

Lab session

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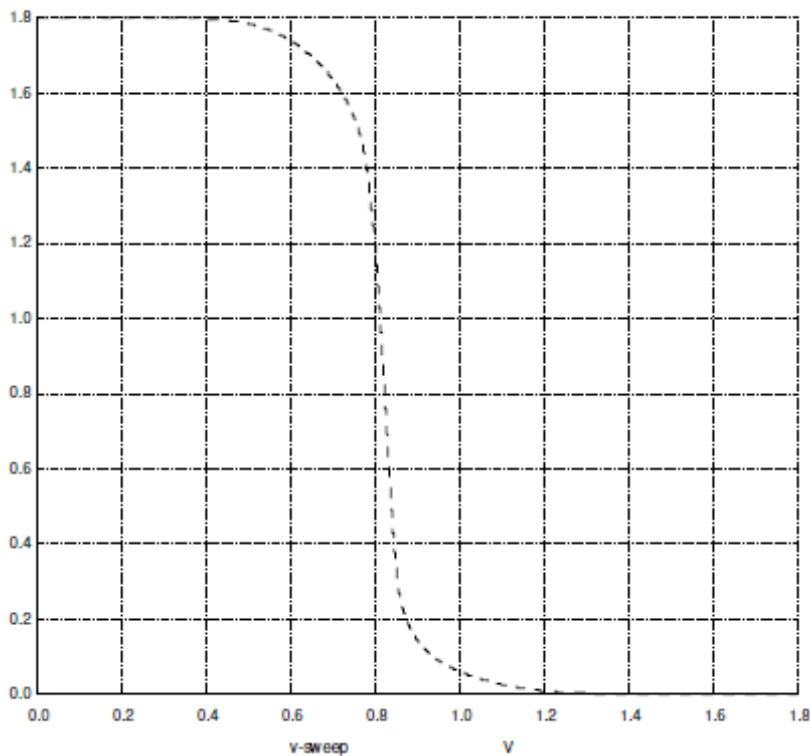
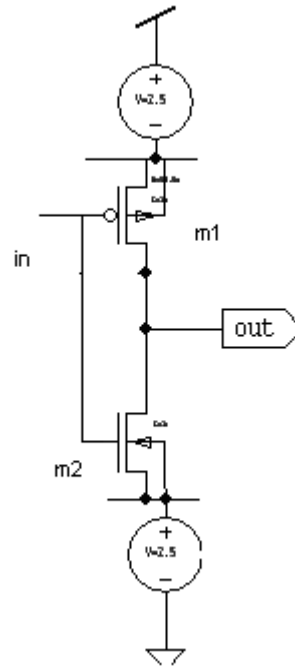
inverter charateristic

```
m1 out in vdd vdd cmosp l=.18u w=.4u
m2 out in 0 0 cmosn l=.18u w=.18u
v1 vdd 0 dc 1.8
.INCLUDE tsmc018.txt
```

inverter dc transfer charateristic

```
v2 in 0 dc 0
.dc v2 0 1.8 .0001
.control
run
print v(out)
plot v(out)
set hcopydevtype = postscript
hardcopy inv018dc_plot.ps v(out)
.endc
.end
```

V -- v(out)

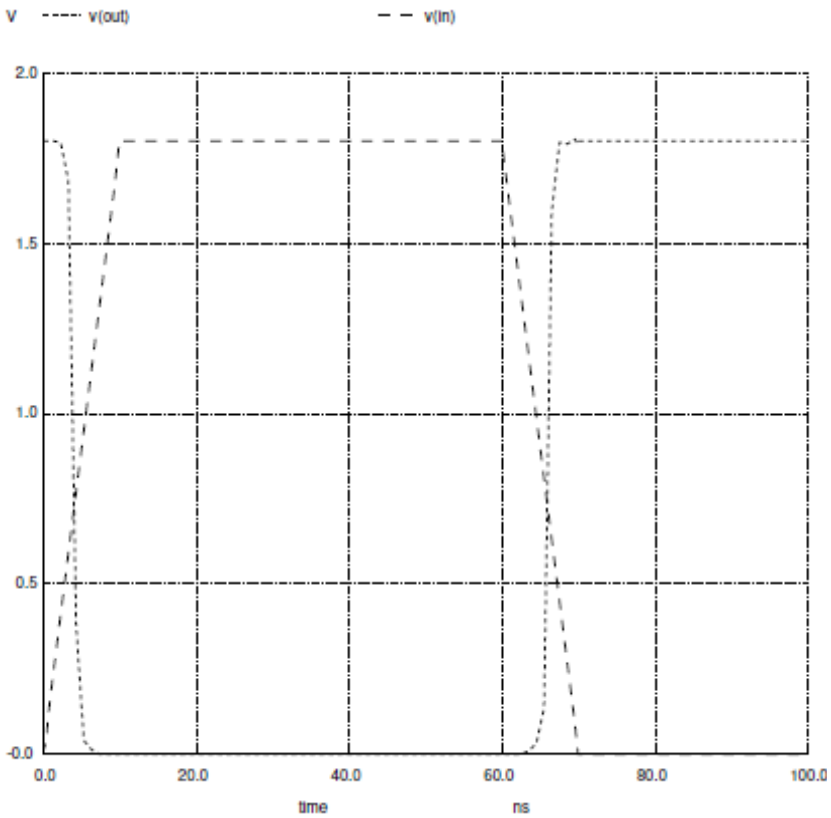


inverter delay charateristic

```

v2 in 0 pulse (0 1.8 0 10n 10n 50n 100n)
.tran 1n 100n
.control
run
print v(in) v(out)
plot v(in) v(out)
set hcopydevtype = postscript
hardcopy inv018delay_plot.ps v(in) v(out)
.endc
.end

