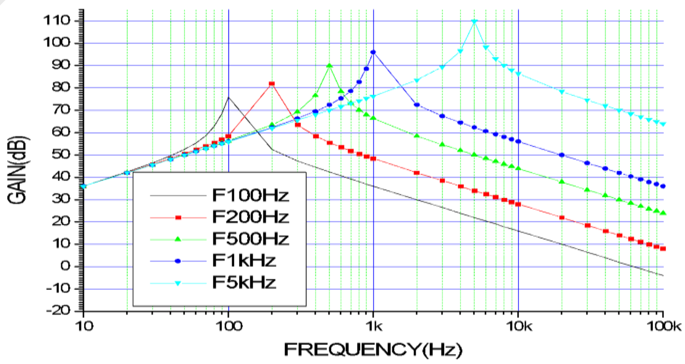


Fig 2: Band-pass response for Q =10

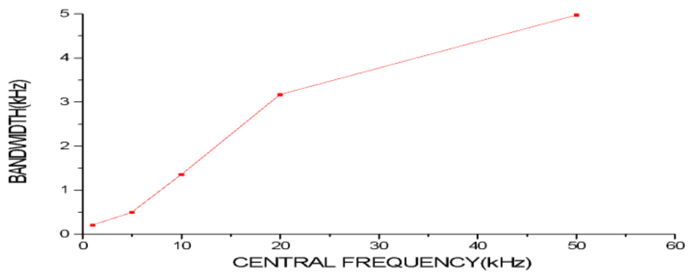


Figure 3: Variation of bandwidth with central frequency

Second Order Current-Mode Filter								
Band-pass response for Q = 10								
F_0 (Hz)	Max. Pass Band Gain (dB)	f_1 (Hz)	f_2 (Hz)	Band-width (Hz)	Gain Roll-off in stop band			
					Leading Part		Trailing Part	
					dB/Octave	Octave Starting at (Hz)	dB/Octave	Octave Starting at (Hz)
100	76	96.2	109.3	13.1	8.2	50	7.8	200
					-	-	5.8	10
200	81.9	183	213	30	7.9	100	8.5	400
					-	-	6.1	20K
500	89.9	476	522	46	13	400	10.7	700
					6.3	100	5.9	20K
1k	95.9	955	1090	135	9.1	600	8	2k
					6.3	100	6.1	20K
5k	110	4.77k	5.22k	0.45k	8.9	3k	8.1	10k
					6.0	200	6.0	30K

5. RESULT AND DISCUSSION:

The circuit performance is studied for different values of Central frequencies with circuit merit factor Q = 10. The general operating range of this filter is 10 Hz to 1MHz. The value of $\beta_1 = \beta_2 = 2\pi$ (6.392) X 10^6[rad/sec]for LF 356 N. The filter response is studied for Central frequencies f_0= 1 kHz, 5 kHz,10 kHz,20 kHz , 50 kHz and 70 kHz.

f_0(kHz)	$R_0(\Omega)$	$R_1(\Omega)$	$R_2(\Omega)$
1	1	5.2k	260k
5	1	1.3k	10.4k
10	1	633	2586
20	1	420	647
50	1	6020	103

Table (2): Resistor values for Q =10

It is found that the filter circuit responds for central frequencies $f_0 \le\le$ 5 kHz. Sharp peak is seen in each response. Peak occurs at the designed frequency in every response. The magnitude of peak gain i.e. the maximum pass band gain increases with increase in central frequency. For instance, maximum pass band gain is 76 dB for f_0 =100Hz.It is 90 dB for f_0 =500Hz and becomes 110 dB for f_0 =5000Hz.

-3 dB bandwidth for f_0 =100Hz is 13.1 Hz and for f_0 =500Hz, bandwidth of filter circuit is 46 Hz. Bandwidth has maximum value of 450 Hz for f_0 =5000Hz.this shows that this filter works excellent for very narrow bandwidth for $f_0 \leq\leq$ 5 kHz.

The pass band distribution of frequency is more symmetric for 1 kHz $\leq\leq f_0 \leq\leq$ 5 kHz. The gain roll-off per octave in leading and trailing part of response is different near pass band whereas it is almost the same away from pass band. For example, the gain roll-off per octave in leading part of curve for f_0 =500Hz is 13 dB/octave for octave starting at 400 kHz and in trailing part; it is 10 dB/octave for octave starting at 700 kHz. For f_0 =5000Hz, the gain roll-off per octave is 6 dB/octave in leading as well as trailing part at far end of stop band. As the bandwidth is narrower, the filter is more selective for $f_0 \leq \leq$1 kHz.

