ELE509E
Current-Mode Analog Circuit Design
Homework 2 (2.11.2009)

Design a CDBA based fourth-order low-pass filter (LP) with a cut-off frequency of 150kHz, employing the CDBA realization with the commercially available CFOA IC of Analog Devices, AD844. Use the CDBA based second order filter topology, shown in Fig.1, by cascading them for the realization of fourth-order filter, as illustrated in Fig.2.

a- Realize a current amplifier employing AD 844 to sense the related low-pass current output.

b- Specify the passive element values. Choose adequate supply voltages.

Use the macromodel of AD 844 available in SPICE library. The CDBA realization with AD844 is illustrated in Fig.3.

Using SPICE simulation program:

c- Draw the frequency responses of the second-order sections i_{out1}/i_{in}, i_{out2}/i_{out1} and the frequency response of the total filter circuit i_{out}/i_{in} (ideal and actual responses together).

Investigate the large signal response of the designed LP filter.

d- Apply a sinusoidal input current in the passband to the input and observe the total harmonic distortion THD at the output for different input levels; draw the plot of THD against i_{out}. (Connect an adequate load resistance to the output terminal).

e- investigate the dependence of the output voltage upon the load resistance R_L keeping the input level constant at a low distortion level, observe the harmonic distortion THD at the output for each load resistance value; draw the plot of V_O against R_L. The load resistance R_L is connected to the output of the current amplifier designed in (a).

f- Give a detailed evaluation of your results.

The normalized Butterworth fourth-order filter function is characterized by the following equation:

$$H(s) = \frac{1}{(s^2 + 0,765s + 1).(s^2 + 1,848s + 1)} \qquad (1)$$

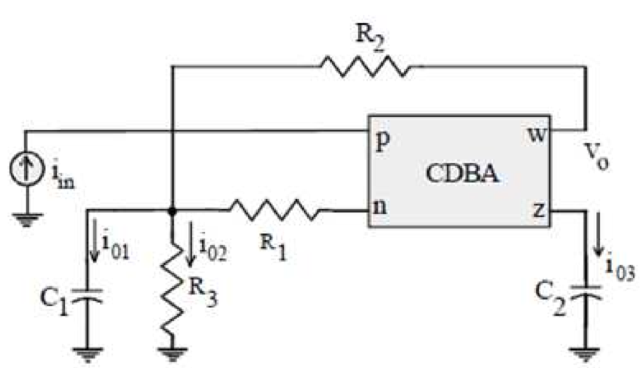

Fig.1. CDBA based second order filter topology.

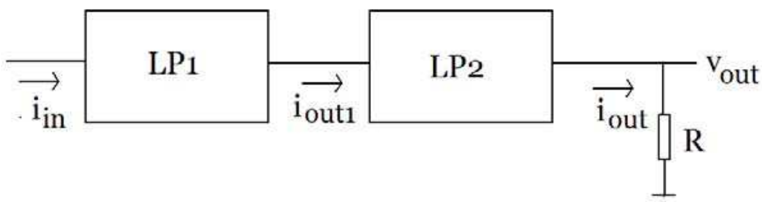

Fig.2. Fourth-order LP Filter realized by cascading two second-order filters

Filter functions realized by the circuit topology of Fig.1:

$$\frac{i_{o1}}{i_{in}} = \frac{\frac{G_2}{C_2}s}{s^2 + \frac{G_1+G_2+G_3}{C_1}s + \frac{G_1G_2}{C_1C_2}} \qquad (2)$$

$$\frac{i_{o2}}{i_{in}} = \frac{\frac{G_2G_3}{C_1C_2}}{s^2 + \frac{G_1+G_2+G_3}{C_1}s + \frac{G_1G_2}{C_1C_2}} \qquad (3)$$

$$\frac{i_{o3}}{i_{in}} = \frac{s^2 + \frac{G_1+G_2+G_3}{C_1}s}{s^2 + \frac{G_1+G_2+G_3}{C_1}s + \frac{G_1G_2}{C_1C_2}} \qquad (4)$$

where the pole frequency and the pole quality factor are defined as

$$\omega_p = \sqrt{\frac{G_1G_2}{C_1C_2}} \qquad (5)$$

$$Q_p = \frac{1}{G_1+G_2+G_3}\sqrt{\frac{G_1G_2C_1}{C_2}} \qquad (6)$$

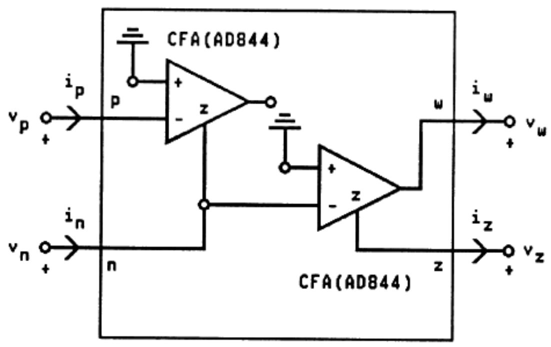

Fig.3. CDBA realization employing CFOA IC of Analog Devices, AD 844.

References:

- *C. Acar, S. Özoguz, "A new versatile building block: Current differencing buffered amplifier suitable for analog signal processing filters", Microelectronics Journal,* ***30*** *(1999), 157–160.*
- *S. Özcan, H. Kuntman and O. Çiçekoğlu, "Cascadable Current Mode Multipurpose Filters Employing Current Differencing Buffered Amplifier (CDBA)", Int. J. Electron. Commun. (AEU),* ***56*** *(2002) No. 2, 67–72.*