```

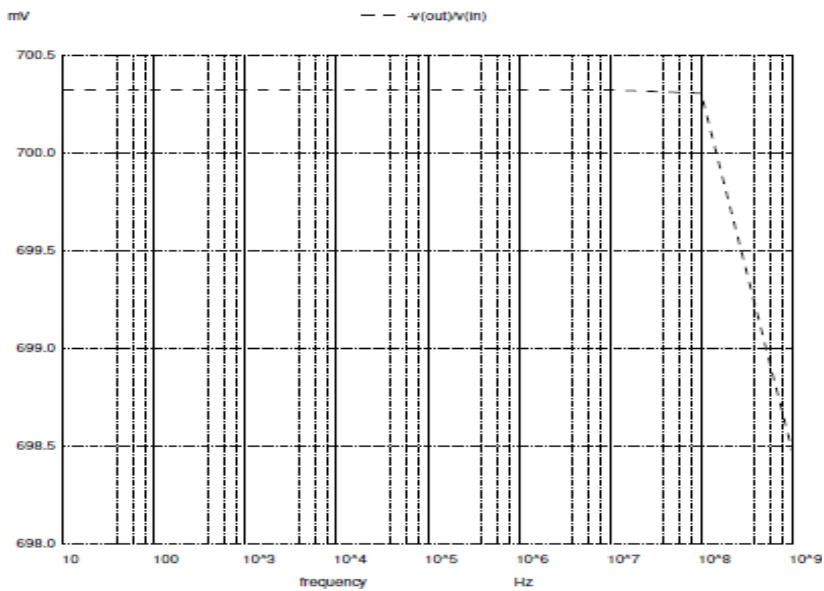


inverter ac characteristic

```

v2 in 0 dc .6 ac 1
.ac dec 1 10 1000meg
.control
run
print -v(out)/ v(in)
plot -v(out)/ v(in)
set hcopydevtype = postscript
hardcopy inv018ac_plot.ps -v(out)/v(in)
.endc
.end

```

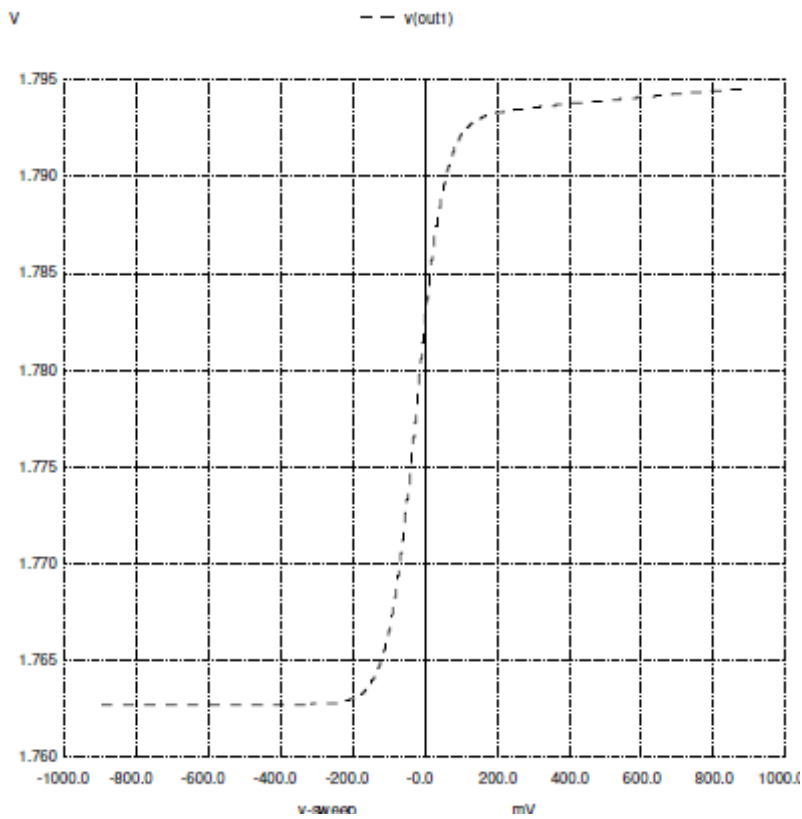


*** comparator transfer charateristic*** (Ref: Book "Cmos Analog circuit design"- Allen and Holberg)

```

m1 out vn vdd vdd cmosp l=.18u w=.4u
m2 out vbias 0 0 cmosn l=.18u w=.18u
v1 vdd 0 dc 1.8
v2 vn 0 dc 1
.INCLUDE tsmc018.txt
v3 vbias 0 dc .8
.dc v2 0 1.8 .0001
.control
run
print v(out)
plot v(out)
set hcopydevtype = postscript
hardcopy compsimple_plot.ps v(out)
.endc
.end

