


```

*-----Bulk-----
+ k1=1.04          k2=-1.209E-01      kt2=-0.2916
+ cdsc=-2.4E-4    cdscd=-1.506E-04      cdscb=-2.219E-04
*-----Mobility-----
+ u0=678          ua=8.964e-10      ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176     ual=5.705e-09      ubl=-1.147E-17   ucl=-1.302E-01
+ vsat=86000     at=20380            elm=2
*-----Resistance-----
+ rsh=70         rdsw=375             prt=-3.287E+02
+ wr=0.7586     prwb=0              prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06   pclm=.19            pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39        pdiblc2=0.0086    drout=0.56
*-----Subthreshold-----
+ nfactor=1.8    cit=-5.0E-04        voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01        dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05    beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2           pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551          pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873        pbsw=0.8
+ cgso=9e-13     cgdo=9e-13         cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07        xpart=0
*-----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10       xti=2.000e+00     nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7         a1=1                a2=1              ags=0.05583
+ b0=6.305e-08  b1=6.579e-08       keta=-1.531E-02
*-----Noise????-----
+ af=1           kf=0                ef=1              em=4.1E+07
+ noia=1E+20     noib=50000          noic=-1.4E-12
*-----dIdW????-----
+ wl=0           wln=1               ww1=0
+ ll=0           lln=1               lw=0              lwn=1
+ lwl=0          llc=2E-13           lwc=0             lwlc=0
+ wlc=0          wwc=0               wwlc=0
*-----Bsim??-----
+ wk3=0          lk3=0               pk3=1.257
+ lk3b=0         wk3b=0              pk3b=0
+ pa0=0.0489     la0=-1.052          lags=0.01093
+ wags=0         pags=0.1573         lketa=0
+ wdwg=0         ldwb=0              wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0              lu0=0             ldwg=0
+ uc1=-1.098E-11 acm=13              wu0=1
+ wua=3.641E-11 lua=9.782E-10   pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19       pu0=1
+ wuc=1.177E-11 luc=-2.164E-10    puc=1.231E-10
*-----Flagged!!-----
* nqsmod         lmlt=1.000e+00     wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
*-----
.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

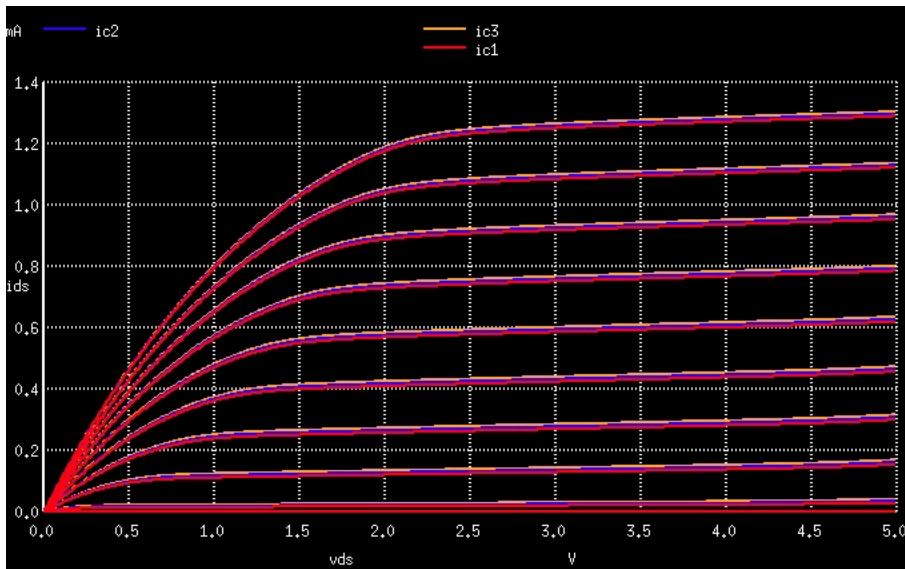
```

=====TOXM=ToxWhichParametersExtracted=====

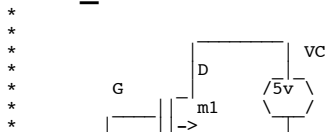
```

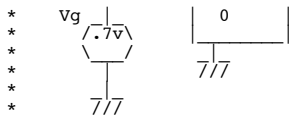
*-----Process-----
+ tox=160e-10    toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06        nch=0.5e+17
*-----

```



NMOS_TOXM vtox=155e-10 160e-10 165e-10





```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*****
Vds D 0 dc 5v
Vgs G 0 dc 1.2v
v1 D 1 dc 0v
m1 1 G 0 0 N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u

```

```

.control
destroy all
altermod N1 toxm=155e-10
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 toxm=160e-10
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 toxm=165e-10
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5

```

```

let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel vds ylabel ids

```

.endc

```

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ua1=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drout=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dIdW????-----
+ w1=0 wln=1 ww1=0
+ l1=0 lln=1 lw=0 lwn=1
+ lw1=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----Bsim??-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pag=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 wua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ nqsmod lmlt=1.000e+00 wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00

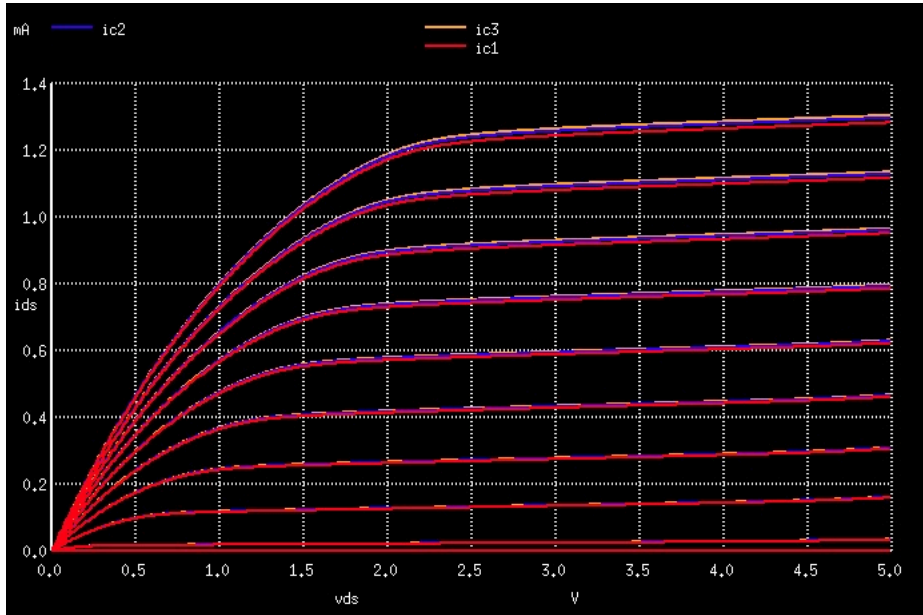
```

.end

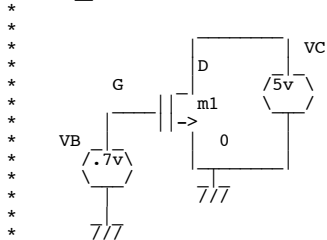
```
* source /Users/don_sauer/Downloads/stable/SI_Lib/Tests.cir
```

=====NGATE=PolySiGateDoping=====

```
*-----Process-----
+ tox=160e-10      toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*
```



NMOS_NGATE ngate=4.000e+19 8.000e+19 16.000e+19



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds D 0 dc 5v
Vgs G 0 dc 1.2v
v1 D 1 dc 0v
m1 1 G 0 0 N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u

```

```

.control
destroy all
altermod N1 ngate=4.000e+19
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 ngate=8.000e+19
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 ngate=16.000e+19
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5

```

```

let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel vds ylabel ids

```

.endc

```

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdscc=-2.4E-4 cdscc=-1.506E-04 cdscc=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ua1=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2

```

```

*-----
+ rsh=70          rdsw=375          prt=-3.287E+02
+ wr=0.7586      prwb=0            prwg=-4.441E-17
*-----
+ lint=.12e-06   pclm=.19          pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39       pdiblc2=0.0086   drout=0.56
*-----
+ nfactor=1.8   cit=-5.0E-04      voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01      dsub=0.7
*-----
+ alpha0=1.61e-05 alpha1=8.276E-05  beta0=36.68
*-----
+ cjswg=2.73e-10 mjswg=0.2         pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551       pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873      pbsw=0.8
+ cgso=9e-13    cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07     xpart=0
*-----
+ js=5.858e-08  jsw=1.25E-10     xti=2.000e+00    nj=1.08
*-----
+ a0=0.7         al=1             a2=1              ags=0.05583
+ b0=6.305e-08  bl=6.579e-08    keta=-1.531E-02
*-----
+ af=1           kf=0             ef=1              em=4.1E+07
+ noia=1E+20    noib=50000       noic=-1.4E-12
*-----
+ wl=0           wln=1            wwl=0
+ ll=0           lln=1            lw=0              lwn=1
+ lwl=0          llc=2E-13       lwc=0             lwlc=0
+ wlc=0          wwc=0            wwlc=0
*-----
+ wk3=0          lk3=0            pk3=1.257
+ lk3b=0         wk3b=0           pk3b=0
+ pa0=0.0489    la0=-1.052      lags=0.01093
+ wags=0         pags=0.1573     lketa=0
+ wdwg=0         ldwb=0           wdwb=0
*-----
+ hdif=2.7E-07  ldif=0           lu0=0            ldwg=0
+ uc1=-1.098E-11 acm=13          wu0=1
+ wua=3.641E-11 lua=9.782E-10  pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19    pu0=1
+ wuc=1.177E-11 luc=-2.164E-10  puc=1.231E-10
*-----
* nqsmod        lmlt=1.000e+00  wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
*-----

```

```

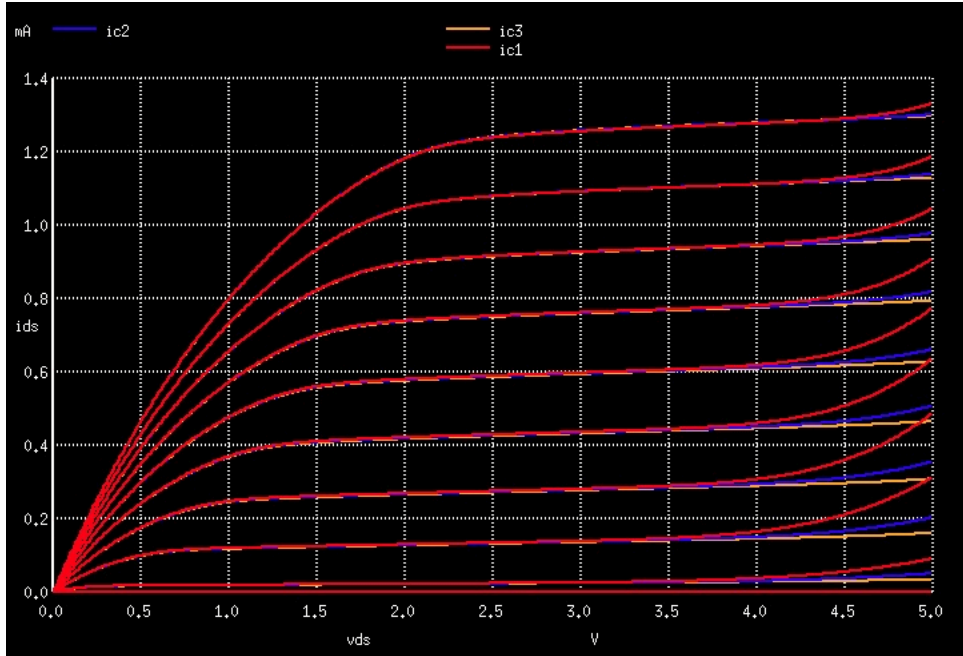
.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

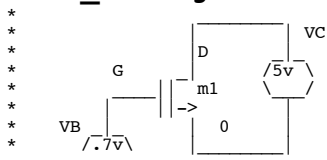
```

===== XJ=S/DJunctionDepth =====
*-----
+ tox=160e-10   toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06   nch=0.5e+17
*-----

```



NMOS_XJ xj=0.105e-06 0.15e-06 0.25e-06





```
*
*
*
*
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*=====
Vds D 0 dc 5v
Vgs G 0 dc 1.2v
v1 D 1 dc 0v
m1 1 G 0 0 N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u
```

```
.control
destroy all
altermod N1 xj=0.105e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 xj=0.15e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 xj=0.25e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
```

```
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 ylabel ids xlabel vds
```

.endc

```
.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ubl=-1.147E-17 ucl=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbel=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drou=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dLdW????-----
+ wl=0 wln=1 wwl=0
+ ll=0 lln=1 llw=0 lwn=1
+ lwl=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----Bsim??-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ ngsmod lmlt=1.000e+00 wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----
```

.end

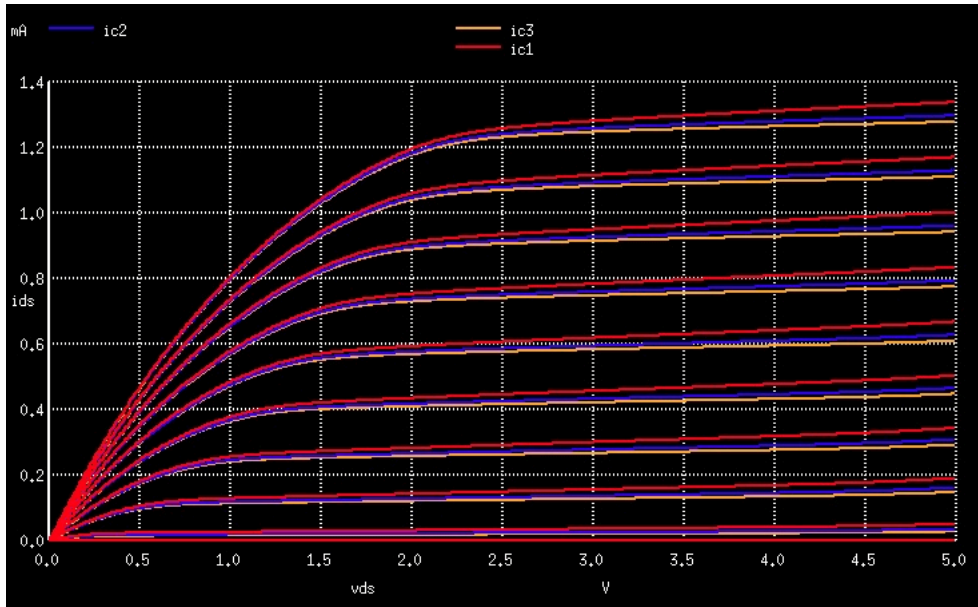
```
* source /Users/don_sauer/Downloads/stable/SI_Lib/Tests.cir
```

