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CFOA Based Filter Design Circuit a New Configuration

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Abstract: *In this paper, CFOA based filters are designed and simulated. Filters are electronic circuits typically used for conditioning. As traditional filters consist of passive elements which require larger chip area and consumes more power. Those passive elements are replaced by active component CFOA which fulfills several purposes with improved slew rate, gain bandwidth and many. The values for the passive components are calculated, and the circuits are then simulated with ICAP to reach the final conclusion which will describe the results of the simulations compared to theoretical results.* [3]

Keywords : *CFOA (Current Feedback Operational Amplifier)*

I. Introduction

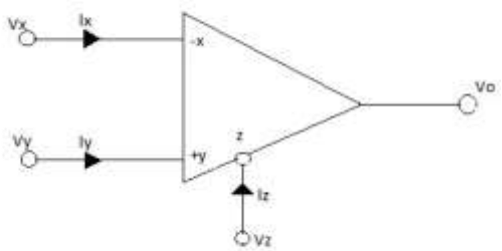
The **current feedback operational amplifier** otherwise known as CFOA is a type of electronic amplifier whose inverting input is sensitive to current, rather than to voltage as in a conventional VFA. CFA do not have the traditional differential amplifier input structure, thus they sacrifice the parameter matching inherent to that structure.

The current feedback operational amplifier (CFOA) [1] is a suitable active block for synthesis of filters for higher frequency domain. When the part with available compensation pin is mentioned, there are too many options to create some new circuits. The design based on synthesis of general filter circuits [2] is a good way to obtain acceptable results. The use of two amplifiers has an advantage, because parameters of a final circuit can be usually set independent.

The transfer function was calculate and expressed for every input-output combination. The terms which exactly match the standards of typical filters were considered as correct. Standards, namely low-pass, high-pass, and band pass are defined as follows:

$$K_{LP} = \frac{K_0 \omega_0}{D(S)} \qquad K_{HP} = \frac{K_0 S^2}{D(S)} \qquad K_{BP} = \frac{K_0 \frac{\omega_0 S}{Q}}{D(S)}$$

CFA Symbol



Terminal Equations of CFA

1. $I_y = 0$ 2. $I_x = I_z$ 3. $V_x = V_y$ 4. $V_z = V_o$

It is necessary to take into account a restriction in this field of circuit design. There are few types of mentioned CFOA with compensational pin, but just one of them is currently available for practical design. It is the amplifier AD844 [7] produced by Analog Devices with trans-impedance 3 MΩ and with relatively narrow declared gain bandwidth 60MHz. other devices, e.g. AD846 and HFA1102, are marked as obsolete.

II. General Circuit for Low Pass Filter

The new circuit with two CFOAs and four admittances was intuitively compiled. The new configured circuit diagram is given next

2.1Circuit Diagram

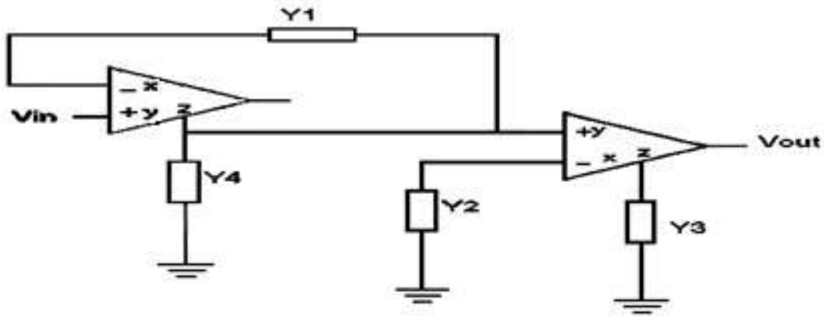


Fig. Low Pass Filter using CFOA

The calculation of characteristic equation (transfer function) is given below:

V_{in} = Input Signal

V_{o1} = Output signal Of first CFOA

V_{o2} = Output Signal of second CFOA

$(0 - V_{o1})Y_2 = (0 - V_{o2})Y_3$ (i)

$(0 - V_{o1})Y_4 + (V_{in} - V_{o1})Y_1 = (V_{o1} - V_{in})Y_1$ (ii)

$V_{o1} = 2Y1.Vin/Y_4 + 2Y_1$ (iii)

From (i) and (ii) we get

$-(2Y_1.Vin/Y_4+2Y_1)Y_2 = V_{o2}.Y_3$ (iv)