```

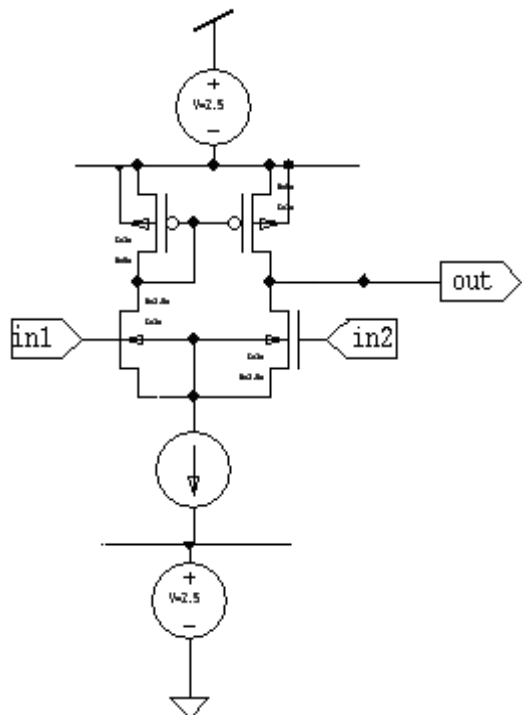


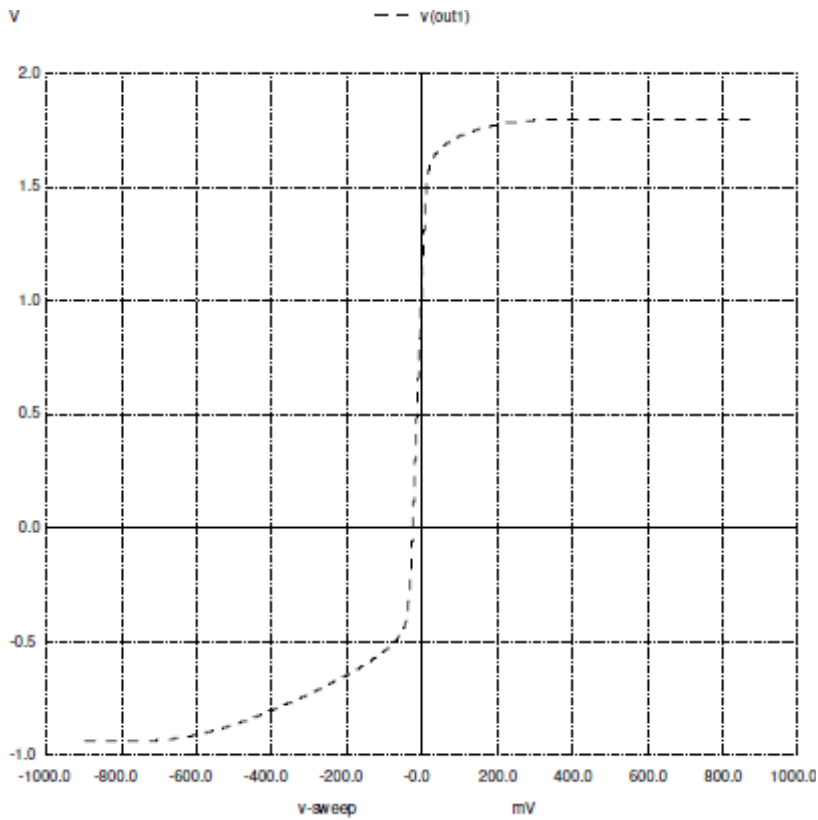
****differential comparator dc characteristic.....

```

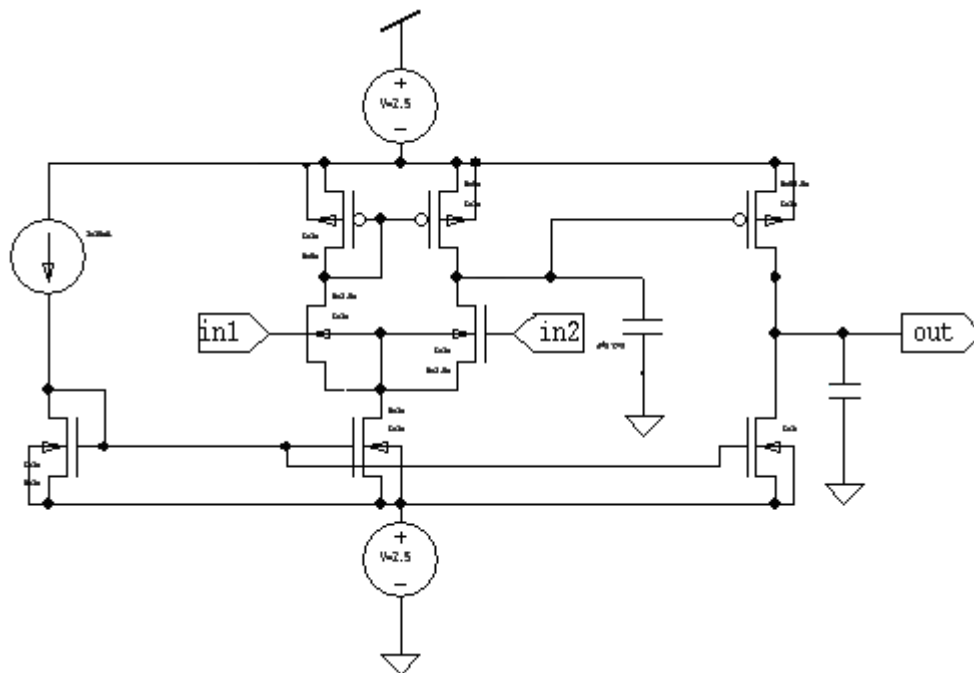
m1 out1 mpl1 vdd vdd cmosp l=.4u w=3u
m2 mpl1 mpl1 vdd vdd cmosp l=.4u w=3u
m3 mpl1 in1 mbp1 0 cmosn l=.4u w=1.5u
m4 out1 in2 mbp1 0 cmosn l=.4u w=1.5u
i1 mbp1 0 dc 45u
v1 vdd 0 dc 1.8
v2 in1 0 dc 1
v3 in2 0 dc 0
.include tsmc018.txt
.dc v2 -0.9 0.9 .0001
.control
run
print v(out1)
plot v(out1)
set hcopydevtype = postscript
hardcopy compdiff_plot.ps v(out1)
.endc
.end

```





*****two stage opamp comparator transfer characteristic. ***(Ref: Book "Cmos Analog circuit design"- Allen and Holberg)....



```

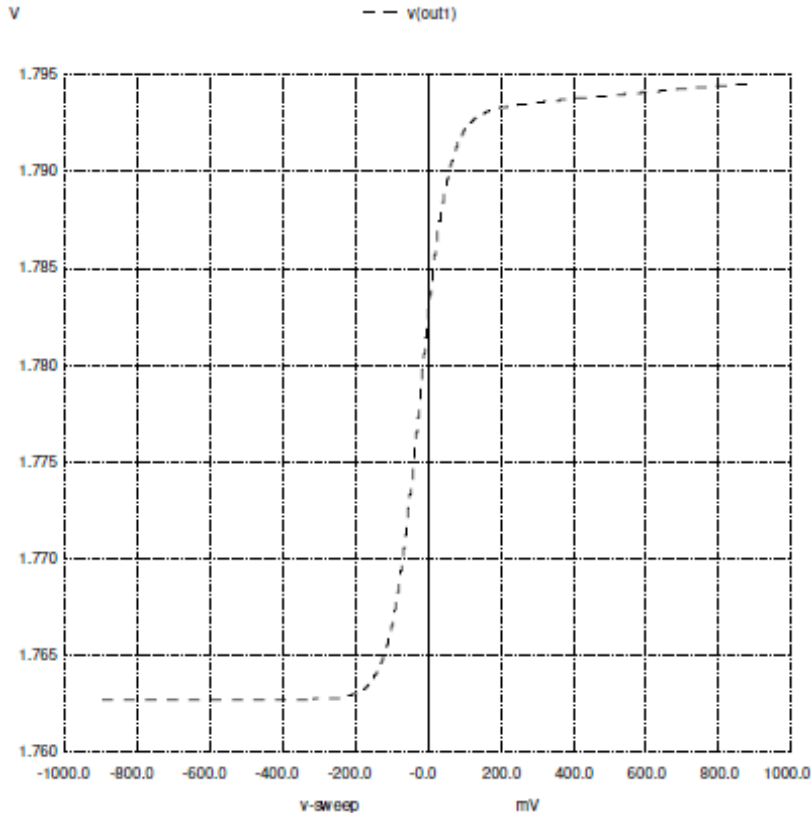
m1 out1 mpl1 vdd vdd cmosp l=.4u w=3u
m2 mpl1 mpl1 vdd vdd cmosp l=.4u w=3u
m3 mpl1 in1 mbp1 0 cmosn l=.4u w=1.5u
m4 out1 in2 mbp1 0 cmosn l=.4u w=1.5u
m5 mbp1 vb 0 0 cmosn l=1u w=0.8u
m6 out out1 vdd vdd cmosp l=0.4u w=32u
m7 out vb 0 0 cmosn l=1u w=0.8u
m8 vb vb 0 0 cmosn l=1u w=0.4u