=====nch=ChannelDopingConcentration=====

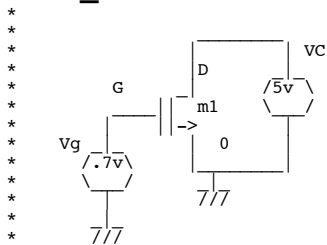
```

*-----Process-----
+ tox=160e-10      toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----

```



NMOS_NCH nch=0.2e+17 0.5e+17 0.9e+17



```

*-----Options-----
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*-----
Vds    D    0    dc    5v
Vgs    G    0    dc    1.2v
v1     D    1    dc    0v
m1     1    G    0    0    N1    W=3u    L=1u    AD=7p    AS=7p    PD=10u    PS=10u

```

```

.control
destroy all
altermod N1 nch=0.2e+17
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 nch=0.5e+17
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 nch=0.9e+17
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5

```

```

let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 ylabel ids xlabel vds

```

.endc

```

.model N1 NMOS
+ Level= 49      Tnom=27.0      version=3.24
+ mobmod=2      capmod=3      noimod=2
*-----Process-----
+ tox=160e-10      toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----V threshold-----
+ vth0=0.72      lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2      dvt1=0.53      dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04      wint=0.16e-06      ww=-9.525E-14      wwn=1.0
+ dvt0w=0      dvt1w=5.3e6      dvt2w=-1.E-01
+ k3=2.53      k3b=-5      dwg=0      dwb=0
*-----Bulk-----
+ k1=1.04      k2=-1.209E-01      kt2=-0.2916
+ cdsc=-2.4E-4      cdscd=-1.506E-04      cdscb=-2.219E-04
*-----Mobility-----
+ u0=678      ua=8.964e-10      ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176      ual=5.705e-09      ub1=-1.147E-17      uc1=-1.302E-01
+ vsat=86000      at=20380      elm=2
*-----Resistance-----
+ rsh=70      rdsw=375      prt=-3.287E+02

```



```

+ wr=0.7586          prwb=0          prwg=-4.441E-17
* -----
+ lint=.12e-06      pclm=.19        pscbel=3.79e+08    pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39    pdiblc2=0.0086    drout=0.56
* -----
+ nfactor=1.8      cit=-5.0E-04    voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01    dsub=0.7
* -----
+ HotElectrons
+ alpha0=1.61e-05  alpha1=8.276E-05  beta0=36.68
* -----
+ Capacitance
+ cjswg=2.73e-10  mjswg=0.2        pbswg=8.800e-01
+ cj=0.0002424    mj=0.3551        pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873      pbsw=0.8
+ cgso=9e-13      cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08       dwc=1.5e-07      xpart=0
* -----
+ BulkDiode
+ js=5.858e-08    jsw=1.25E-10     xti=2.000e+00    nj=1.08
* -----
+ BulkChargeEffect
+ a0=0.7          a1=1             a2=1             ags=0.05583
+ b0=6.305e-08   b1=6.579e-08    keta=-1.531E-02
* -----
+ Noise????
+ af=1           kf=0             ef=1             em=4.1E+07
+ noia=1E+20     noib=50000       noic=-1.4E-12
* -----
+ dLdW????
+ wl=0           wln=1           wwl=0
+ ll=0           lln=1           lw=0             lwn=1
+ lwl=0          llc=2E-13       lwc=0            lwlc=0
+ wlc=0          wwc=0           wwlc=0
* -----
+ Bsim??
+ wk3=0          lk3=0           pk3=1.257
+ lk3b=0         wk3b=0          pk3b=0
+ pa0=0.0489    la0=-1.052      lags=0.01093
+ wags=0         pags=0.1573    lketa=0
+ wdwg=0         ldwb=0          wdwb=0
* -----
+ HspiceBSIM4??
+ hdif=2.7E-07  ldif=0          lu0=0            ldwg=0
+ uc1=-1.098E-11 acm=13          wu0=1
+ wua=3.641E-11 lua=9.782E-10  pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19  pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
* -----
+ Flagged!!
+ nqsmod         lmlt=1.000e+00  wmlt=1.000e+00
+ tlev=0.000e+00
* -----

```

```

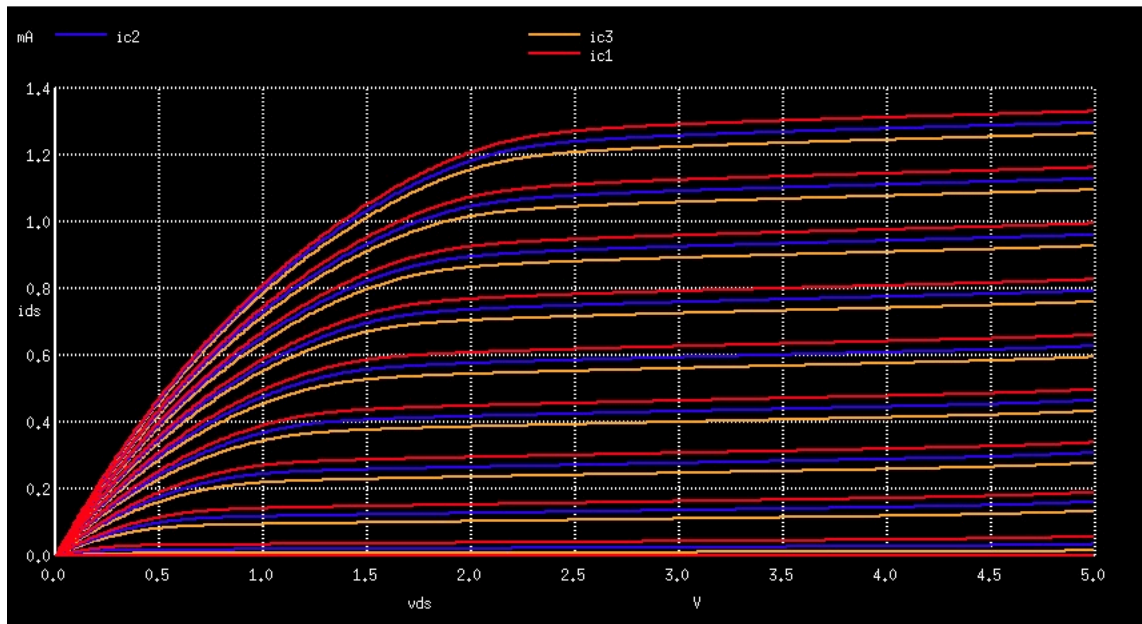
.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

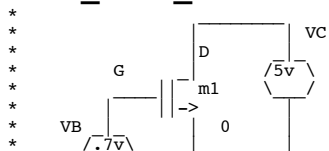
```

=====Vth0=ThreshholdVoltage=====
* -----
+ V threshold
+ vth0=0.72      lvth0=0.025     nlx=0.12e-06     kt1=-0.9821
+ dvt0=2.2       dvt1=0.53       dvt2=-1.521E-01
* -----

```



NMOS_VTH0_CURVETRACE vth0=0.62 0.72 0.82





```

*
*
*
*
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds      D      0      dc      5v
Vgs      G      0      dc      1.2v
v1       D      1      dc      0v
m1       1      G      0      0      N1      W=3u      L=1u      AD=7p      AS=7p      PD=10u      PS=10u

```

```

.control
destroy all
altermod N1 vth0=0.62
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 vth0=0.72
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 vth0=0.82
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5

```

```

let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 ylabel ids xlabel vds

```

.endc

```

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ubl=-1.147E-17 ucl=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbel=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drout=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dLdW????-----
+ wl=0 wln=1 wwl=0
+ ll=0 lln=1 llw=0 lwn=1
+ lwl=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----Bsim??-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ ngsmod lmlt=1.000e+00 wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

```

=====
*-----vth0=ThresholdVoltage-----
*-----v_threshold-----
+ vth0=0.72      lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2      dvt1=0.53        dvt2=-1.521E-01
*-----

```

3.2 Extraction of Threshold Voltage

A graphically based method has been considered for determining threshold voltage. Calculation steps are given below:

In Fig. 1 it is shown that the application of the threshold voltage extraction steps and obtaining.

- Measure I_{ds} - V_{gs} characteristics at low V_{ds} (<0.1V, typically 50mV),
- Determine the **maximum slope** of the I_{ds} - V_{gs} curve, that is maximum gm point,
- **Extrapolate** I_{ds} - V_{gs} from the max gm point to $I_{ds}=0$,
- Note the corresponding extrapolated V_{GS} value (V_{GS0}) for $I_{ds}=0$ point.
- Calculate V_{th} according **$V_{th} = V_{GS0} - 0.5 \cdot V_{ds}$**

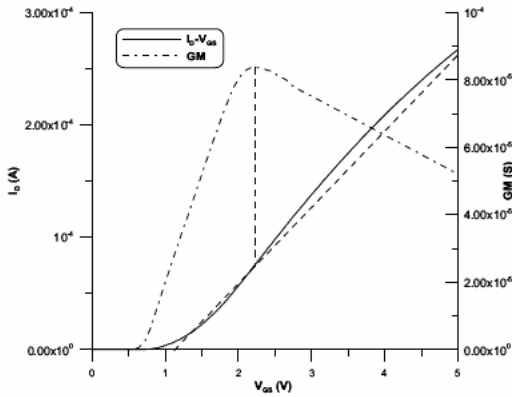
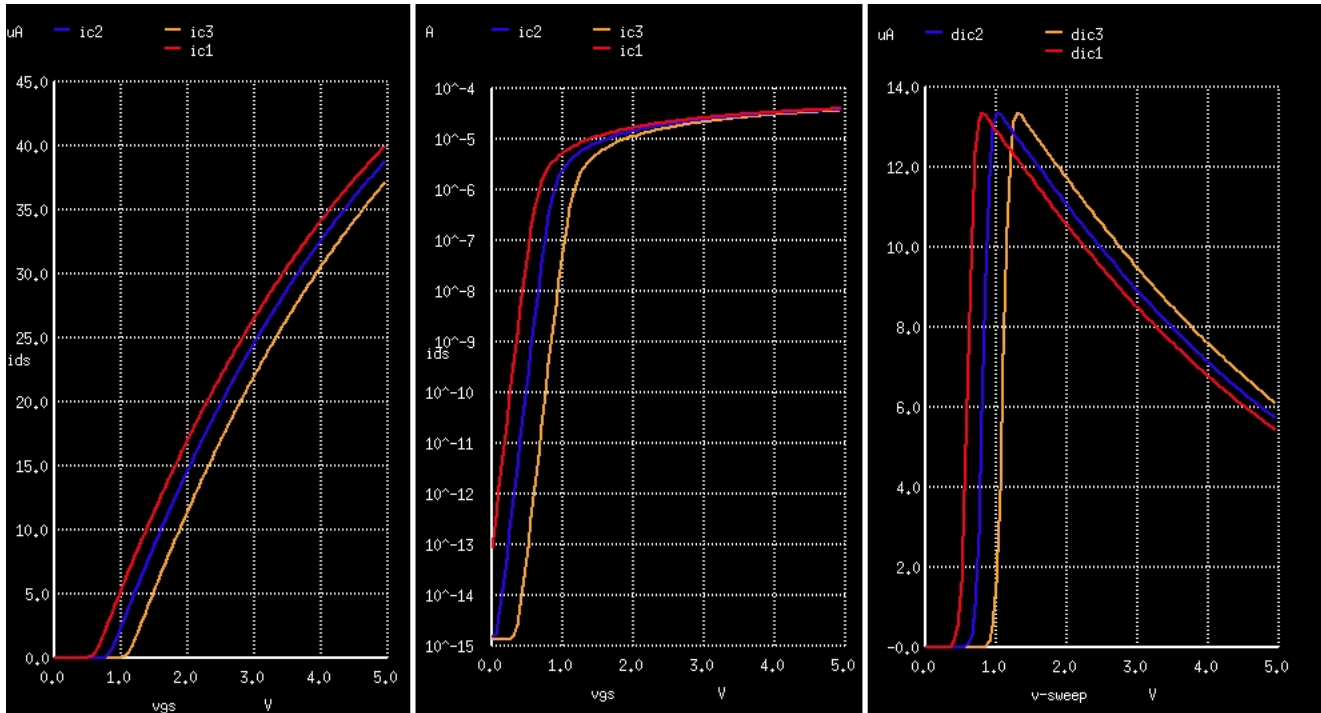


Fig. 2. Extraction of threshold voltage

```

Circuit: nmos_vth0_extract  vth0=0.5 0.72 1.0
vtt1 = 5.387191e-01
vtt2 = 7.583627e-01
vtt3 = 1.038719e+00

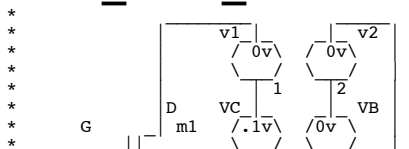
```



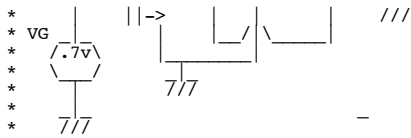
```

NMOS_VTH0_EXTRACT  vth0=0.5 0.72 1.0

