ELE509E
Current-Mode Analog Circuit Design
Final Project

Design a current-mode sixth-order Butterworth LP filter with a cut-off frequency of 3.5MHz. Use the CCII based filter topology illustrated in Figure 1 and the CMOS CCII circuit designed in Homework 3.

a) Choose appropriate values for the resistance and capacitance values.

Using SPICE simulation results

a) draw the frequency and phase responses of the filter, determine the actual cut-off frequency,
b) Compare the simulated frequency and phase responses with the theoretical results.
c) investigate the large signal behaviour of the filter by applying a sinusoidal input current in the passband of the filter and observing the total harmonic distortion THD at the output for different input levels; draw the plot of THD against i_{in},
d) investigate the dependence of the output voltage upon the load resistance R_L keeping the input level constant, observe the harmonic distortion THD at the output for each load resistance value; draw the plot of V_O against R_L,
e) Give a detailed evaluation of your results.

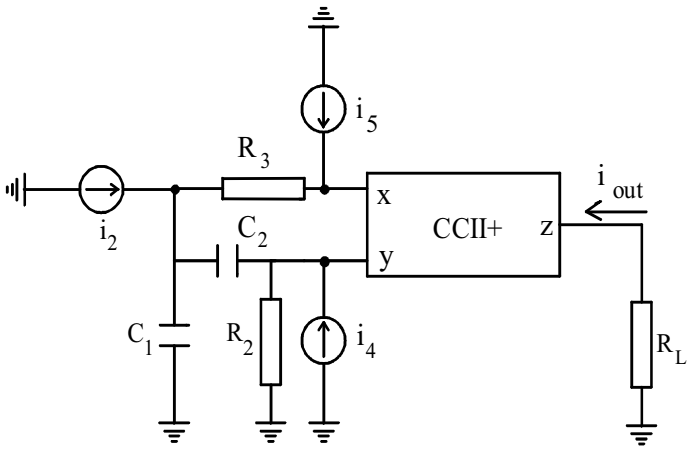

Fig. 1. CCII based filter topology

For $i_5 = i_4 = 0$

$$\frac{i_{out}}{i_2} = \frac{G_2 G_3}{s^2 C_1 C_2 + s(C_1 + C_2) G_2 + G_2 G_3}$$

For $i_2 = i_5 = 0$

$$\frac{i_{out}}{i_4} = \frac{sC_1 G_3}{s^2 C_1 C_2 + sG_2(C_1 + C_2) + G_2 G_3}$$

Providing the conditions

$$i_2 = -i_5$$
$$i_4 = i_5 \frac{G_2(C_1 + C_2)}{G_3 C_1}$$

$$\frac{i_{out}}{i_5} = \frac{s^2 C_1 C_2}{s^2 C_1 C_2 + sG_2(C_1 + C_2) + G_2 G_3}$$

The pole angular frequency and the quality factor of the filter are given by

$$\omega_o = \sqrt{\frac{G_2 G_3}{C_1 C_2}}$$
$$Q = \frac{1}{(C_1 + C_2)} \sqrt{\frac{C_1 C_2 G_3}{G_2}}$$

References:

1. S. Özcan, O. Çiçekoğlu, H. Kuntman, Multi-input single output filter with reduced number of passive elements employing single current conveyor, Computers & Electrical Engineering, Vol.29, pp.45-53, 2003.
2. S. Özcan, O. Çiçekoglu, H. Kuntman, A Novel multi-input single-output filter with reduced number of passive elements using single current conveyor, Proceedings of MWSCAS2000 (the 43rd Midwest Symposium on Circuits and Systems, Michigan, USA, 8-11 August 2000.