```

```

i1 vdd vb0 dc 45u
v1 vdd 0 dc 1.8
v2 in1 0 dc 1
v3 in2 0 dc 0
.include tsmc018.txt
.dc v2 -0.9 0.9 .0001
.control
run
print v(out1)
plot v(out1)
set hcopydevtype = postscript
hardcopy compopampdc_plot.ps v(out1)
.endc
.end

```



Two stage opamp (BSIM level1)comparator propagation delay*

```

vdd 10 0 dc 5v
vss 11 0 dc -5v
vn 1 0 dc 0
vp 2 0 pulse(-1 1 0 1n 1n 500n 1u)
m1 3 1 5 5 mnmos w=20u l= 10u
m2 6 2 5 5 mnmos w=20u l=10u
m3 3 3 10 10 mpmos w=10u l=10u
m4 6 3 10 10 mpmos w=10u l=10u
m5 5 8 11 11 mnmos w=10u l=10u
m6 9 6 10 10 mpmos w=40u l=10u
m7 9 8 11 11 mnmos w=20u l=10u
m8 8 8 11 11 mnmos w=10u l=10u
c1 6 0 0 0.3p
c2 9 0 10p
is 0 8 dc 20u

.model mnmos nmos vto=1 kp=17u
+lambd=0.015 gamma=0.8 phi=0.6

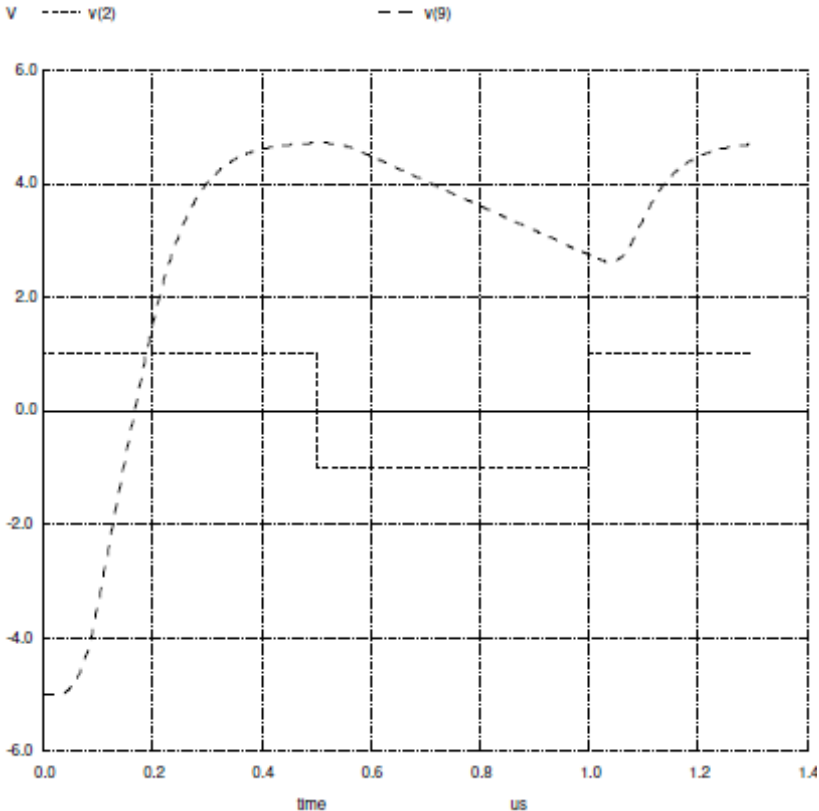
```

```

.model mpmos pmos vto=-1 kp=8u
+lambda=0.02 gamma=0.4 phi=0.6

.tran 2n 1300n
.control
run
print v(9) v(2)
plot v(9) v(2)
plot v(2)
set hcopydevtype = postscript
hardcopy holbergcomptran.ps v(9) v(2)
.endc
.end