```



It looks like vth0 defines where $I_{ds}=0.1u$ @ $V_{ds}=100mV$



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds D 0 dc .1v
Vgs G 0 dc 1.2v
Vbs 0 B dc 0v
v1 D 1 dc 0v
m1 1 G 0 B N1 W=3u L=3u AD=7p AS=7p PD=10u PS=10u

```

```

.control
destroy all
altermod N1 vth0=0.5
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs lm 5 0.05
altermod N1 vth0=0.72
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs lm 5 0.05
altermod N1 vth0=1
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs lm 5 0.05
* =====collect three dc plots=====
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel VGS ylabel IDS
plot ic1 ic2 ic3 xlabel VGS ylabel IDS ylog title whynotwork
* =====find slopes=====
let dic1= deriv(ic1)
let dic2= deriv(ic2)
let dic3= deriv(ic3)
plot dic1 dic2 dic3
* =====find maximum of slopes=====
let ic1max = vecmax(dic1)
let ic2max = vecmax(dic2)
let ic3max = vecmax(dic3)
let numb = length(ic1) -1
* =====find index for each maximum of slopes=====
let n = 0
let nn1 = 0
let nn2 = 0
let nn3 = 0
repeat $&numb
if ( dic1[n] >= ic1max )
let nn1 = n
end
if ( dic2[n] >= ic2max )
let nn2 = n
end
if ( dic3[n] >= ic3max )
let nn3 = n
end
let n = n +1
endrepeat
* print nn1 nn2 nn3
let vstep= g[1] -g[0]
* =====find zero crossings solving this equation { y = mx+b }=====
let vtt1 = - ic1[nn1]/dic1[nn1] +vstep*nn1 -.1/2
let vtt2 = - ic2[nn2]/dic2[nn2] +vstep*nn2 -.1/2
let vtt3 = - ic3[nn3]/dic3[nn3] +vstep*nn3 -.1/2
print vtt1 vtt2 vtt3
.endc

```

```

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
*-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsd=-2.4E-4 cdsd=-1.506E-04 cdsdcb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ub1=-1.147E-17 ucl=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drout=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614

```

```

+ cjsw=2.73e-10      mjsw=0.3873      pbsw=0.8
+ cgso=9e-13        cgdo=9e-13        cgbo=7e-10
+ dlc=5e-08         dwc=1.5e-07      xpart=0
* -----
+ js=5.858e-08      BulkDiode
+ js=5.858e-08      jsw=1.25E-10     xti=2.000e+00    nj=1.08
* -----
+ BulkChargeEffect
+ a0=0.7            a1=1              a2=1              ags=0.05583
+ b0=6.305e-08     b1=6.579e-08     keta=-1.531E-02
* -----
+ Noise????
+ af=1              kf=0              ef=1              em=4.1E+07
+ noia=1E+20       noib=50000       noic=-1.4E-12
* -----
+ dLdW????
+ wl=0              wln=1             wwl=0
+ ll=0              lln=1             lw=0              lwn=1
+ lw1=0            llc=2E-13        lwc=0             lwlc=0
+ wlc=0            wwc=0            wwlc=0
* -----
+ Bsim??
+ wk3=0            lk3=0             pk3=1.257
+ lk3b=0           wk3b=0            pk3b=0
+ pa0=0.0489      la0=-1.052        lags=0.01093
+ wags=0           pags=0.1573      lketa=0
+ wdwg=0           ldwb=0            wdwb=0
* -----
+ HspiceBSIM4??
+ hdif=2.7E-07     ldif=0            lu0=0             ldwg=0
+ uc1=-1.098E-11  acm=13            wu0=1
+ wua=3.641E-11   lua=9.782E-10    pua=-4.46E-10    lub=-7.249E-19
+ wub=1.056E-20   pub=8.812E-19    pu0=1
+ wuc=1.177E-11   luc=-2.164E-10   puc=1.231E-10
* -----
+ Flagged!!
* nqsmod           lmlt=1.000e+00   wmlt=1.000e+00
* tlev=0.000e+00  tlevc=0.000e+00
* -----
.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

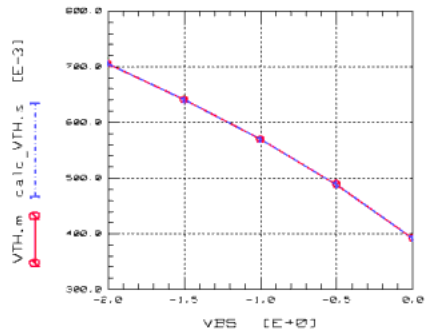
```

```

=====vth0=ThresholdVoltage=====
* -----
+ V threshold
+ vth0=0.72        lvth0=0.025      nlx=0.12e-06     kt1=-0.9821
+ dvt0=2.2         dvt1=0.53        dvt2=-1.521E-01
* -----

```

Figure 73 Threshold Voltage Vth as a Function of Vbs




```

if      ( dic2[n] >= ic2max )
let nn2 = n
end
if      ( dic3[n] >= ic3max )
let nn3 = n
end
let n   = n + 1
endrepeat
* print nn1 nn2 nn3
let vstep= g[1] -g[0]
* =====find zero crossings solving this equation { y = mx+b }=====
let vtt1 = - ic1[nn1]/dic1[nn1] +vstep*nn1 -.1/2
let vtt2 = - ic2[nn2]/dic2[nn2] +vstep*nn2 -.1/2
let vtt3 = - ic3[nn3]/dic3[nn3] +vstep*nn3 -.1/2
print    vtt1 vtt2 vtt3
let vtvals = vector(3)
let vtvals[0] = vtt1
let vtvals[1] = vtt2
let vtvals[2] = vtt3
let bvvals = vector(3)
let bvvals[0] = 0
let bvvals[1] = 2.5
let bvvals[2] = 5
plot     vtvals vs bvvals xlabel VBS ylabel VTH
.endc

```

```

.model          N1          NMOS
+ Level= 49      Tnom=27.0   version=3.24
+ mobmod=2      capmod=3     noimod=2
**-----Process-----
+ tox=160e-10   toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06   nch=0.5e+17
*-----V threshold-----
+ vth0=0.72     lvth0=0.025   nlx=0.12e-06   kt1=-0.9821
+ dvt0=2.2      dvt1=0.53     dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04    wint=0.16e-06   ww=-9.525E-14   wwn=1.0
+ dvt0w=0       dvt1w=5.3e6    dvt2w=-1.E-01   dwg=0
+ k3=2.53       k3b=-5
*-----Bulk-----
+ k1=1.04       k2=-1.209E-01   kt2=-0.2916
+ cdsc=-2.4E-4  cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678        ua=8.964e-10   ub=1.472e-18   uc=-4.441E-17
+ ute=-1.176    ual=5.705e-09   ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000    at=20380       elm=2
*-----Resistance-----
+ rsh=70        rdsw=375       prt=-3.287E+02
+ wr=0.7586     prwb=0         prwg=-4.441E-17
*-----VAR-----
+ lint=.12e-06  pclm=.19       pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39   pdiblc2=0.0086   dROUT=0.56
*-----Subthreshold-----
+ nfactor=1.8   cit=-5.0E-04   voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01   dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2       pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551      pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873    pbsw=0.8
+ cgso=9e-13     cgdo=9e-13     cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07    xpart=0
*-----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10   xti=2.000e+00   nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7         a1=1           a2=1             ags=0.05583
+ b0=6.305e-08   b1=6.579e-08   keta=-1.531E-02
*-----Noise????-----
+ af=1           kf=0           ef=1             em=4.1E+07
+ noia=1E+20     noib=50000     noic=-1.4E-12
*-----dIdW????-----
+ wl=0           wln=1          wwl=0
+ ll=0           lln=1          lw=0             lwn=1
+ lw1=0          llc=2E-13     lwc=0            lwlc=0
+ wlc=0          wwc=0          wwlc=0
*-----Bsim??-----
+ wk3=0          lk3=0          pk3=1.257
+ lk3b=0         wk3b=0         pk3b=0
+ pa0=0.0489     la0=-1.052     lags=0.01093
+ wags=0         pags=0.1573    lketa=0
+ wdwg=0         ldwb=0         wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0         lu0=0            ldwg=0
+ uc1=-1.098E-11 acm=13         wu0=1
+ wua=3.641E-11  lua=9.782E-10  pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20  pub=8.812E-19  pu0=1
+ wuc=1.177E-11  luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
* nqsmod         lmlt=1.000e+00 wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

```

=====lvth0=====
*-----V_threshold-----

```



```

*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04      voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01      dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05  beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2         pbswg=8.800e-01
+ cj=0.0002424    mj=0.3551         pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873       pbsw=0.8
+ cgso=9e-13      cgdo=9e-13        cgbo=7e-10
+ dlc=5e-08        dwc=1.5e-07       xpart=0
*-----BulkDiode-----
+ js=5.858e-08    jsw=1.25E-10      xti=2.000e+00    nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7           a1=1               a2=1              ags=0.05583
+ b0=6.305e-08    b1=6.579e-08      keta=-1.531E-02
*-----Noise????-----
+ af=1             kf=0               ef=1               em=4.1E+07
+ noia=1E+20       noib=50000         noic=-1.4E-12
*-----dLDW????-----
+ wl=0             wln=1              wwl=0
+ ll=0             lln=1              lw=0               lwn=1
+ lw=0             llc=2E-13          lwc=0              lwlc=0
+ wlc=0            wwc=0              wwlc=0
*-----Bsim???-----
+ wk3=0            lk3=0              pk3=1.257
+ lk3b=0           wk3b=0             pk3b=0
+ pa0=0.0489      la0=-1.052         lags=0.01093
+ wags=0           pags=0.1573        lketa=0
+ wdwg=0           ldwb=0             wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07     ldif=0             lu0=0              ldwg=0
+ uc1=-1.098E-11  acm=13             wu0=1
+ wua=3.641E-11   lua=9.782E-10      pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20   pub=8.812E-19      pu0=1
+ wuc=1.177E-11   luc=-2.164E-10     puc=1.231E-10
*-----Flagged!!-----
+ nqsmod           lmlt=1.000e+00    wmlt=1.000e+00
+ tlev=0.000e+00  tlevc=0.000e+00
*-----

```

```

.end
* source /Users/don_sauer/Downloads/stable/SI_Lib/Tests.cir

```

=====**nlx=LateralNon-uniformDopingParameter**=====

```

*-----V threshold-----
+ vth0=0.72        lvth0=0.025        nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2         dvt1=0.53          dvt2=-1.521E-01
*-----

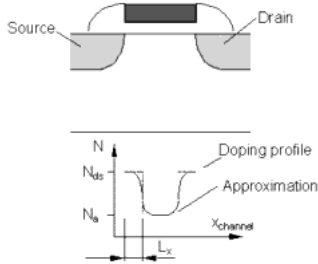
```

Non-Uniform Lateral Channel Doping

The doping concentration N_d s near the drain and the source is higher than the concentration N_a in the middle of the channel.

This is referred to as lateral non-uniform doping concentration and is shown in [Figure 74](#).

Figure 74 Lateral Doping Profile in the Channel




```

*-----Capacitance-----
+ cjswg=2.73e-10    mjswg=0.2          pbswg=8.800e-01
+ cj=0.0002424     mj=0.3551         pb=0.5614
+ cjsw=2.73e-10    mjsw=0.3873      pbsw=0.8
+ cgso=9e-13       cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08        dwc=1.5e-07      xpart=0
*-----BulkDiode-----
+ js=5.858e-08     jsw=1.25E-10     xti=2.000e+00    nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7           a1=1              a2=1              ags=0.05583
+ b0=6.305e-08    b1=6.579e-08     keta=-1.531E-02
*-----Noise????-----
+ af=1             kf=0              ef=1              em=4.1E+07
+ noia=1E+20       noib=50000        noic=-1.4E-12
*-----dLdW????-----
+ wl=0             wln=1             ww1=0             lwn=1
+ ll=0             lln=1             lw=0              lwlc=0
+ lw1=0           llc=2E-13         lwc=0             wwlc=0
+ wlc=0           wwc=0             wwlc=0
*-----Bsim???-----
+ wk3=0            lk3=0             pk3=1.257
+ lk3b=0           wk3b=0            pk3b=0
+ pa0=0.0489      la0=-1.052        lags=0.01093
+ wags=0           pags=0.1573       lketa=0
+ wdwg=0           ldwb=0            wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07     ldif=0            lu0=0             ldwg=0
+ uc1=-1.098E-11  acm=13            wu0=1
+ wua=3.641E-11   lua=9.782E-10    pua=-4.46E-10    lub=-7.249E-19
+ wub=1.056E-20   pub=8.812E-19    pu0=1
+ wuc=1.177E-11   luc=-2.164E-10   puc=1.231E-10
*-----Flagged!!-----
+ nqsmod           lmlt=1.000e+00   wmlt=1.000e+00
* tlev=0.000e+00  tlevc=0.000e+00
*-----

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

```

=====nlx=LateralNon-uniformDopingParameter=====
*-----V_threshold-----
+ vth0=0.72        lvth0=0.025      nlx=0.12e-06     kt1=-0.9821
+ dvt0=2.2         dvt1=0.53        dvt2=-1.521E-01
*-----