$V_{o2} = 2Y_1.Y_2.V_{in}/Y_3(Y_4+2Y_1)$ (v)

The individual admittances are defined as follows

$Y_1 = G_1$ and $Y_2 = G_2$, $Y_3 = SC_3+G_3$ and $Y_4 = SC_4$

Applying this in above equation we get,

$V_{o1}/V_{in} = 2G1.G_2 /([Sc_3+G_3][SC_4 +2G_1])$

The characteristic equation is

$\mathbf{T(s) = V_{out}/V_{in} = V_{o2}/V_{in} = 2G_1.G_2/(S^2.C_3.C_4+S(2G_1.C_3+C4.G_3)+2G_1.G_3}$

$\omega_0 = \sqrt{}(2G_1.G_3/C_3.C_4)$

$G_1=1/R_1=1/470\Omega = 2.127*10^{-3}$

$G_3 = 1/R_3=1/10^3$ $C_3 = 0.01\mu f$

$C_4 = 0.01\mu f$

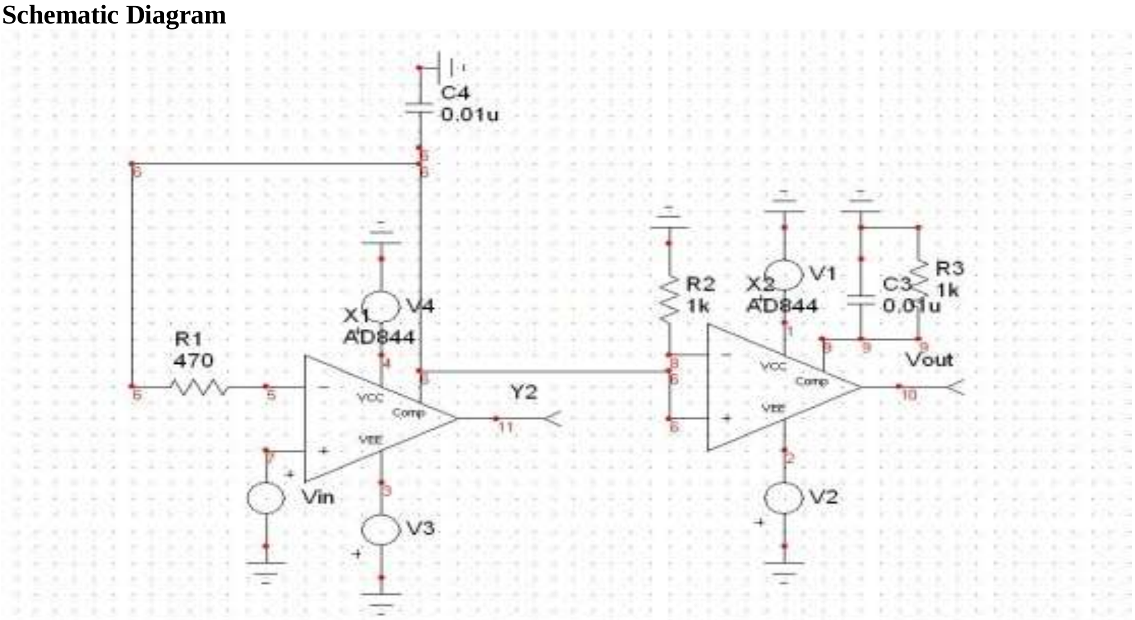
$\omega_0 = 2.062*10^5$

Cut-off frequency for the filter is calculated as

$\mathbf{f_o = \omega_o/2\pi = 32.8\ KHz}$

The result of simulation i.e. the schematic diagram and resulted waveform is given below

2.2 Schematic Diagram



III. General Circuit for High Pass Filter

The new circuit with two CFOAs and four admittances was intuitively compiled. The new configured circuit diagram is given next

3.1Circuit Diagram

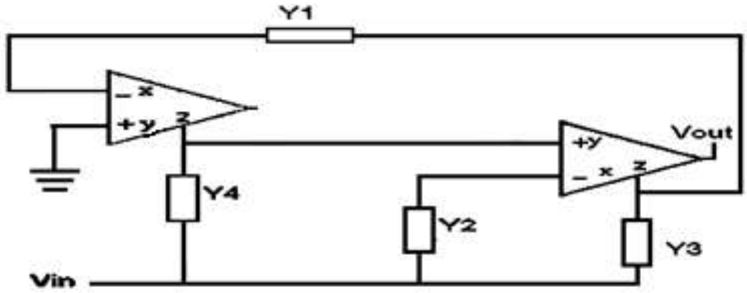


Fig. High Pass Filter using CFOA

The calculation of characteristic equation (transfer function) is given below:

V_{in} = Input Signal

V_{o1} = Output signal Of first CFOA

V_{o2} = Output Signal of second CFOA

$(V_{in} – V_{o1})Y_4 = (V_{o2} – 0)Y_1$

$(V_{in} – V_{o1})Y_4 = V_{o2}Y_1$ (i)

$(V_{in} – V_{o2})Y_3 = (V_{o2} – 0)Y_1 + (V_{in} – V_{o1})Y_2$ (ii)

$V_{o1}/V_{in} = [Y_1Y_2 + Y_4(Y_1+Y_3) – Y_1]/[Y_1Y_2+Y_4(Y_1+Y_3)]$

Now using equation (i) in eq (ii)

$(V_{in} – V_{o2})Y_3 = V_{o2}Y_1 + V_{in}Y_2 – [Y4.V_{in}-V_{o2}Y_1]Y_2/Y_4$

The characteristic equation obtained is

$\mathbf{V_{o2}/V_{in} = S^2/(S^2+SG/C_3+G_1G_2/C_3C_4)}$ (iii)

$\omega_0 = \sqrt{(G_1.G_2/C_3.C_4)}$

$G_1=1/R_1=1/470\Omega = 2.127*10^{-3}$

$G_3 = 1/R_3=1/10^3$

$C_3 = 0.01\mu f$

$C_4 = 0.01\mu f$

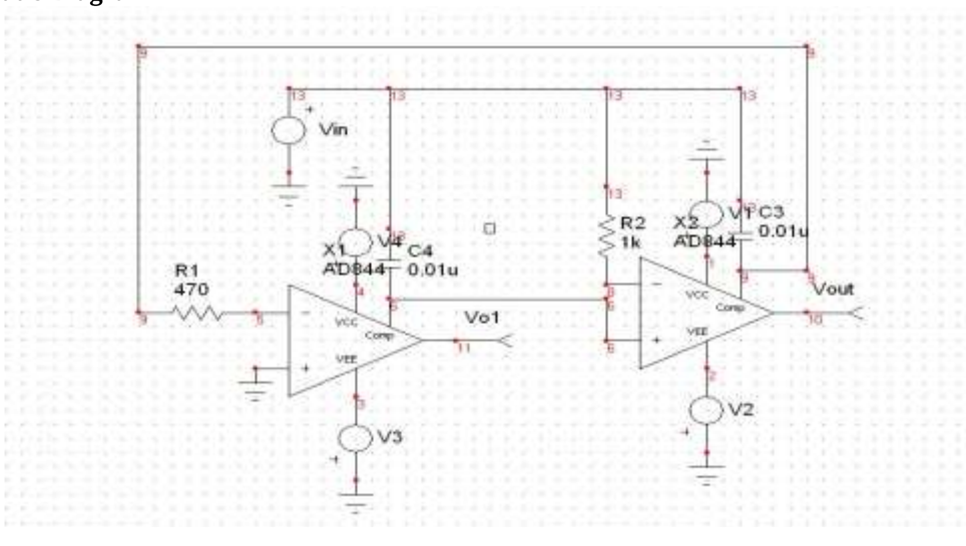
$\omega_0 = \sqrt{(2127*10^6)}$

Cut-off frequency for the filter is calculated as

$\mathbf{f_o = \omega_o/2\pi = 23.23\ KHz}$

The result of simulation i.e. the schematic diagram and resulted waveform is given below

3.2 Schematic Diagram



IV. General Circuit For Band Pass Filter

The new circuit with two CFOAs and four admittances was intuitively compiled. The new configured circuit diagram is given next

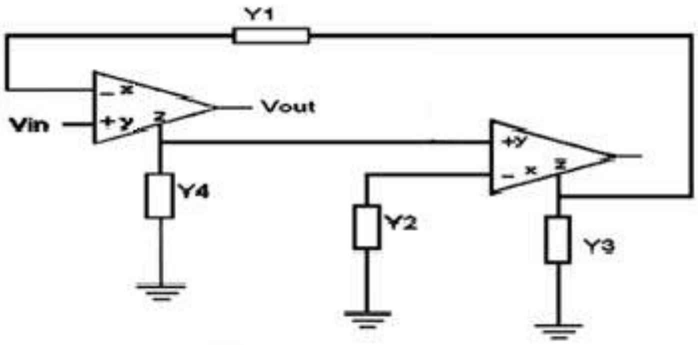


Fig. Band Pass Filter using CFOA

The calculation of characteristic equation (transfer function) is given below:

V_{in} = Input Signal

V_{o1} = Output signal of first CFOA

V_{o2} = Output Signal of second CFOA

$(0 - V_{o1})Y_4 = (V_{o2} - V_{in})Y_1$ (i)

$V_{o1} = -(V_{o2} - V_{in})Y_1/Y_4$ (ii)

$(0 - V_{o1})Y_2 + (V_{o2} - V_{in})Y_1 = (0 - V_{o2})Y_3$ (iii)

Putting V_{o1} in eq (iii)

$V_{o2} = (V_{in}Y_1 - V_{o1}Y_4)/Y_1$

Putting eq (iv) in eq (iii)

$V_{o1}Y_2 + V_{in}Y_1 = [V_{in}Y_1 - V_{o1}Y_4][Y_1+Y_3]$

The characteristic equation calculated is

$\mathbf{V_{o1}/V_{in} = Y_1Y_3/(Y_1Y_2+Y_4(Y_1+Y_3))}$

The individual admittances are as follows

$Y_4 = S.C_4$, $Y_1 = G_1$, $Y_3 = S.C_3$, $Y_2 = G_2$

$V_{o1}/V_{in} = (G_1/C_4S)/(S^2+S.G_1/C_3+G_1G_2/C_3C_4)$

$\omega_0 = \sqrt{}(G_1.G_2/C_3.C_4)$

$G_1 = 1/R_1 = 1/470\Omega = 2.127*10^{-3}$

$G_3 = 1/R_3 = 1/10^3$ $C_3 = 0.01\mu f$

$C_4 = 0.01\mu f$

$\omega_0 = \sqrt{}(2127*10^6)$

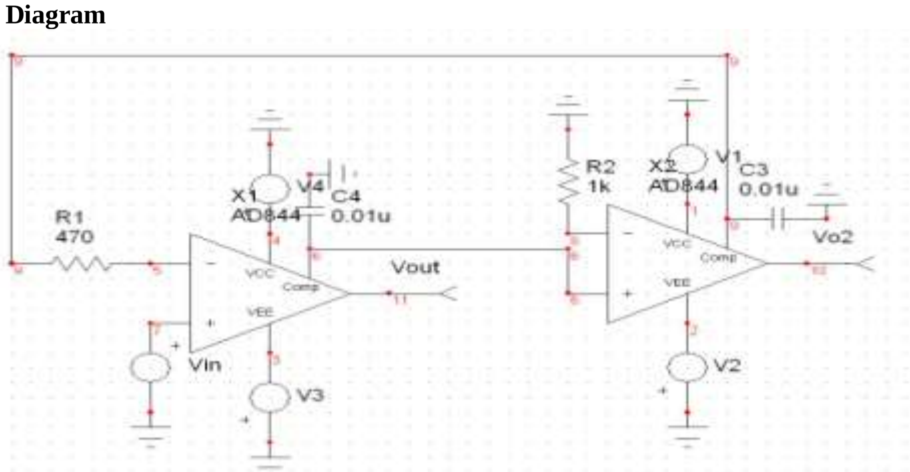
Cut-off frequency and bandwidth calculated is

$\mathbf{f_o = \omega_o/2\pi = 23.23}$ **KHz**

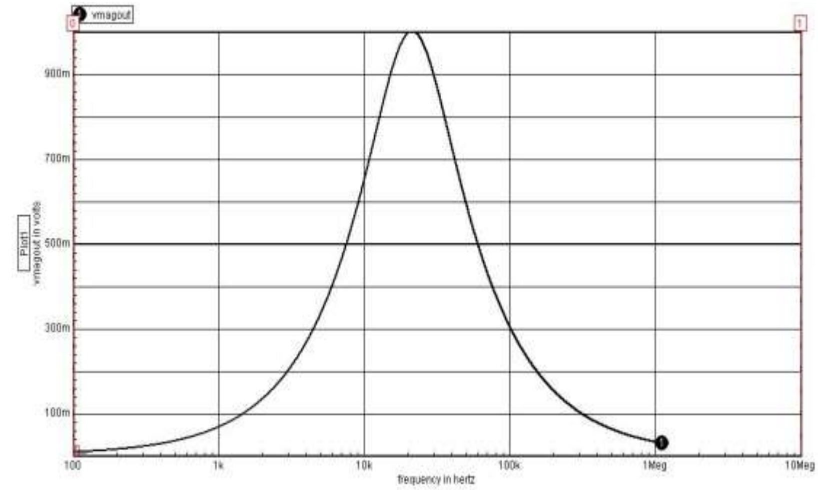
$\mathbf{Bandwidth = \omega_o/Q = G_1/C_3 = C_3.R_1}$