```



***** opamp hp05 comparator transient analysis*****

```

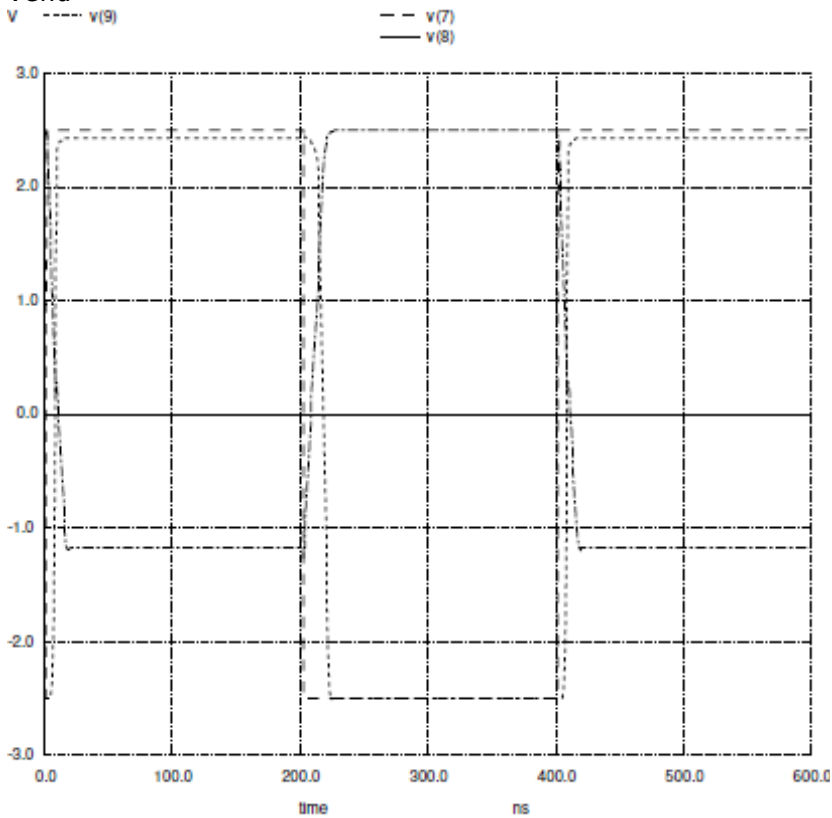
m1 3 3 1 1 cmosp l=1u w=4.5u
m2 8 3 1 1 cmosp l=1u w=4.5u
m3 3 5 6 2 cmosn l=1u w=3u
m4 8 7 6 2 cmosn l=1u w=3u
m5 6 10 2 2 cmosn l=1u w=4.5u
m6 9 8 1 1 cmosp l=1u w=38u
m7 9 10 2 2 cmosn l=1u w=35u
m8 10 10 2 2 cmosn l=1u w=4.5u
i1 1 10 dc 30u
v1 5 0 dc 0
vdd 1 0 dc 2.5
vss 0 2 dc 2.5
v2 7 0 pulse(-2.5 2.5 1n 1n 1n 200n 400n )
c1 9 0 .4p
c2 8 0 0.01p
.include HP05.txt
.tran 1n 600n
.control

```

```

run
print v(7) v(9) v(8)
plot v(7) v(9) v(8)
set hcopydevtype = postscript
hardcopy hp05compopamprancs_plot.ps v(7) v(9) v(8)
.endc
.end

```



***** opamp comparator tsmc018 transient characteristic*****

```

m1 3 3 1 1 cmosp l=0.4u w=1u
m2 8 3 1 1 cmosp l=0.4u w=1u
m3 3 5 6 2 cmosn l=0.4u w=3u
m4 8 7 6 2 cmosn l=0.4u w=3u
m5 6 10 2 2 cmosn l=1u w=0.8u
m6 9 8 1 1 cmosp l=0.4u w=32u
m7 9 10 2 2 cmosn l=0.4u w=2.7u
m8 10 10 2 2 cmosn l=1u w=0.4u
i1 1 10 dc 45u
v1 5 0 dc 0
vdd 1 0 dc 0.9
vss 0 2 dc 0.9
v2 7 0 pulse(-0.9 0.9 1n 1n 1n 200n 400n )
c1 9 0 2p
c2 8 9 .3p
.include tsmc018.txt
.tran 1n 400n
.control
run
print v(7) v(9)
plot v(7) v(9) v(8)
plot v(7)
plot v(9)
plot v(8)

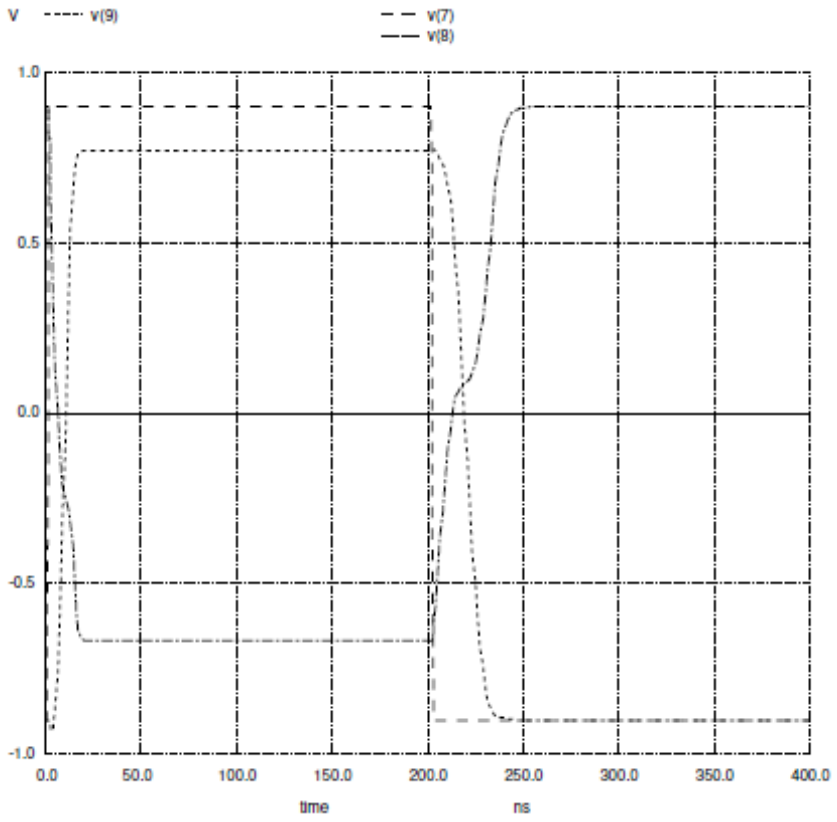
```