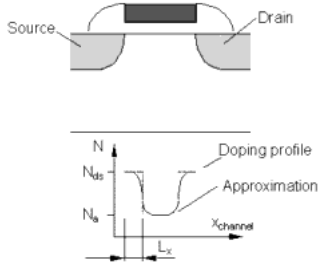
```

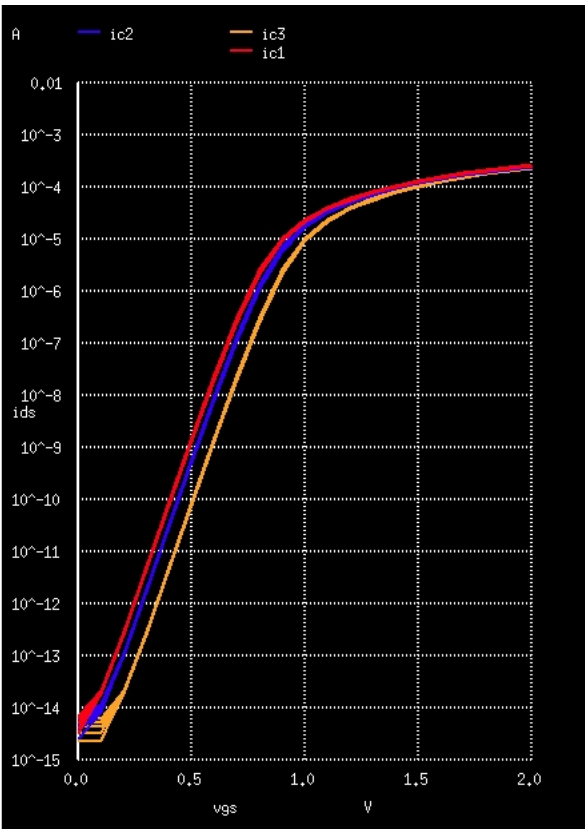
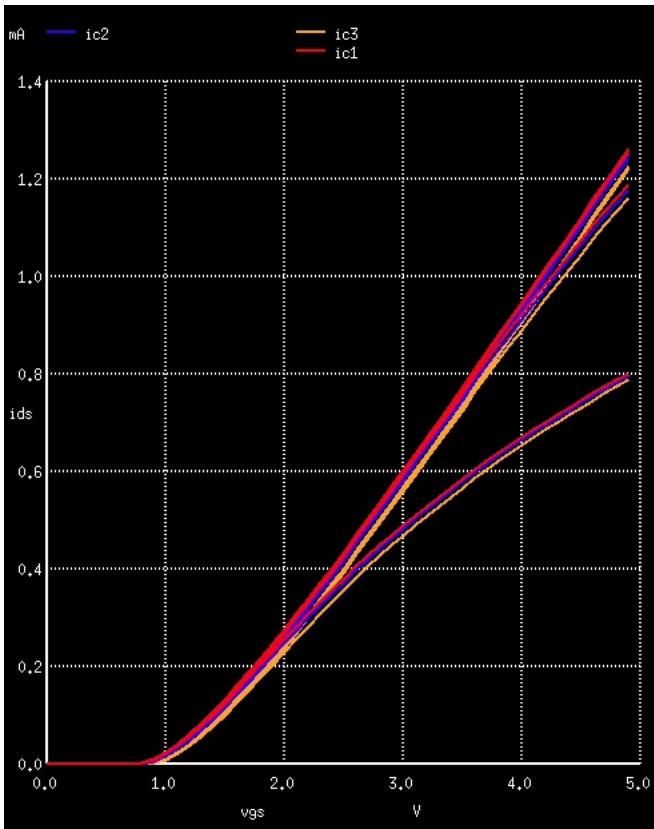
Non-Uniform Lateral Channel Doping

The doping concentration N_{ds} near the drain and the source is higher than the concentration N_a in the middle of the channel.

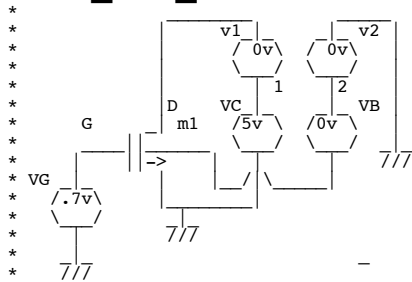
This is referred to as lateral non-uniform doping concentration and is shown in [Figure 74](#).

Figure 74 Lateral Doping Profile in the Channel





NMOS_NLX_SLOPE nlx=0.06e-06 0.12e-06 0.24e-06



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds D 0 dc .1v
Vgs G 0 dc 1.2v
Vbs 0 B dc 0v
v1 D 1 dc 0v
m1 1 G 0 B N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u
.control
destroy all
altermod N1 nlx=0.06e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs 1m 5 0.1 Vds 1 5 1
altermod N1 nlx=0.12e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs 1m 5 0.1 Vds 1 5 1
altermod N1 nlx=0.24e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs 1m 5 0.1 Vds 1 5 1
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel VGS ylabel IDS
plot ic1 ic2 ic3 xlabel VGS ylabel IDS ylog title fff xlimit 0 2
.endc
.model
+ Level= 49 N1 NMOS Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10 nch=0.5e+17
+ ngate=8.000e+19 xj=0.25e-06
*-----V_threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdscd=-1.506E-04 cdscb=-2.219E-04

```

```

*-----Mobility-----
+ u0=678          ua=8.964e-10      ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176     ual=5.705e-09      ubl=-1.147E-17   uc1=-1.302E-01
+ vsat=86000     at=20380            elm=2
*-----Resistance-----
+ rsh=70         rdsw=375            prt=-3.287E+02
+ wr=0.7586     prwb=0              prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06   pclm=.19            pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39        pdiblc2=0.0086    drout=0.56
*-----Subthreshold-----
+ nfactor=1.8    cit=-5.0E-04        voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01        dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05    beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2           pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551           pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873         pbsw=0.8
+ cgso=9e-13    cgdo=9e-13          cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07         xpart=0
*-----BulkDiode-----
+ js=5.858e-08  jsw=1.25E-10        xti=2.000e+00     nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7         a1=1                 a2=1               ags=0.05583
+ b0=6.305e-08  b1=6.579e-08        keta=-1.531E-02
*-----Noise????-----
+ af=1           kf=0                 ef=1               em=4.1E+07
+ noia=1E+20     noib=50000           noic=-1.4E-12
*-----dLdw????-----
+ wl=0           wln=1                ww1=0
+ ll=0           lln=1                lw=0               lwn=1
+ lw1=0          llc=2E-13            lwc=0              lwlc=0
+ wlc=0          wwc=0                wwlc=0
*-----Bsim???-----
+ wk3=0          lk3=0                pk3=1.257
+ lk3b=0         wk3b=0               pk3b=0
+ pa0=0.0489     la0=-1.052           lags=0.01093
+ wags=0         pags=0.1573          lketa=0
+ wdwg=0         ldwb=0               wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0               lu0=0              ldwg=0
+ uc1=-1.098E-11 acm=13                wu0=1
+ wua=3.641E-11 lua=9.782E-10     pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19     pu0=1
+ wuc=1.177E-11 luc=-2.164E-10     puc=1.231E-10
*-----Flagged!!-----
+ nqsmod         lmlt=1.000e+00      wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----
.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

```

=====kt1=TemperatureCoefficientThresholdVoltage=====
*-----V_threshold-----
+ vth0=0.72      lvth0=0.025         nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2       dvt1=0.53           dvt2=-1.521E-01
*-----

```

Figure 127 Threshold Voltage $V_{th}=f(T)$ of a Large Device

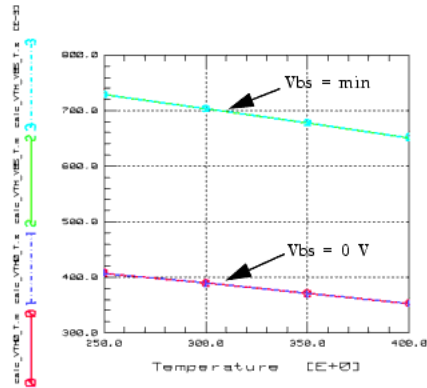
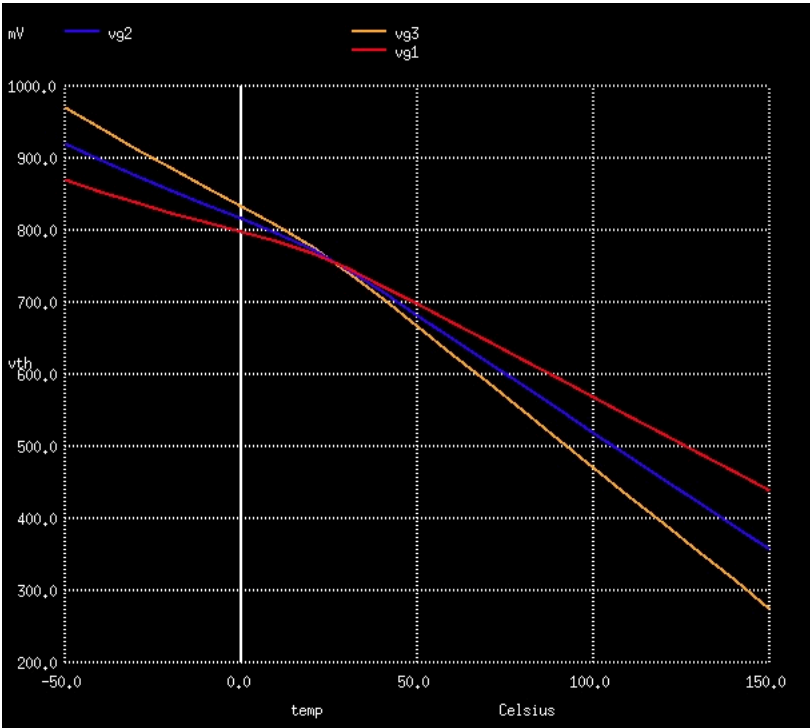
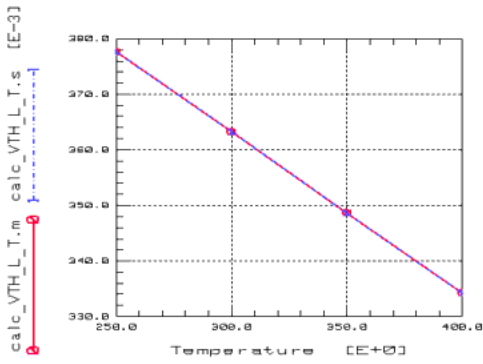
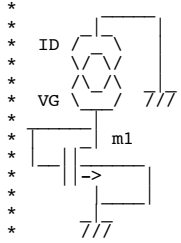


Figure 128 Threshold Voltage $V_{th}=f(T)$ of a Short Device



NMOS_KT1 **kt1=-0.7821 -0.9821 -1.1821**



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*=====
Ids 0 VG dc .5u
m1 VG VG 0 B N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u
.control
destroy all
altermod N1 kt1=-0.7821
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc TEMP -50 1 50 10
altermod N1 kt1=-0.9821
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc TEMP -50 150 10
altermod N1 kt1=-1.1821
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc TEMP -50 150 10
let vg1 = mag(dc1.v(vg))
let vg2 = mag(dc2.v(vg))
let vg3 = mag(dc3.v(vg))
plot vg1 vg2 vg3 xlabel Temp ylabel Vth
.endc

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24

```

```

+ mobmod=2          capmod=3          noimod=2
**-----
+ tox=160e-10      toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06          nch=0.5e+17
*-----
+ vth0=0.72        lvth0=0.025          nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2         dvt1=0.53           dvt2=-1.521E-01
*-----
+ w0=2.6e-04       wint=0.16e-06       ww=-9.525E-14    wwn=1.0
+ dvt0w=0          dvt1w=5.3e6         dvt2w=-1.E-01    dwg=0
+ k3=2.53          k3b=-5              dwg=0             dwb=0
*-----
+ k1=1.04          k2=-1.209E-01       kt2=-0.2916
+ cdsc=-2.4E-4     cdscd=-1.506E-04    cdscb=-2.219E-04
*-----
+ u0=678           ua=8.964e-10        ub=1.472e-18     uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09       ubl=-1.147E-17  ucl=-1.302E-01
+ vsat=86000       at=20380            elm=2
*-----
+ rsh=70           rdsw=375            prt=-3.287E+02
+ wr=0.7586        prwb=0              prwg=-4.441E-17
*-----
+ lint=.12e-06     pclm=.19            pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39        pdiblc2=0.0086   drou=0.56
*-----
+ nfactor=1.8      cit=-5.0E-04        voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01        dsub=0.7
*-----
+ alpha0=1.61e-05  alpha1=8.276E-05    beta0=36.68
*-----
+ cjswg=2.73e-10  mjswg=0.2           pbswg=8.800e-01
+ cj=0.0002424    mj=0.3551           pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873         pbsw=0.8
+ cgso=9e-13      cgdo=9e-13          cgbo=7e-10
+ dlc=5e-08       dwc=1.5e-07         xpart=0
*-----
+ js=5.858e-08    jsw=1.25E-10        xti=2.000e+00    nj=1.08
*-----
+ a0=0.7           a1=1                 a2=1              ags=0.05583
+ b0=6.305e-08    b1=6.579e-08        keta=-1.531E-02
*-----
+ af=1             kf=0                 ef=1              em=4.1E+07
+ noia=1E+20       noib=50000          noic=-1.4E-12
*-----
+ w1=0             wln=1                ww1=0
+ l1=0             lln=1                lw=0              lwn=1
+ lw1=0           llc=2E-13            lwc=0             lwlc=0
+ wlc=0           wwc=0                wwlc=0
*-----
+ wk3=0           lk3=0                pk3=1.257
+ lk3b=0          wk3b=0               pk3b=0
+ pa0=0.0489     la0=-1.052           lags=0.01093
+ wags=0          pags=0.1573          lketa=0
+ wdwg=0          ldwb=0               wdwb=0
*-----
+ hdif=2.7E-07    ldif=0               lu0=0             ldwg=0
+ uc1=-1.098E-11  acm=13              wu0=1
+ wua=3.641E-11  lua=9.782E-10        pua=-4.46E-10    lub=-7.249E-19
+ wub=1.056E-20  pub=8.812E-19        pu0=1
+ wuc=1.177E-11  luc=-2.164E-10       puc=1.231E-10
*-----
+ nqsmod          lmlt=1.000e+00      wmlt=1.000e+00
* tlev=0.000e+00  tlevc=0.000e+00
*-----

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

=====DVTO=FirstCoefficientShort-channelOnVth=====