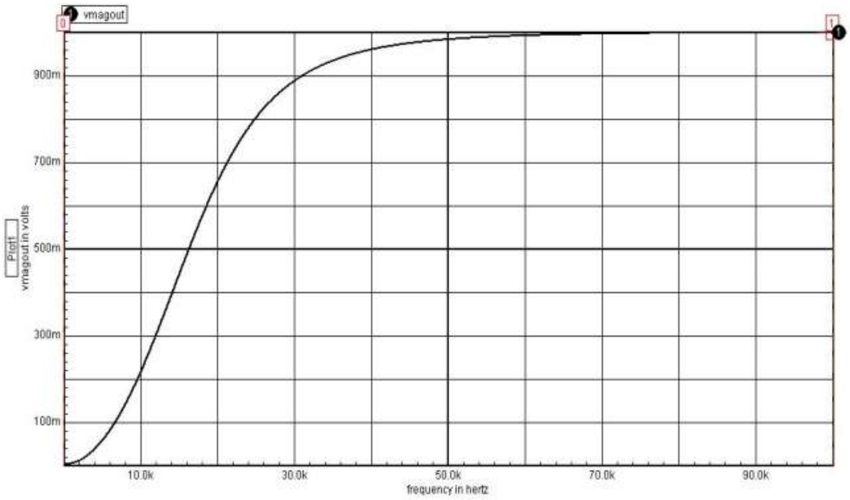
= 33.8 KHz

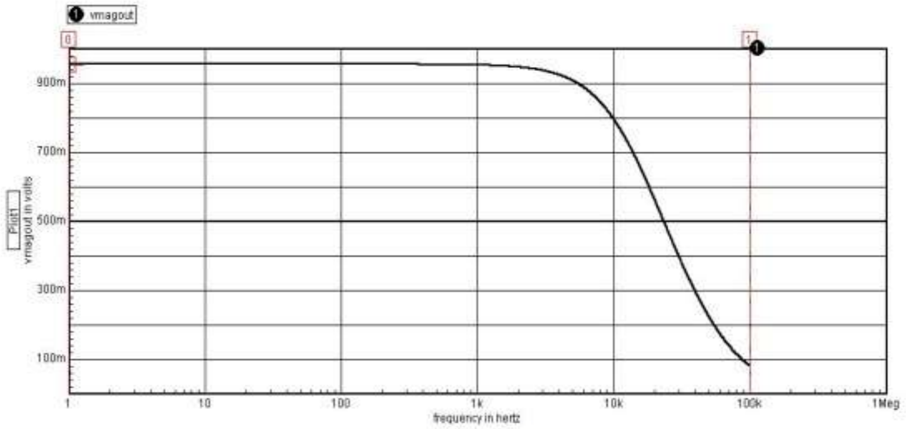
4.1 Schematic Diagram



Figures And Tables







Type of filter	**Transfer Function T(s)**
Low Pass filter	$G_2/(S^2.C_3.C_4+S(2G_1.C_3+C4.G_3)+2G_1.G_3$
High Pass Filter	$S^2/(S^2+SG/C_3+G_1G_{2/}C_3C_4)$
Band Pass Filter	$Y_1Y_3/(Y_1Y_2+Y_4(Y_1+Y_3))$

Low Pass Filter	
Practical cut-off frequency	Theoretical cut-off frequency
22.00 KHz	**32.80 KHz**
High Pass Filter	
Practical cut-off frequency	Theoretical cut-off frequency
23.00 KHz	**23.23 KHz**

Band Pass Filter		
Parameter	Practical result	Theoretical result
Centre Frequency(fo)	**25.00 KHz**	**23.23 KHz**
Bandwidth	**34.00 KHz**	**33.80 KHz**

V. Conclusion

Different circuits are implemented successfully using the CFOA. All the circuits are working properly within the Experimental error limits. Circuits implemented have many industrial applications which are discussed in following section.

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