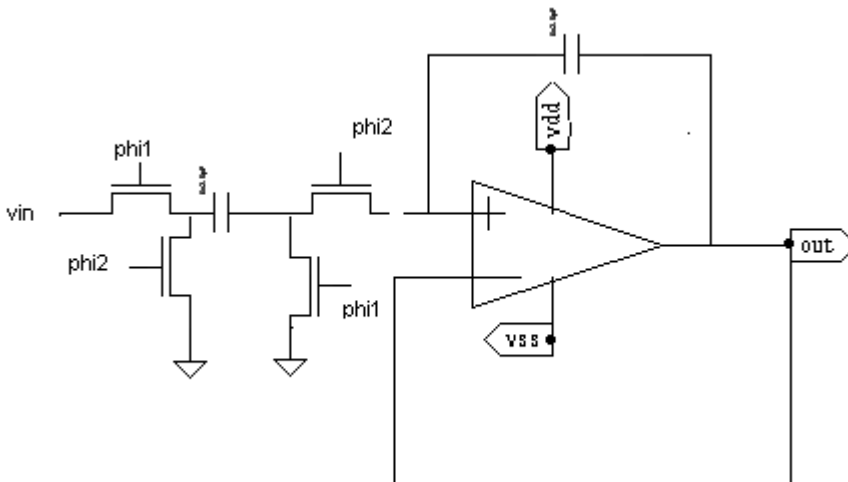
```

set hcopydevtype = postscript
hardcopy compopamptran_plot.ps v(7) v(9) v(8)
hardcopy compopamptran_plotv7.ps v(7)
hardcopy compopamptran_plotv8.ps v(8)
hardcopy compopamptran_plotv9.ps v(9)
.endc
.end

```



***** scf integrator***** (Ref: "CMOS mixed signal Design and layout" –Baker, lee)

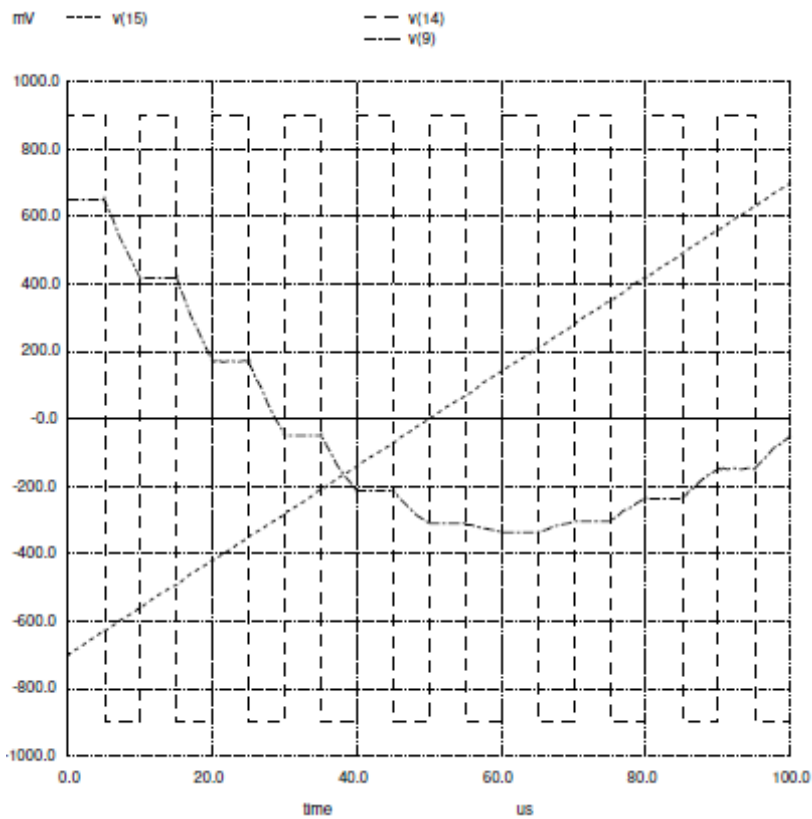


```

m1 3 3 1 1 cmosp l=0.4u w=1u
m2 8 3 1 1 cmosp l=0.4u w=1u
m3 3 5 6 0 cmosn l=0.4u w=3u
m4 8 7 6 0 cmosn l=0.4u w=3u
m5 6 10 2 0 cmosn l=1u w=0.8u
m6 9 8 1 1 cmosp l=0.4u w=32u
m7 9 10 2 0 cmosn l=0.4u w=2.7u

```

```
m8 10 10 2 0 cmosn l=1u w=0.4u
m9 5 11 12 0 cmosn l=0.18u w=0.18u
m10 12 14 0 0 cmosn l=0.18u w=0.18u
m11 13 14 15 0 cmosn l=0.18u w=0.18u
m12 13 11 0 0 cmosn l=0.18u w=0.18u
i1 1 10 dc 45u
v1 7 0 dc 0
vdd 1 0 dc 0.9
vss 0 2 dc 0.9
v3 11 0 pulse(0.9 -0.9 1n 1n 1n 5u 10u )
v4 14 0 pulse(-0.9 0.9 1n 1n 1n 5u 10u )
v2 15 0 pulse(-0.7 .7 1n 100u 20u 200u )
c1 9 0 2p
c2 8 9 .3p
c3 5 9 500p
c4 12 13 1n
.include tsmc018.txt
.tran 1u 100u
.control
run
print v(15)
print v(11)
print v(14)
print v(13)
print v(9)
plot v(14) v(15) v(9)
plot v(15)
plot v(11)
plot v(14)
plot v(13)
plot v(9)
set hcopydevtype = postscript
hardcopy scf_plot.ps v(14) v(15) v(9)
hardcopy scf_plot14.ps v(14)
hardcopy scf_plot15.ps v(15)
hardcopy scf_plot9.ps v(9)
hardcopy scf_plot11.ps v(11)
hardcopy scf_plot13.ps v(13)
.endc
.end
```