```

*-----
+ vth0=0.72        lvth0=0.025          nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2         dvt1=0.53           dvt2=-1.521E-01
*-----

```

Figure 75 Threshold Voltage as a Function of Gate Length Due to Lateral Non-Uniform Doping

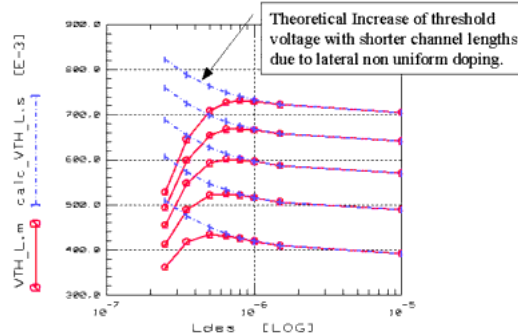


Figure 76 Influence of Short Channel Effects on the Threshold Voltage

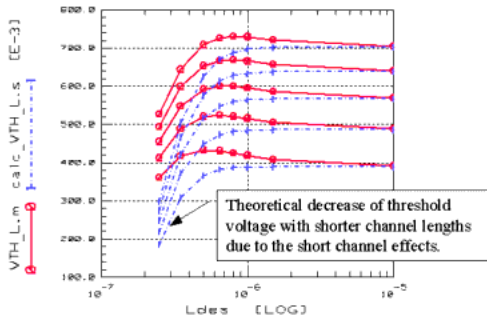
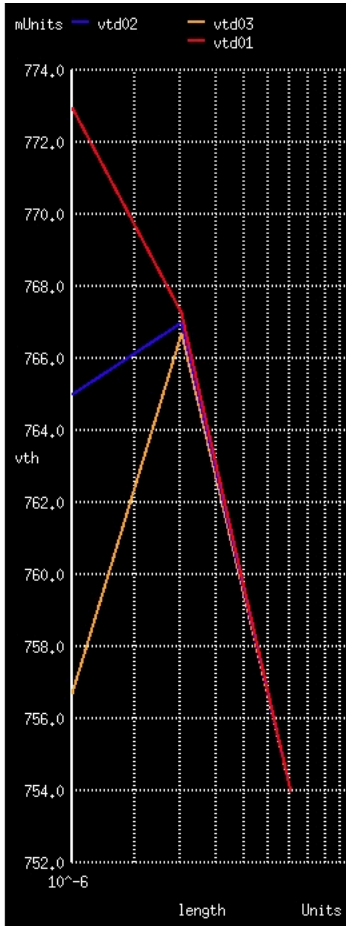
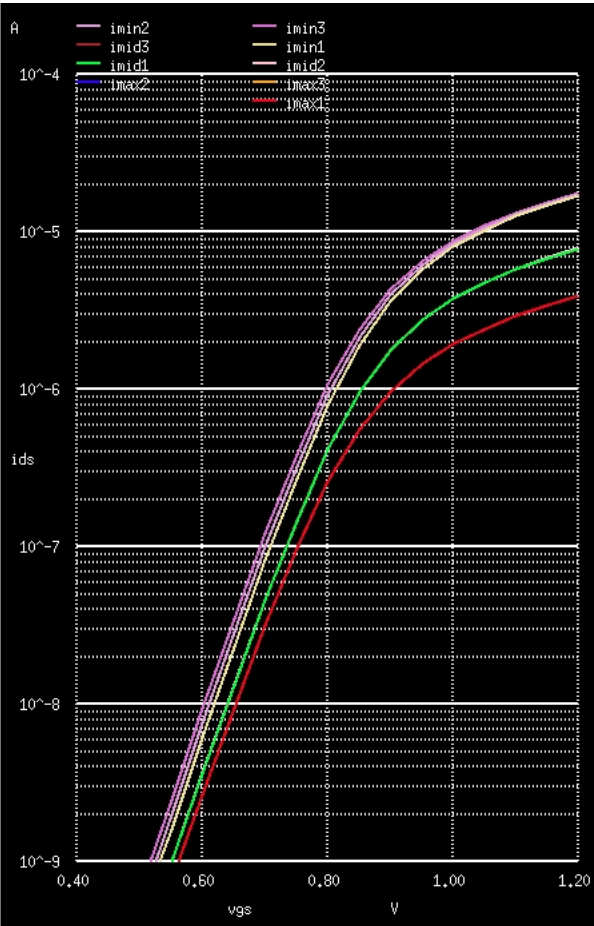
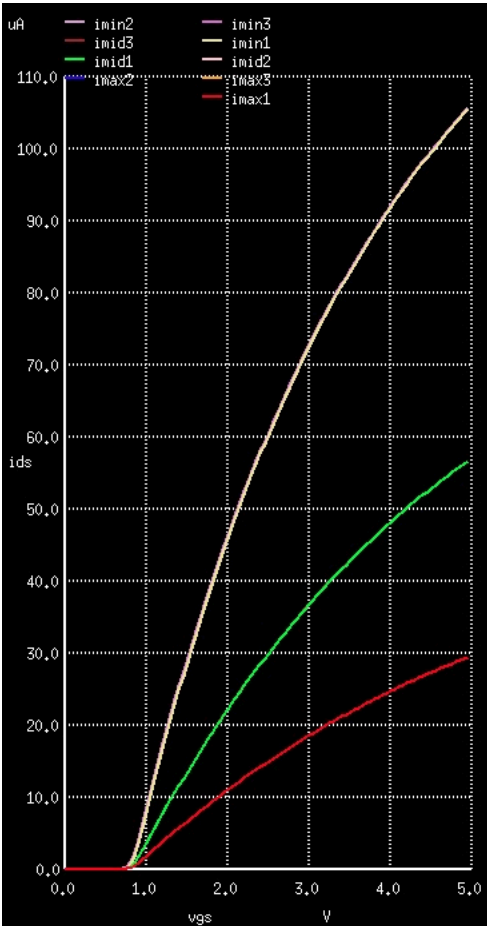
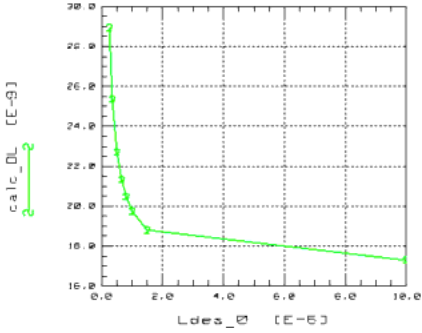
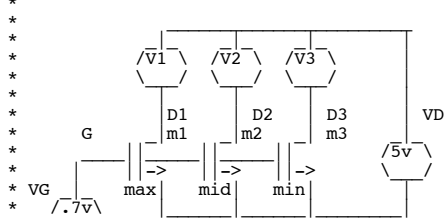


Figure 81 Channel Length Reduction ΔL as a Function of Channel Length L



NMOS_DVT0 dvt0=1.8 2.2 2.6




```

end
let n = n + 1
endrepeat
*print      nx1 nx2 nx3 nd1 nd2 nd3 nn1 nn2 nn3
let vstep= g[1] -g[0]
* =====find zero crossings solving this equation { y = mx+b }=====
let vtx1 = - imax1[nx1]/dimax1[nx1] +vstep*nx1 -.1/2
let vtx2 = - imax2[nx2]/dimax2[nx2] +vstep*nx2 -.1/2
let vtx3 = - imax3[nx3]/dimax1[nx3] +vstep*nx3 -.1/2
let vtd1 = - imid1[nd1]/dimid1[nd1] +vstep*nd1 -.1/2
let vtd2 = - imid2[nd2]/dimid2[nd2] +vstep*nd2 -.1/2
let vtd3 = - imid3[nd3]/dimid1[nd3] +vstep*nd3 -.1/2
let vtn1 = - imin1[nn1]/dimin1[nn1] +vstep*nn1 -.1/2
let vtn2 = - imin2[nn2]/dimin2[nn2] +vstep*nn2 -.1/2
let vtn3 = - imin3[nn3]/dimin1[nn3] +vstep*nn3 -.1/2
print vtx1 vtx2 vtx3 vtd1 vtd2 vtd3 vtn1 vtn2 vtn3

* =====construct plots for length vs three values=====
let vtd01 = vector(3)
let vtd02 = vector(3)
let vtd03 = vector(3)
let lvals = vector(3)
let vtd01[0] = vtx1
let vtd01[1] = vtd1
let vtd01[2] = vtn1
let vtd02[0] = vtx2
let vtd02[1] = vtd2
let vtd02[2] = vtn2
let vtd03[0] = vtx3
let vtd03[1] = vtd3
let vtd03[2] = vtn3
let lvals[0] = 4u
let lvals[1] = 2u
let lvals[2] = 1u
plot      vtd01 vtd02 vtd03 vs xlog lvals xlabel length ylabel VTH
.endc

```

```

.model      N1      NMOS
+ Level= 49      Tnom=27.0      version=3.24
+ mobmod=2      capmod=3      noimod=2
**-----Process-----
+ tox=160e-10    toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----V threshold-----
+ vth0=0.72      lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2      dvt1=0.53      dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04      wint=0.16e-06    ww=-9.525E-14     wwn=1.0
+ dvt0w=0        dvt1w=5.3e6      dvt2w=-1.E-01     dwg=0
+ k3=2.53        k3b=-5
*-----Bulk-----
+ k1=1.04        k2=-1.209E-01    kt2=-0.2916
+ cdsc=-2.4E-4   cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678         ua=8.964e-10     ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176     ual=5.705e-09    ub1=-1.147E-17    ucl=-1.302E-01
+ vsat=86000     at=20380         elm=2
*-----Resistance-----
+ rsh=70         rdsw=375         prt=-3.287E+02
+ wr=0.7586      prwb=0           prwg=-4.441E-17
*-----VAR-----
+ lint=.12e-06   pclm=.19         pscbe1=3.79e+08    pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39     pdiblc2=0.0086     drout=0.56
*-----Subthreshold-----
+ nfactor=1.8    cit=-5.0E-04     voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01     dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2        pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551        pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873      pbsw=0.8
+ cgso=9e-13     cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07      xpart=0
*-----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10     xti=2.000e+00     nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7         a1=1             a2=1               ags=0.05583
+ b0=6.305e-08   b1=6.579e-08     keta=-1.531E-02
*-----Noise????-----
+ af=1           kf=0             ef=1               em=4.1E+07
+ noia=1E+20     noib=50000       noic=-1.4E-12
*-----dIdW????-----
+ w1=0           wln=1           ww1=0
+ l1=0           lln=1           lw=0               lwn=1
+ lwl=0          llc=2E-13       lwc=0               lwlc=0
+ wlc=0          wwc=0           wwlc=0
*-----Bsim???-----
+ wk3=0          lk3=0           pk3=1.257
+ lk3b=0         wk3b=0          pk3b=0
+ pa0=0.0489     la0=-1.052      lags=0.01093
+ wags=0          pags=0.1573     lketa=0
+ wdwg=0          ldwb=0          wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0          lu0=0              ldwg=0
+ uc1=-1.098E-11 acm=13          wu0=1
+ wua=3.641E-11 lua=9.782E-10  pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19  pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----

```



```

let imid2=dc2.i(v2)
let imid3=dc3.i(v2)
let imin1=dc1.i(v3)
let imin2=dc2.i(v3)
let imin3=dc3.i(v3)
plot      imax1 imax2 imax3  imid1 imid2 imid3 imin1 imin2 imin3  ylabel ids xlabel vgs
*plot     imax1 imax2 imax3  imid1 imid2 imid3 imin1 imin2 imin3  ylabel ids xlabel vgs ylog
plot      imax1 imax2 imax3  imid1 imid2 imid3 imin1 imin2 imin3  ylabel ids xlabel vgs ylog xlimit .4 1.2 ylimit 1n 100u
* =====find slopes=====
let dimax1= deriv(imax1)
let dimax2= deriv(imax2)
let dimax3= deriv(imax3)
let dimid1= deriv(imid1)
let dimid2= deriv(imid2)
let dimid3= deriv(imid3)
let dimin1= deriv(imin1)
let dimin2= deriv(imin2)
let dimin3= deriv(imin3)
*plot     dimax1 dimax2 dimax3 dimid1 dimid2 dimid3 dimin1 dimin2 dimin3
* =====find maximum of slopes =====
let mximax1 = vecmax(dimax1)
let mximax2 = vecmax(dimax2)
let mximax3 = vecmax(dimax3)
let mximid1 = vecmax(dimid1)
let mximid2 = vecmax(dimid2)
let mximid3 = vecmax(dimid3)
let mximin1 = vecmax(dimin1)
let mximin2 = vecmax(dimin2)
let mximin3 = vecmax(dimin3)
*print    mximax1 mximax2 mximax3 mximid1 mximid2 mximid3 mximin1 mximin2 mximin3
let numb  = length(imax1)
*print numb
* =====find index for each maximum of slopes=====
let n = 0
let nx1 = 0
let nx2 = 0
let nx3 = 0
let nd1 = 0
let nd2 = 0
let nd3 = 0
let nn1 = 0
let nn2 = 0
let nn3 = 0
repeat $&numb
if ( dimax1[n] >= mximax1 )
let nx1 = n
end
if ( dimax2[n] >= mximax2 )
let nx2 = n
end
if ( dimax3[n] >= mximax3 )
let nx3 = n
end
if ( dimid1[n] >= mximid1 )
let nd1 = n
end
if ( dimid2[n] >= mximid2 )
let nd2 = n
end
if ( dimid3[n] >= mximid3 )
let nd3 = n
end
if ( dimin1[n] >= mximin1 )
let nn1 = n
end
if ( dimin2[n] >= mximin2 )
let nn2 = n
end
if ( dimin3[n] >= mximin3 )
let nn3 = n
end
let n = n +1
endrepeat
*print nx1 nx2 nx3 nd1 nd2 nd3 nn1 nn2 nn3
let vstep= g[1] -g[0]
* =====find zero crossings solving this equation { y = mx+b }=====
let vtx1 = - imax1[nx1]/dimax1[nx1] +vstep*nx1 -.1/2
let vtx2 = - imax2[nx2]/dimax2[nx2] +vstep*nx2 -.1/2
let vtx3 = - imax3[nx3]/dimax1[nx3] +vstep*nx3 -.1/2
let vtd1 = - imid1[nd1]/dimid1[nd1] +vstep*nd1 -.1/2
let vtd2 = - imid2[nd2]/dimid2[nd2] +vstep*nd2 -.1/2
let vtd3 = - imid3[nd3]/dimid1[nd3] +vstep*nd3 -.1/2
let vtn1 = - imin1[nn1]/dimin1[nn1] +vstep*nn1 -.1/2
let vtn2 = - imin2[nn2]/dimin2[nn2] +vstep*nn2 -.1/2
let vtn3 = - imin3[nn3]/dimin1[nn3] +vstep*nn3 -.1/2
print vtx1 vtx2 vtx3 vtd1 vtd2 vtd3 vtn1 vtn2 vtn3

