ELE509E
Current-Mode Analog Circuit Design
Homework 3 (26.11.2004)

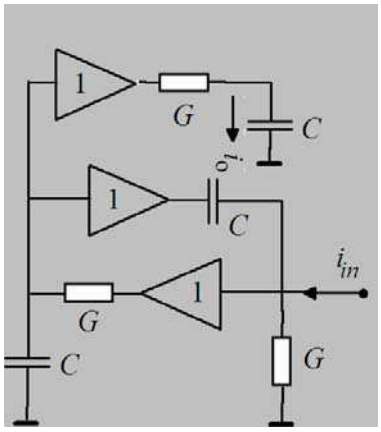

Figure 1. The third order Butterworth filter with all equal valued capacitors and resistors.

The third order Butterworth filter with all equal valued capacitors and resistors shown in Figure 1 realizes the following transfer function

$$\frac{i_0}{i_{in}} = \frac{sCG^2}{(G+sC)(G^2+sCG+s^2C^2)}$$

a- Realize the filter circuit by replacing the unity gain buffers with CCIIs and taking the output current from an adequate high-impedance terminal.

b- Choose passive element values to obtain a pole frequeny of 150 kHz.

Using SPICE simulation program

c- Draw the plot of i_o/i_{in} against frequency (ideal and actual responses together).

d- Draw the plot of i_o/i_{in} against frequency by applying RC-CR transformation (ideal and actual responses together).

Construct a 6th order band-pass filter by cascading the sections in c and d. Using SPICE simulation program

e- Draw the frequency response of the total circuit (ideal and actual responses together).

Investigate the large signal response of the total filter.

f- 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).

g- investigate the dependence of the output voltage upon the load resistance R_L keeping the input level constant at a low distortion level determined in f, observe the harmonic distortion THD at the output for each load resistance value; draw the plot of V_O against R_L.

h- Give a detailed evaluation of your results.

References

1) H. Kuntman, O. Çiçekoğlu, S. Özcan, “Third Order Betterworth Fikter For Current-Mode Operation Equal Valued Capacitors , Equal Valued Resistors And Unity Gain Active Elements”, Proceedings of the 13th International Conference on Microelectronics (ICM’2001), pp. 149-152, Rabat, Morocco, October 29-31, 2001.
2) M. Aksoy, S. Ozcan, O. Çiçekoglu and H. Kuntman," High Output Impedance Current Mode Third Order Butterworth Filter Topologies Employing Unity Gain Voltage Buffers and Equal-Valued Passive Components", International Journal of Electronics, vol. 90, No.9, pp. 589-598, 2003.

Note: For SPICE simulations use the DOCCII structure designed in Homework 2

Table 1. Transistor parameters of 0.5µm CMOS process

.MODEL NT NMOS LEVEL=3

+UO=460.5 TOX=1.0E-8 TPG=1 VTO=.62 JS=1.8E-6 XJ=.15E-6 RS=417 RSH=2.73

LD=0.04E-6 ETA=0 +VMAX=130E3 NSUB=1.71E17 PB=.761 PHI=0.905

THETA=0.129 GAMMA=0.69 KAPPA=0.1 AF=1 +WD=.11E-6 CJ=76.4E-5 MJ=0.357

CJSW=5.68E-10 MJSW=.302 CGSO=1.38E-10 CGDO=1.38E-10 +CGBO=3.45E-10

KF=3.07E-28 DELTA=0.42 NFS=1.2E11

.MODEL PT PMOS LEVEL=3

+UO=100 TOX=1E-8 TPG=1 VTO=-.58 JS=.38E-6 XJ=0.1E-6 RS=886 RSH=1.81
LD=0.03E-6 ETA=0 +VMAX=113E3 NSUB=2.08E17 PB=.911 PHI=0.905
THETA=0.120 GAMMA=0.76 KAPPA=2 AF=1 +WD=.14E-6 CJ=85E-5 MJ=0.429
CJSW=4.67E-10 MJSW=.631 CGSO=1.38E-10 CGDO=1.38E-10 +CGBO=3.45E-10
KF=1.08E-29 DELTA=0.81 NFS=0.52E11