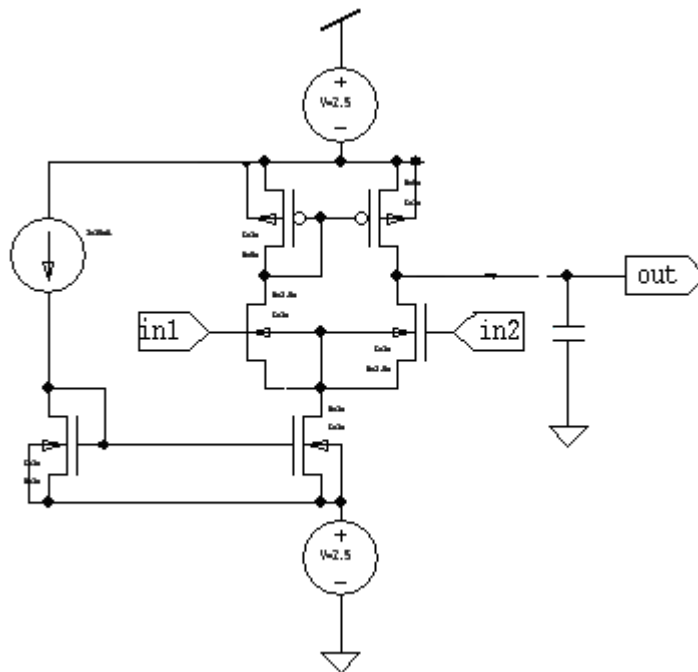


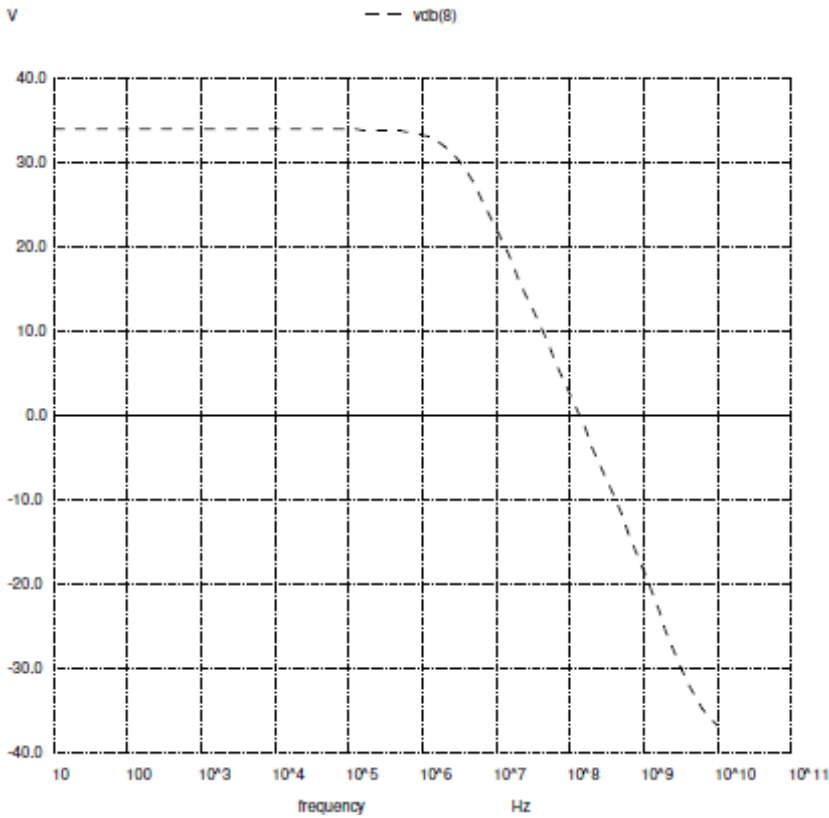
***** gmcf****Ref : "CMOS analog design"-Razavi

```

m1 3 3 1 1 cosp l=0.4u w=1u
m2 8 3 1 1 cosp l=0.4u w=1u
m3 3 5 6 2 cmosn l=0.4u w=3u
m4 8 7 6 2 cmosn l=0.4u w=3u
m5 6 10 2 2 cmosn l=1u w=0.8u
m8 10 10 2 2 cmosn l=1u w=0.4u
i1 1 10 dc 45u
v1 5 0 dc 0
vdd 1 0 dc 0.9
vss 0 2 dc 0.9
v2 7 0 dc 0 ac 1
c2 8 0 .3p
.include tsmc018.txt
.ac dec 10 10 100meg
.control
run
print vdb(8)
plot vdb(8)
set hcopydevtype = postscript
hardcopy gmcfac_plot.ps vdb(8)
.endc
.end

```





***** gmcf1, gmcf2, gmcf3..*****

vary current.