* =====construct plots for length vs three values=====
let vtd01 = vector(3)
let vtd02 = vector(3)
let vtd03 = vector(3)
let lvals = vector(3)

let vtd01[0] = vtx1
let vtd01[1] = vtd1
let vtd01[2] = vtn1
let vtd02[0] = vtx2
let vtd02[1] = vtd2
let vtd02[2] = vtn2
let vtd03[0] = vtx3
let vtd03[1] = vtd3
let vtd03[2] = vtn3

```

```

let lvals[0] = 4u
let lvals[1] = 2u
let lvals[2] = 1u
plot vtd01 vtd02 vtd03 vs xlog lvals xlabel length ylabel VTH
.endc

```

```

.model          N1          NMOS
+ Level= 49      Tnom=27.0    version=3.24
+ mobmod=2      capmod=3      noimod=2
**-----Process-----
+ tox=160e-10   toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06    nch=0.5e+17
*-----V threshold-----
+ vth0=0.72     lvth0=0.025    nlx=0.12e-06    kt1=-0.9821
+ dvt0=2.2      dvt1=0.53      dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04    wint=0.16e-06  ww=-9.525E-14   wwn=1.0
+ dvt0w=0       dvt1w=5.3e6    dvt2w=-1.E-01   dwb=0
+ k3=2.53       k3b=-5         dwg=0
*-----Bulk-----
+ k1=1.04       k2=-1.209E-01  kt2=-0.2916
+ cdscc=-2.4E-4 cdsccb=-1.506E-04 cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678        ua=8.964e-10   ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176    ual=5.705e-09  ubl=-1.147E-17  ucl=-1.302E-01
+ vsat=86000    at=20380       elm=2
*-----Resistance-----
+ rsh=70        rdsw=375       prt=-3.287E+02
+ wr=0.7586     prwb=0         prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06  pclm=.19       pscbel=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39   pdiblc2=0.0086   drout=0.56
*-----Subthreshold-----
+ nfactor=1.8   cit=-5.0E-04   voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01   dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2      pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551     pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873   pbsw=0.8
+ cgso=9e-13    cgdo=9e-13    cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07   xpart=0
*-----BulkDiode-----
+ js=5.858e-08  jsw=1.25E-10   xti=2.000e+00   nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7         a1=1           a2=1             ags=0.05583
+ b0=6.305e-08  b1=6.579e-08  keta=-1.531E-02
*-----Noise????-----
+ af=1           kf=0           ef=1             em=4.1E+07
+ noia=1E+20     noib=50000     noic=-1.4E-12
*-----dLdW????-----
+ wl=0           wln=1          wwl=0
+ ll=0           lln=1          lw=0             lwn=1
+ lwl=0          llc=2E-13     lwc=0            lwlc=0
+ wlc=0          wwc=0          wwlc=0
*-----Bsim???-----
+ wk3=0          lk3=0          pk3=1.257
+ lk3b=0         wk3b=0         pk3b=0
+ pa0=0.0489    la0=-1.052     lags=0.01093
+ wags=0         pags=0.1573    lketa=0
+ wdwg=0         ldwb=0         wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0         lu0=0            ldwg=0
+ uc1=-1.098E-11 acm=13         wu0=1
+ wua=3.641E-11 lua=9.782E-10  pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19  pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ ngsmod         lmlt=1.000e+00 wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00

```

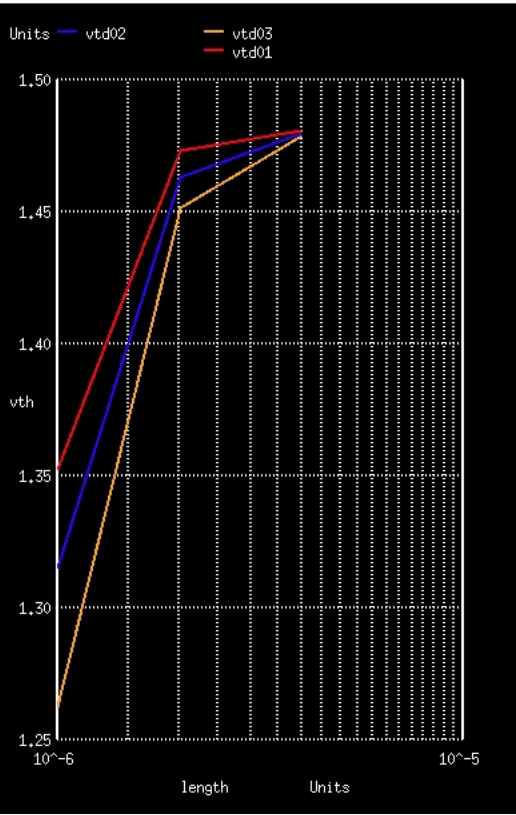
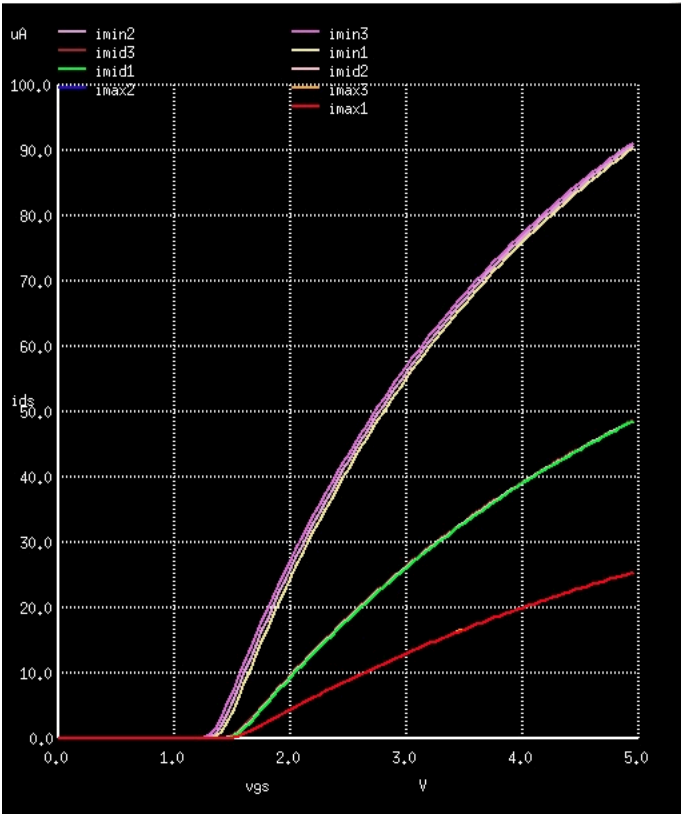
```
.end
```

```
* source /Users/don_sauer/Downloads/stable/SI_Lib/Tests.cir
```

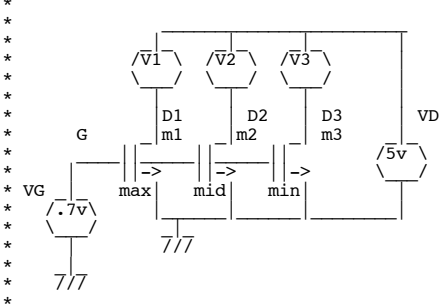
```

=====DVT2=BodyCoefficientShort-channelOnVth=====
*-----V threshold-----
+ vth0=0.72     lvth0=0.025    nlx=0.12e-06    kt1=-0.9821
+ dvt0=2.2      dvt1=0.53      dvt2=-1.521E-01
*-----

```



NMOS_DVT2 dvt2=-1.021E-01 -1.521E-01 -2.021E-01



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
VD      D      0      dc      .1v
VG      G      0      dc      5v
VB      B      0      dc      -3v
v1      D      1      dc      0v
v2      D      2      dc      0v
v3      D      3      dc      0v
m1      1      G      0      B      N1      W=3u   L=4u   AD=7p  AS=7p  PD=10u  PS=10u
m2      2      G      0      B      N1      W=3u   L=2u   AD=7p  AS=7p  PD=10u  PS=10u
m3      3      G      0      B      N1      W=3u   L=1u   AD=7p  AS=7p  PD=10u  PS=10u

.control
destroy all
altermod N1 dvt2=-1.021E-01
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc VG 1m 5 0.05
altermod N1 dvt2=-1.521E-01
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc VG 1m 5 0.05
altermod N1 dvt2=-2.021E-01
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc VG 1m 5 0.05
* =====collect nine dc plots =====
let imax1=dc1.i(v1)
let imax2=dc2.i(v1)
let imax3=dc3.i(v1)
let imid1=dc1.i(v2)
let imid2=dc2.i(v2)
let imid3=dc3.i(v2)
let imin1=dc1.i(v3)
let imin2=dc2.i(v3)
let imin3=dc3.i(v3)
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs
*plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog xlimit .4 1.2 ylimit 1n 100u
* =====find slopes =====
let dimax1= deriv(imax1)
let dimax2= deriv(imax2)

```

```

let dimax3= deriv(imax3)
let dimid1= deriv(imid1)
let dimid2= deriv(imid2)
let dimid3= deriv(imid3)
let dimin1= deriv(imin1)
let dimin2= deriv(imin2)
let dimin3= deriv(imin3)
*plot      dimax1 dimax2 dimax3 dimid1 dimid2 dimid3 dimin1 dimin2 dimin3
* =====find maximum of slopes =====
let mximax1 = vecmax(dimax1)
let mximax2 = vecmax(dimax2)
let mximax3 = vecmax(dimax3)
let mximid1 = vecmax(dimid1)
let mximid2 = vecmax(dimid2)
let mximid3 = vecmax(dimid3)
let mximin1 = vecmax(dimin1)
let mximin2 = vecmax(dimin2)
let mximin3 = vecmax(dimin3)
*print      mximax1 mximax2 mximax3 mximid1 mximid2 mximid3 mximin1 mximin2 mximin3
let numb    = length(imax1)
*print      numb
* =====find index for each maximum of slopes=====
let n      = 0
let nx1    = 0
let nx2    = 0
let nx3    = 0
let nd1    = 0
let nd2    = 0
let nd3    = 0
let nn1    = 0
let nn2    = 0
let nn3    = 0
repeat $numb
if ( dimax1[n] >= mximax1 )
let nx1 = n
end
if ( dimax2[n] >= mximax2 )
let nx2 = n
end
if ( dimax3[n] >= mximax3 )
let nx3 = n
end
if ( dimid1[n] >= mximid1 )
let nd1 = n
end
if ( dimid2[n] >= mximid2 )
let nd2 = n
end
if ( dimid3[n] >= mximid3 )
let nd3 = n
end
if ( dimin1[n] >= mximin1 )
let nn1 = n
end
if ( dimin2[n] >= mximin2 )
let nn2 = n
end
if ( dimin3[n] >= mximin3 )
let nn3 = n
end
let n = n +1
endrepeat
*print      nx1 nx2 nx3 nd1 nd2 nd3 nn1 nn2 nn3
let vstep=  g[1] -g[0]
* =====find zero crossings solving this equation { y = mx+b }=====
let vtx1 = - imax1[nx1]/dimax1[nx1] +vstep*nx1 -.1/2
let vtx2 = - imax2[nx2]/dimax2[nx2] +vstep*nx2 -.1/2
let vtx3 = - imax3[nx3]/dimax1[nx3] +vstep*nx3 -.1/2
let vtd1 = - imid1[nd1]/dimid1[nd1] +vstep*nd1 -.1/2
let vtd2 = - imid2[nd2]/dimid2[nd2] +vstep*nd2 -.1/2
let vtd3 = - imid3[nd3]/dimid1[nd3] +vstep*nd3 -.1/2
let vtn1 = - imin1[nn1]/dimin1[nn1] +vstep*nn1 -.1/2
let vtn2 = - imin2[nn2]/dimin2[nn2] +vstep*nn2 -.1/2
let vtn3 = - imin3[nn3]/dimin1[nn3] +vstep*nn3 -.1/2
print      vtx1 vtx2 vtx3 vtd1 vtd2 vtd3 vtn1 vtn2 vtn3

* =====construct plots for length vs three values=====
let vtd01  = vector(3)
let vtd02  = vector(3)
let vtd03  = vector(3)
let lvals  = vector(3)

let vtd01[0] = vtx1
let vtd01[1] = vtd1
let vtd01[2] = vtn1
let vtd02[0] = vtx2
let vtd02[1] = vtd2
let vtd02[2] = vtn2
let vtd03[0] = vtx3
let vtd03[1] = vtd3
let vtd03[2] = vtn3
let lvals[0] = 4u
let lvals[1] = 2u
let lvals[2] = 1u
plot      vtd01 vtd02 vtd03 vs xlog lvals xlabel length ylabel VTH

.endc

.model          N1          NMOS
+ Level= 49      Tnom=27.0   version=3.24
+ mobmod=2      capmod=3    noimod=2
**-----Process-----

