ELE509E
Current-Mode Analog Circuit Design
Homework 4 (12.12.2003)

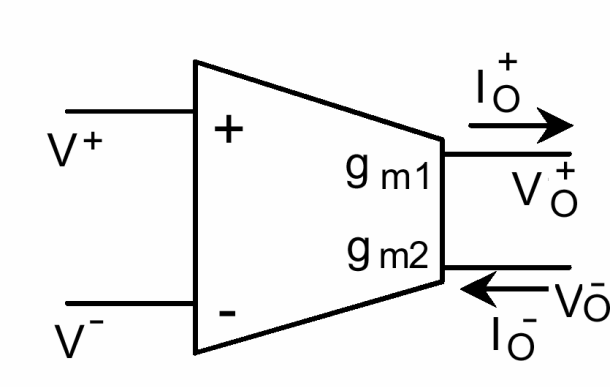

Figure 1. Circuit symbol of dual output transconductor

Design a CMOS dual output transconductor (DO-OTA) with inverting and noninverting outputs. The circuit will be operated in the frequency range of several MHz and used for analog signal processing. The circuit will provide
1. the transconductances $g_{m1} = g_{m2} = 50\mu A/V$,
2. output terminal resistances $R_{O1}, R_{O2} > 10$ M.Ohms,

The supply voltages are given as V_{DD} =2.5V, $-V_{SS}$ = -2.5V. The model parameters of the MOS transistors are given in Table 1.

a) Specify the CMOS DO-OTA structure, determine transistor dimensions.

Using SPICE simulation results

b) draw the the plots of I_O^+ and I_O^- against V_{IN} (the outputs are short-circuited to the ground, V_{IN} is defined as $V_{IN} = V^+ - V^-$),
c) specify the limits of the operation region, the limits of the output currents.
d) draw the frequency response of the transconductances and determine the bandwidth,
e) draw the the plots of V_O^+ and V_O^- against V_{IN} (the outputs are open-circuited),
f) specify the limits of the operation region, the limits of the output voltages,
g) draw the frequency response of the voltage gain and determine the bandwidth,
h) draw the plot of the terminal impedances against the frequency,
i) investigate the large signal behaviour of the DO-OTA by applying to the input a sinusoidal voltage and observing the total harmonic distortion THD at the outputs

for different input levels; draw the plot of THD against v_{in} for each output terminal. (Connect adequate load resistances to the output terminals.)

j) Investigate the dependence of the transconductances on the biasing current. Draw the plots of g_{m1} and g_{m2} against biasing current.

k) Give a detailed evaluation of your results.

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