*****use HP05.txt & TSMC018.txt*****

*****TSMC018.txt*****

```
.MODEL CMOSN NMOS (
+VERSION = 3.1          TNOM = 27          TOX = 4.1E-9
+XJ = 1E-7            NCH = 2.3549E17      VTH0 = 0.3823463
+K1 = 0.5810697       K2 = 4.774618E-3      K3 = 0.0431669
+K3B = 1.1498346      W0 = 1E-7          NLX = 1.910552E-7
+DVT0W = 0            DVT1W = 0          DVT2W = 0
+DVT0 = 1.2894824     DVT1 = 0.3622063   DVT2 = 0.0713729
+U0 = 280.633249      UA = -1.208537E-9  UB = 2.158625E-18
+UC = 5.342807E-11   VSAT = 9.366802E4  A0 = 1.7593146
+AGS = 0.3939741     B0 = -6.413949E-9  B1 = -1E-7
+KETA = -5.180424E-4  A1 = 0              A2 = 1
+RDSW = 105.5517558  PRWG = 0.5         PRWB = -0.1998871
+WR = 1              WINT = 57.904732E-10 LINT = 1.571424E-8
+DWG = 1.297221E-9   VOFF = -0.0955434  NFACTOR = 2.4358891
+DWB = 1.479041E-9   CDSC = 2.4E-4      CDSCD = 0
+CIT = 0              ETA0 = 3.104851E-3  ETAB = -2.512384E-5
+CDSCB = 0           PCLM = 0.8073191   PDIBLC1 = 0.1666161
+DSUB = 0.0167075    PDIBLCB = -0.1     DROUT = 0.7875618
+PDIBLC2 = 3.112892E-3 PSCBE2 = 9.213635E-10 PVAG = 3.85243E-3
+PSCBE1 = 8E10       RSH = 6.7          MOBMOD = 1
+DELTA = 0.01        UTE = -1.5         KT1 = -0.11
+PRT = 0             KT2 = 0.022        UA1 = 4.31E-9
+KT1L = 0           UC1 = -5.6E-11     AT = 3.3E4
+UB1 = -7.61E-18     WLN = 1            WW = 0
+WL = 0              WWL = 0            LL = 0
+WWN = 1             LW = 0             LWN = 1
+LLN = 1             CAPMOD = 2         XPART = 0.5
+LWL = 0             CGS0 = 7.08E-10   CGB0 = 1E-12
+CGDO = 7.08E-10     PB = 0.8           MJ = 0.3864502
+CJ = 9.68858E-4     PBSW = 0.809286   MJSW = 0.1060414
+CJSW = 2.512138E-10
```

```
+CJSWG = 3.3E-10      PBSWG = 0.809286      MJSWG = 0.1060414
+CF     = 0           PVTH0  = -1.192722E-3   PRDSW  = -5
+PK2    = 6.450505E-5 WKETA  = -4.27294E-4    LKETA  = -0.0104078
+PU0    = 6.3268729  PUA    = 2.226552E-11  PUB    = 0
+PVSAT  = 969.1480157 PETA0  = 1E-4        PKETA  = -1.049509E-3 )
*
```

```
.MODEL CMOS PMOS (
+VERSION = 3.1          TNOM    = 27          LEVEL  = 8
+XJ      = 1E-7        NCH    = 4.1589E17   TOX    = 4.1E-9
+K1      = 0.5479015   K2     = 0.0360586   VTH0   = -0.3823463
+K3B     = 5.7086622   W0     = 1E-6        K3     = 0.0993095
+DVT0W   = 0          DVT1W  = 0          NLX    = 1.313191E-7
+DVT0    = 0.4911363  DVT1   = 0.2227356  DVT2W  = 0
+U0      = 115.6852975 UA     = 1.505832E-9  DVT2   = 0.1
+UC      = -1E-10     VSAT   = 1.329694E5  UB     = 1E-21
+AGS     = 0.3641621  B0     = 3.427126E-7  A0     = 1.7590478
+KETA    = 0.0134667  A1     = 0.6859506   B1     = 1.062928E-6
+RDSW   = 168.5705677 PRWG   = 0.5        A2     = 0.3506788
+WR      = 1          WINT   = 0.5E-8     PRWB   = -0.4987371
+DWG     = -2.349633E-8 VOFF   = -0.0994037  LINT   = 3.028832E-8
+DWB     = -7.152486E-9 CDSC   = 2.4E-4       NFACTOR = 1.9424315
+CIT     = 0          CDSCD  = 0          CDSCD  = 0
+CDSCB   = 0          ETA0   = 0.0608072   ETAB   = -0.0426148
+DSUB    = 0.7343015 PCLM   = 3.2579974   PDIBLC1 = 7.229527E-6
+PDIBLC2 = 0.025389  PDIBLCB = -1E-3       DROUT  = 0
+PSCBE1  = 1.454878E10 PSCBE2 = 4.202027E-9  PVAG   = 15
+DELTA   = 0.01      RSH    = 7.8        MOBMOD = 1
+PRT     = 0          UTE    = -1.5       KT1    = -0.11
+KT1L    = 0          KT2    = 0.022      UA1    = 4.31E-9
+UB1     = -7.61E-18 UC1     = -5.6E-11   AT     = 3.3E4
+WL      = 0          WLN    = 1         WW     = 0
+WWN     = 1          WWL    = 0         LL     = 0
+LLN     = 1          LW     = 0         LWN    = 1
+LWL     = 0          CAPMOD = 2         XPART  = 0.5
+CGDO    = 6.32E-10  CGSO   = 6.32E-10   CGB0   = 1E-12
+CJ      = 1.172138E-3 PB      = 0.8421173  MJ     = 0.4109788
+CJSW    = 2.242609E-10 PBSW   = 0.8        MJSW   = 0.3752089
+CJSWG   = 4.22E-10  PBSWG  = 0.8        MJSWG  = 0.3752089
+CF      = 0          PVTH0  = 1.888482E-3  PRDSW  = 11.5315407
+PK2     = 1.559399E-3 WKETA  = 0.0319301   LKETA  = 2.955547E-3
+PU0     = -1.1105313 PUA    = -4.62102E-11  PUB    = 1E-21
+PVSAT   = 50        PETA0  = 1E-4        PKETA  = -4.346368E-3 )
*****HP05.txt*****
```

```
.MODEL cmosn NMOS LEVEL=3 PHI=0.700000 TOX=9.6000E-09 XJ=0.200000U
+TPG=1 VTO=0.7118 DELTA=2.3060E-01 LD=2.9830E-08 KP=1.820147E-04
+UO=506.0 THETA=1.90900E-01 RSH=1.8940E+01 GAMMA=0.6051
+NSUB=1.4270E+17 NFS=7.1500E+11 VMAX=2.4960E+05 ETA=2.5510E-02
+KAPPA=1.8530E-01 CGDO=9.0000E-11 CGSO=9.0000E-11 CGB0=3.7295E-10
+CJ=6.02E-04 MJ=0.805 CJSW=2.00E-11 MJSW=0.761 PB=0.99
* Weff = Wdrawn - Delta_W * The suggested Delta_W is 4.1080E-07
.MODEL cmosp PMOS LEVEL=3 PHI=0.700000 TOX=9.6000E-09 XJ=0.200000U
+TPG=-1 VTO=-0.9016 DELTA=4.2020E-01 LD=4.3860E-08 KP=4.1582E-05
+UO=115.6 THETA=3.7990E-02 RSH=9.0910000E-02 GAMMA=0.4496
+NSUB=7.8780E+16 NFS=6.49900E+11 VMAX=2.3130E+05 ETA=2.858000E-02
+KAPPA=9.9270E+00 CGDO=9.0000E-11 CGSO=9.0000E-11 CGB0=3.6835E-10
+CJ=9.34E-04 MJ=0.491 CJSW=2.41E-10 MJSW=0.222 PB=0.90
* Weff = Wdrawn - Delta_W * The suggested Delta_W is 3.6220E-07
```

```
*****references*****
**http://newton.ex.ac.uk/teaching/CDHW/Electronics2/userguide/
**Iit Bombay course ee705/ee707.
**Book "Cmos Analog circuit design"- Allen and Holberg
```

**Book "Design of Analog Cmos Integrated Circuit" - Razavi
**Book "Cmos mixed signal design and layout" - baker
*****the end*****