```

```

+ tox=160e-10      toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
* -----V threshold-----
+ vth0=0.72        lvth0=0.025       nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2         dvt1=0.53         dvt2=-1.521E-01
* -----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06     ww=-9.525E-14     wwn=1.0
+ dvt0w=0          dvt1w=5.3e6       dvt2w=-1.E-01     dwg=0
+ k3=2.53          k3b=-5            dwg=0              dwb=0
* -----Bulk-----
+ k1=1.04          k2=-1.209E-01     kt2=-0.2916
+ cdscc=-2.4E-4   cdscc=-1.506E-04  cdscc=-2.219E-04
* -----Mobility-----
+ u0=678           ua=8.964e-10      ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09     ubl=-1.147E-17    ucl=-1.302E-01
+ vsat=86000       at=20380          elm=2
* -----Resistance-----
+ rsh=70           rdsw=375          prt=-3.287E+02
+ wr=0.7586        prwb=0            prwg=-4.441E-17
* -----VAF-----
+ lint=.12e-06     pclm=.19          pscbel=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39     pdiblc2=0.0086    drout=0.56
* -----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04      voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01      dsub=0.7
* -----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05  beta0=36.68
* -----Capacitance-----
+ cjswg=2.73e-10   mjswg=0.2         pbswg=8.800e-01
+ cj=0.0002424     mj=0.3551         pb=0.5614
+ cjsw=2.73e-10   mjsw=0.3873       pbsw=0.8
+ cgso=9e-13       cgdo=9e-13        cgbo=7e-10
+ dlc=5e-08        dwc=1.5e-07       xpart=0
* -----BulkDiode-----
+ js=5.858e-08     jsw=1.25E-10      xti=2.000e+00     nj=1.08
* -----BulkChargeEffect-----
+ a0=0.7           a1=1              a2=1
+ b0=6.305e-08    bl=6.579e-08     keta=-1.531E-02   ags=0.05583
* -----Noise????-----
+ af=1             kf=0              ef=1              em=4.1E+07
+ noia=1E+20       noib=50000        noic=-1.4E-12
* -----dLdw????-----
+ wl=0             wln=1             wwl=0
+ ll=0             lln=1             lw=0              lwn=1
+ lwl=0            llc=2E-13         lwc=0             lwlc=0
+ wlc=0            wwc=0             wwlc=0
* -----Bsim???-----
+ wk3=0            lk3=0             pk3=1.257
+ lk3b=0           wk3b=0            pk3b=0
+ pa0=0.0489       la0=-1.052        lags=0.01093
+ wags=0           pags=0.1573       lketa=0
+ wdwg=0           ldwb=0            wdwb=0
* -----HspiceBSIM4???-----
+ hdif=2.7E-07     ldif=0            lu0=0             ldwg=0
+ uc1=-1.098E-11   acm=13            wu0=1
+ wua=3.641E-11    lua=9.782E-10     pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20    pub=8.812E-19     pu0=1
+ wuc=1.177E-11    luc=-2.164E-10    puc=1.231E-10
* -----Flagged!!-----
+ nqsmod           lmlt=1.000e+00    wmlt=1.000e+00
* tlev=0.000e+00  tlevc=0.000e+00
* -----

```

.end

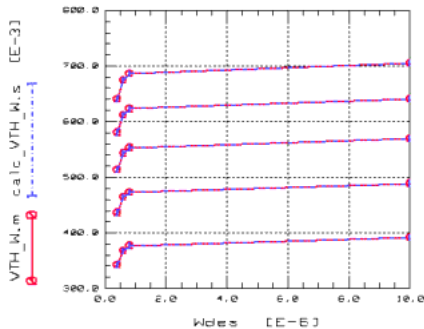
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

=====W0=NarrowWidthParameter=====
* -----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06     ww=-9.525E-14     wwn=1.0
+ dvt0w=0          dvt1w=5.3e6       dvt2w=-1.E-01     dwg=0
+ k3=2.53          k3b=-5            dwg=0              dwb=0
* -----

```

Figure 77 Influence of Narrow Channel Effects on the Threshold Voltage




```

plot      imax1 imax2 imax3  imid1 imid2 imid3  imin1 imin2 imin3  ylabel ids xlabel  vgs ylog  xlimit .4 1.2 ylimit 1n 100u
* =====find slopes=====
let dimax1= deriv(imax1)
let dimax2= deriv(imax2)
let dimax3= deriv(imax3)
let dimid1= deriv(imid1)
let dimid2= deriv(imid2)
let dimid3= deriv(imid3)
let dimin1= deriv(imin1)
let dimin2= deriv(imin2)
let dimin3= deriv(imin3)
*plot      dimax1 dimax2 dimax3 dimid1 dimid2 dimid3 dimin1 dimin2 dimin3
* =====find maximum of slopes =====
let mximax1 = vecmax(dimax1)
let mximax2 = vecmax(dimax2)
let mximax3 = vecmax(dimax3)
let mximid1 = vecmax(dimid1)
let mximid2 = vecmax(dimid2)
let mximid3 = vecmax(dimid3)
let mximin1 = vecmax(dimin1)
let mximin2 = vecmax(dimin2)
let mximin3 = vecmax(dimin3)
*print      mximax1 mximax2 mximax3 mximid1 mximid2 mximid3 mximin1 mximin2 mximin3
let numb    = length(imax1)
*print      numb
* =====find index for each maximum of slopes=====
let n      = 0
let nx1    = 0
let nx2    = 0
let nx3    = 0
let nd1    = 0
let nd2    = 0
let nd3    = 0
let nn1    = 0
let nn2    = 0
let nn3    = 0
repeat $&numb
if ( dimax1[n] >= mximax1 )
let nx1 = n
end
if ( dimax2[n] >= mximax2 )
let nx2 = n
end
if ( dimax3[n] >= mximax3 )
let nx3 = n
end
if ( dimid1[n] >= mximid1 )
let nd1 = n
end
if ( dimid2[n] >= mximid2 )
let nd2 = n
end
if ( dimid3[n] >= mximid3 )
let nd3 = n
end
if ( dimin1[n] >= mximin1 )
let nn1 = n
end
if ( dimin2[n] >= mximin2 )
let nn2 = n
end
if ( dimin3[n] >= mximin3 )
let nn3 = n
end
let n = n +1
endrepeat
*print      nx1 nx2 nx3 nd1 nd2 nd3 nn1 nn2 nn3
let vstep=  g[1] -g[0]
* =====find zero crossings solving this equation { y = mx+b }=====
let vtx1 = - imax1[nx1]/dimax1[nx1] +vstep*nx1 -.1/2
let vtx2 = - imax2[nx2]/dimax2[nx2] +vstep*nx2 -.1/2
let vtx3 = - imax3[nx3]/dimax1[nx3] +vstep*nx3 -.1/2
let vtd1 = - imid1[nd1]/dimid1[nd1] +vstep*nd1 -.1/2
let vtd2 = - imid2[nd2]/dimid2[nd2] +vstep*nd2 -.1/2
let vtd3 = - imid3[nd3]/dimid1[nd3] +vstep*nd3 -.1/2
let vtn1 = - imin1[nn1]/dimin1[nn1] +vstep*nn1 -.1/2
let vtn2 = - imin2[nn2]/dimin2[nn2] +vstep*nn2 -.1/2
let vtn3 = - imin3[nn3]/dimin1[nn3] +vstep*nn3 -.1/2
print      vtx1 vtx2 vtx3 vtd1 vtd2 vtd3 vtn1 vtn2 vtn3

* =====construct plots for length vs three values=====
let vtd01  = vector(3)
let vtd02  = vector(3)
let vtd03  = vector(3)
let lvals  = vector(3)

let vtd01[0] = vtx1
let vtd01[1] = vtd1
let vtd01[2] = vtn1
let vtd02[0] = vtx2
let vtd02[1] = vtd2
let vtd02[2] = vtn2
let vtd03[0] = vtx3
let vtd03[1] = vtd3
let vtd03[2] = vtn3
let lvals[0] = 6u
let lvals[1] = 3u
let lvals[2] = 1u
plot      vtd01 vtd02 vtd03 vs xlog lvals  xlabel width  ylabel VTH
.endc

.model      N1      NMOS

```

```

+ Level= 49          Tnom=27.0          version=3.24
+ mobmod=2          capmod=3          noimod=2
**-----Process-----
+ tox=160e-10       toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----V threshold-----
+ vth0=0.72        lvth0=0.025      nlx=0.12e-06    kt1=-0.9821
+ dvt0=2.2         dvt1=0.53        dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06    ww=-9.525E-14   wwn=1.0
+ dvt0w=0          dvt1w=5.3e6      dvt2w=-1.E-01   dwg=0
+ k3=2.53          k3b=-5           dwb=0
*-----Bulk-----
+ k1=1.04          k2=-1.209E-01    kt2=-0.2916
+ cdscc=-2.4E-4    cdscc=-1.506E-04 cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678           ua=8.964e-10     ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09    ub1=-1.147E-17  ucl=-1.302E-01
+ vsat=86000       at=20380         elm=2
*-----Resistance-----
+ rsh=70           rdsw=375         prt=-3.287E+02
+ wr=0.7586        prwb=0           prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06     pclm=.19          pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39     pdiblc2=0.0086   drou=0.56
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04     voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01     dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10   mjswg=0.2        pbswg=8.800e-01
+ cj=0.0002424     mj=0.3551        pb=0.5614
+ cjsw=2.73e-10    mjsw=0.3873      pbsw=0.8
+ cgso=9e-13       cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08        dwc=1.5e-07      xpart=0
*-----BulkDiode-----
+ js=5.858e-08     jsw=1.25E-10     xti=2.000e+00    nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7           a1=1             a2=1             ags=0.05583
+ b0=6.305e-08     bi=6.579e-08     keta=-1.531E-02
*-----Noise????-----
+ af=1             kf=0             ef=1             em=4.1E+07
+ noia=1E+20       noib=50000       noic=-1.4E-12
*-----dLdW????-----
+ wl=0             wln=1            wwl=0
+ ll=0             lln=1            lw=0             lwn=1
+ lw1=0           llc=2E-13        lwc=0            lwlc=0
+ wlc=0           wwc=0            wwlc=0
*-----Bsim??-----
+ wk3=0           lk3=0            pk3=1.257
+ lk3b=0          wk3b=0           pk3b=0
+ pa0=0.0489      la0=-1.052       lags=0.01093
+ wags=0          pags=0.1573      lketa=0
+ wdwg=0          ldwb=0           wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07     ldif=0           lu0=0            ldwg=0
+ uc1=-1.098E-11   acm=13           wu0=1
+ wua=3.641E-11    lua=9.782E-10    pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20    pub=8.812E-19    pu0=1
+ wuc=1.177E-11    luc=-2.164E-10   puc=1.231E-10
*-----Flagged!!-----
+ ngsmo           lmlt=1.000e+00   wmlt=1.000e+00
+ tlev=0.000e+00  tlevc=0.000e+00
*-----

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

=====WINT=Channel-widthOffsetParameter=====
*-----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06    ww=-9.525E-14   wwn=1.0
+ dvt0w=0          dvt1w=5.3e6      dvt2w=-1.E-01   dwg=0
+ k3=2.53          k3b=-5           dwb=0
*-----

```

Figure 82 Influence of Channel Width Reduction on the Drain Current


```

*
*
*
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
VD      D      0      dc      5v
VG      G      0      dc      5v
VB      B      0      dc      0v
v1      D      1      dc      0v
v2      D      2      dc      0v
v3      D      3      dc      0v
m1      1      G      0      B      N1      W=6u    L=1u    AD=7p  AS=7p  PD=10u  PS=10u
m2      2      G      0      B      N1      W=3u    L=1u    AD=7p  AS=7p  PD=10u  PS=10u
m3      3      G      0      B      N1      W=1u    L=1u    AD=7p  AS=7p  PD=10u  PS=10u

.control
destroy all
altermod N1 wint=0.10e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc VG 1m 5 0.1
altermod N1 wint=0.16e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc VG 1m 5 0.1
altermod N1 wint=0.20e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc VG 1m 5 0.1

let imax1=dc1.i(v1)
let imax2=dc2.i(v1)
let imax3=dc3.i(v1)
let imid1=dc1.i(v2)
let imid2=dc2.i(v2)
let imid3=dc3.i(v2)
let imin1=dc1.i(v3)
let imin2=dc2.i(v3)
let imin3=dc3.i(v3)
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog xlimit .6 2 ylimit 1n 100u

.endc

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ubl=-1.147E-17 ucl=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbel=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drout=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dLdW????-----
+ wl=0 wln=1 wwl=0
+ ll=0 lln=1 lw=0 lwn=1
+ lwl=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----Bsim??-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1

```



```

let imid1=dc1.i(v2)
let imid2=dc2.i(v2)
let imid3=dc3.i(v2)
let imin1=dc1.i(v3)
let imin2=dc2.i(v3)
let imin3=dc3.i(v3)
plot   imax1 imax2 imax3   imid1 imid2 imid3   imin1 imin2 imin3   ylabel ids xlabel   vgs
plot   imax1 imax2 imax3   imid1 imid2 imid3   imin1 imin2 imin3   ylabel ids xlabel   vgs ylog
plot   imax1 imax2 imax3   imid1 imid2 imid3   imin1 imin2 imin3   ylabel ids xlabel   vgs ylog   xlimit .6 2 ylimit 1n 100u

```

.endc