6. SENSITIVITIES:

Equations of the ω_0 and Q Sensitivitiesof the transfer function with respect to the parameters k_1,k_2, β_1, β_2, g_0, g_1 and g_2 are as follows.

ω_0 Sensitivities:

$$S_{K_1}^{\omega 0} = S_{K_2}^{\omega 0} = \frac{1}{2}$$

$$S_{g_0}^{\omega 0} = -\frac{1}{2}\left(\frac{g_0}{g_0+g_1+g_2}\right)$$

$$S_{g_1}^{\omega 0} = -\frac{1}{2}\left(\frac{g_1}{g_0+g_1+g_2}\right)$$

$$S_{g_2}^{\omega 0} = \frac{1}{2}\left(\frac{g_0+g_1}{g_0+g_1+g_2}\right)$$

Q Sensitivities

$$S_{K_1}^{Q} = -\frac{1}{2} \;,\; S_{K_2}^{Q} = \frac{1}{2}$$

$$S_{g_0}^{Q} = -\frac{1}{2}\left(\frac{g_0}{g_0+g_1+g_2}\right)$$

$$S_{g_1}^{Q} = -\frac{1}{2}\left(\frac{g_1}{g_1+g_2}\right) \; S_{g_2}^{Q} = \frac{(g_0+g_1)}{2(g_0+g_1+g_2)}$$

β Sensitivities:

$$S_{\beta_1}^{\omega 0} = S_{\beta_2}^{\omega 0} = \frac{1}{2}$$

$$S_{\beta_1}^{Q} = -\frac{1}{2}$$

$$S_{\beta_2}^{Q} = \frac{1}{2}$$

7. CONCLUDING REMARKS:

A realization of current-mode second order feed forward filter has been proposed. The Filter is built with two internally compensated op-amps. Low sinusoidal current is applied at the inverting terminal of first op-amp through voltage divider. The input signal is fed forward to the inverting terminal of second op-amp. Bandwidth increases from 13 Hz to 435Hz with f_0 for Q=10. The curves are symmetric about the peak which occurs at the designed central frequencies. The filter designed has low active and passive sensitivitiesless than unity.The circuit performance is close to ideal requirement for $5\leq f_0\leq 20$ kHz.

REFERENCES

1. S.K.Mitra,"Analysis and Synthesis of Linear Active Networks", New York, Wiley, 1969.
2. GovindDaryani,"Principles of Active Network Synthesis and Design", New York, Wiley, 1976.
3. Z.H.Meiskin,"Complete guide to Active filter design, Op-amps and passive components" Prentice Hall, Englewood Cliffs, New Jersey.
4. Berlin H.M.," The Design of Active filters with Experiments", Derby, CT: E and L.Instruments Inc., 1977.
5. G.N.Shinde, P.R.Mirkute and P.D.Achole," Second order active-R filter with multiple feedback for different Q", Indian J.Physics, Vol.77B (2).pp.237-239, 2003.
6. G.N.Shinde, P.R.Mirkute and P.D.Achole," A Third order active-R filter with feed forward Input signal for different Centre frequency F_0" Bulletin of Pure and Allied Sciences, Vol.21 D (No.2) pp.77-83, 2002.
7 M.A.Soderstand," Design of Active-R filter using resistance and operational amplifier" Intl.J.Electronics Vol.40 (No.5) pp.23-31, 1976
8. Budak and D.M.Petrela,"Frequency limitation of active filter using operational amplifier" IEEE Trans.Circuits Theory, 19: 322-328, 1972.
9 RadhakrishnaraoK.andS.Srinivasan,"Low sensitivity active filtering the operational Amplifier pole", IEEE Trans.Circuits and system, OAS-21, 2, 260-262, 1972.
10. "Active filter design Techniques" Chapter-16, Literature Number SLOAO88, TEXAS INSTRUMENTATION.
11 G.N. Shinde and D.D.Mulajkar," Electronically tunable current-mode second order high pass filter for cutoff frequency 50 k with variable Q", National Conference on recent trends in Physics and Laser Technology,GraminMahavidyalaya,Vasmatnagar(Maharashtra), pp.47, Aug 28-29, 2009.