```

.model          N1          NMOS
+ Level= 49      Tnom=27.0    version=3.24
+ mobmod=2       capmod=3     noimod=2
**-----Process-----
+ tox=160e-10    toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06    nch=0.5e+17
*-----V threshold-----
+ vth0=0.72      lvth0=0.025    nlx=0.12e-06    kt1=-0.9821
+ dvt0=2.2       dvt1=0.53      dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04     wint=0.16e-06  ww=-9.525E-14   wwn=1.0
+ dvt0w=0       dvt1w=5.3e6   dvt2w=-1.E-01
+ k3=2.53       k3b=-5        dwg=0           dwb=0
*-----Bulk-----
+ k1=1.04        k2=-1.209E-01  kt2=-0.2916
+ cdscc=-2.4E-4  cdsd=-1.506E-04 cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678         ua=8.964e-10   ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176    ua1=5.705e-09  ub1=-1.147E-17  uc1=-1.302E-01
+ vsat=86000     at=20380       elm=2
*-----Resistance-----
+ rsh=70         rdsw=375       prt=-3.287E+02
+ wr=0.7586     prwb=0       prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06   pclm=.19       pscbel=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39   pdiblc2=0.0086   drou=0.56
*-----Subthreshold-----
+ nfactor=1.8    cit=-5.0E-04   voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2      pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551     pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873   pbsw=0.8
+ cgso=9e-13     cgdo=9e-13    cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07   xpart=0
*-----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10  xti=2.000e+00   nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7         a1=1           a2=1
+ b0=6.305e-08  b1=6.579e-08 keta=-1.531E-02 ags=0.05583
*-----Noise????-----
+ af=1           kf=0           ef=1             em=4.1E+07
+ noia=1E+20     noib=50000     noic=-1.4E-12
*-----dLdW????-----
+ wl=0           wln=1          wwl=0
+ ll=0           lln=1          lw=0             lwn=1
+ lwl=0          llc=2E-13      lwc=0            lwlc=0
+ wlc=0          wwc=0          wwlc=0
*-----Bsim???-----
+ wk3=0          lk3=0          pk3=1.257
+ lk3b=0         wk3b=0         pk3b=0
+ pa0=0.0489     la0=-1.052     lags=0.01093
+ wags=0         pags=0.1573   lketa=0
+ wdwg=0         ldwb=0         wdw=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0         lu0=0            ldwg=0
+ uc1=-1.098E-11 acm=13         wu0=1
+ wua=3.641E-11 lua=9.782E-10  puu=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19  pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ ngsmod         lmlt=1.000e+00 wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00

```

.end

```
* source /Users/don_sauer/Downloads/stable/SI_Lib/Tests.cir
```

```

===== WNN=PowerWidthDependencefoWidthOffset =====
*-----NarrowChannel-----
+ w0=2.6e-04     wint=0.16e-06  ww=-9.525E-14   wwn=1.0
+ dvt0w=0       dvt1w=5.3e6   dvt2w=-1.E-01
+ k3=2.53       k3b=-5        dwg=0           dwb=0

```



```

.model          N1          NMOS
+ Level= 49     Tnom=27.0    version=3.24
+ mobmod=2     capmod=3     noimod=2
**-----Process-----
+ tox=160e-10  toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06    nch=0.5e+17
*-----V threshold-----
+ vth0=0.72    lvth0=0.025    nlx=0.12e-06    kt1=-0.9821
+ dvt0=2.2     dvt1=0.53      dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04   wint=0.16e-06  ww=-9.525E-14   wwn=1.0
+ dvt0w=0      dvt1w=5.3e6    dvt2w=-1.E-01
+ k3=2.53      k3b=-5         dwg=0            dwb=0
*-----Bulk-----
+ k1=1.04      k2=-1.209E-01  kt2=-0.2916
+ cdscc=-2.4E-4 cdscc=-1.506E-04 cdscc=-2.219E-04
*-----Mobility-----
+ u0=678       ua=8.964e-10   ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176   ua1=5.705e-09  ub1=-1.147E-17  uc1=-1.302E-01
+ vsat=86000   at=20380       elm=2
*-----Resistance-----
+ rsh=70       rdsw=375       prt=-3.287E+02
+ wr=0.7586    prwb=0         prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19       pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39   pdiblc2=0.0086   drout=0.56
*-----Subthreshold-----
+ nfactor=1.8  cit=-5.0E-04   voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01   dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2      pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551     pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873   pbsw=0.8
+ cgso=9e-13    cgdo=9e-13    cgbo=7e-10
+ dlcc=5e-08    dwc=1.5e-07   xpart=0
*-----BulkDiode-----
+ js=5.858e-08  jsw=1.25E-10  xti=2.000e+00   nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7        a1=1           a2=1             ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1          kf=0           ef=1             em=4.1E+07
+ noia=1E+20    noib=50000    noic=-1.4E-12
*-----dLdW????-----
+ wl=0          wln=1          ww1=0
+ ll=0          lln=1          lw=0            lwn=1
+ lw1=0         llc=2E-13     lwc=0           lwlc=0
+ wlc=0         wwc=0          wwlc=0
*-----Bsim??-----
+ wk3=0         lk3=0          pk3=1.257
+ lk3b=0        wk3b=0         pk3b=0
+ pa0=0.0489    la0=-1.052     lags=0.01093
+ wags=0         pags=0.1573    lketa=0
+ wdwg=0         ldwb=0         wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07  ldif=0         lu0=0           ldwg=0
+ uc1=-1.098E-11 acm=13         wu0=1
+ wua=3.641E-11 lua=9.782E-10  pua=-4.46E-10  lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19  pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
* ngsmod        lmlt=1.000e+00  wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

=====DVTOW=FirstCoefficientNarrowWidthSmallChannelLength=====
*-----NarrowChannel-----
+ w0=2.6e-04   wint=0.16e-06  ww=-9.525E-14   wwn=1.0
+ dvt0w=0      dvt1w=5.3e6    dvt2w=-1.E-01
+ k3=2.53      k3b=-5         dwg=0            dwb=0
*-----

```



```

+ Level= 49          Tnom=27.0          version=3.24
+ mobmod=2          capmod=3          noimod=2
**-----Process-----
+ tox=160e-10      toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----V threshold-----
+ vth0=0.72        lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2         dvt1=0.53        dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06    ww=-9.525E-14     wwn=1.0
+ dvt0w=0          dvt1w=5.3e6      dvt2w=-1.E-01     dwg=0
+ k3=2.53          k3b=-5           dwb=0
*-----Bulk-----
+ k1=1.04          k2=-1.209E-01    kt2=-0.2916
+ cdscc=-2.4E-4    cdscc=-1.506E-04 cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678           ua=8.964e-10     ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09    ub1=-1.147E-17    ucl=-1.302E-01
+ vsat=86000       at=20380         elm=2
*-----Resistance-----
+ rsh=70           rdsw=375         prt=-3.287E+02
+ wr=0.7586        prwb=0           prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06     pclm=.19          pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39     pdiblc2=0.0086    drou=0.56
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04     voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01     dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10   mjswg=0.2        pbswg=8.800e-01
+ cj=0.0002424    mj=0.3551        pb=0.5614
+ cjsw=2.73e-10   mjsw=0.3873      pbsw=0.8
+ cgso=9e-13      cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08       dwc=1.5e-07      xpart=0
*-----BulkDiode-----
+ js=5.858e-08    jsw=1.25E-10     xti=2.000e+00     nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7           a1=1             a2=1               ags=0.05583
+ b0=6.305e-08    bi=6.579e-08     keta=-1.531E-02
*-----Noise????-----
+ af=1             kf=0             ef=1               em=4.1E+07
+ noia=1E+20      noib=50000       noic=-1.4E-12
*-----dLdW????-----
+ wl=0            wln=1            wwl=0
+ ll=0            lln=1            lw=0               lwn=1
+ lw1=0           llc=2E-13        lwc=0              lwlc=0
+ wlc=0           wwc=0            wwlc=0
*-----Bsim??-----
+ wk3=0           lk3=0            pk3=1.257
+ lk3b=0          wk3b=0           pk3b=0
+ pa0=0.0489     la0=-1.052       lags=0.01093
+ wags=0          pags=0.1573      lketa=0
+ wdwg=0          ldwb=0           wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07    ldif=0           lu0=0              ldwg=0
+ ucl=-1.098E-11  acm=13           wu0=1
+ wua=3.641E-11  lua=9.782E-10    pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20  pub=8.812E-19    pu0=1
+ wuc=1.177E-11  luc=-2.164E-10  puc=1.231E-10
*-----Flagged!!-----
+ ngsmod          lmlt=1.000e+00   wmlt=1.000e+00
+ tlev=0.000e+00  tlevc=0.000e+00
*-----

```

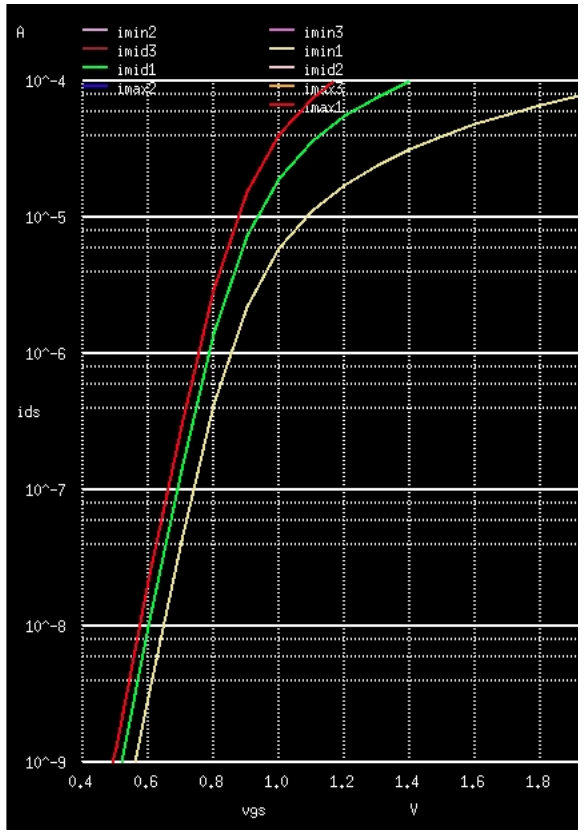
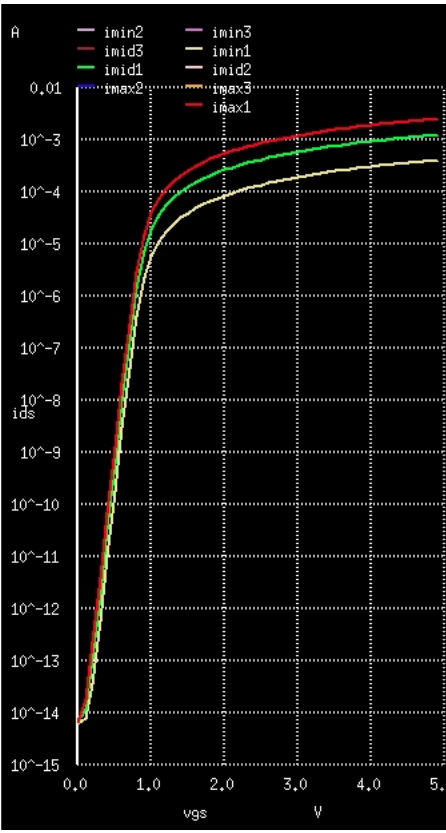
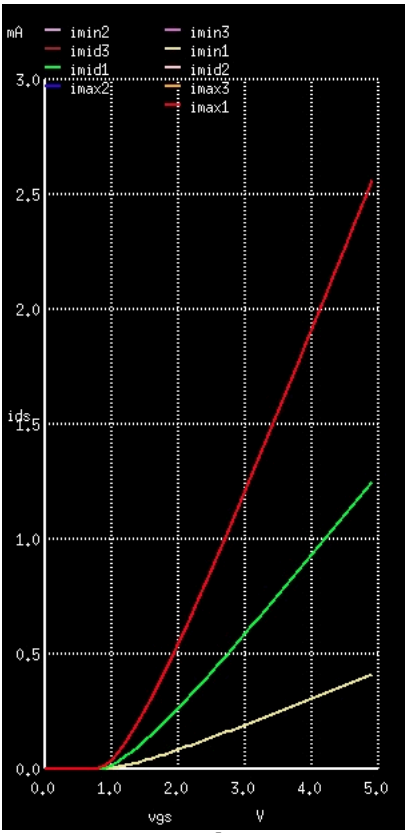
.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Te

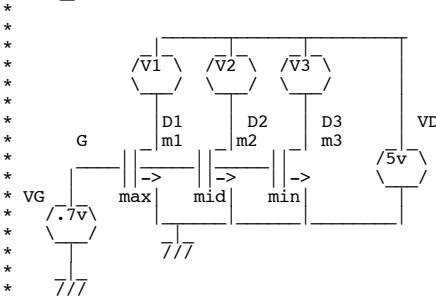
```

=====DVT1W=SecondCoefficientNarrowWidthSmallChannelLength=====
*-----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06    ww=-9.525E-14     wwn=1.0
+ dvt0w=0          dvt1w=5.3e6      dvt2w=-1.E-01     dwg=0
+ k3=2.53          k3b=-5           dwb=0
*-----

```



NMOS_DVT1W dvt1w=5.3e4 5.3e6 5.3e8



```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
```

Component	Type	Value	DC	AC	Model	W	L	AD	AS	PD	PS
VD	D	0	dc	5v							
VG	G	0	dc	5v							
VB	B	0	dc	0v							
v1	D	1	dc	0v	N1	W=6u	L=1u	AD=7p	AS=7p	PD=10u	PS=10u
v2	D	2	dc	0v	N1	W=3u	L=1u	AD=7p	AS=7p	PD=10u	PS=10u
v3	D	3	dc	0v	N1	W=1u	L=1u	AD=7p	AS=7p	PD=10u	PS=10u
m1	1	G	0	B							
m2	2	G	0	B							
m3	3	G	0	B							

```
.control
destroy all
altermod N1 dvt1w=5.3e4
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc VG 1m 5 0.1
altermod N1 dvt1w=5.3e6
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc VG 1m 5 0.1
altermod N1 dvt1w=5.3e8
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc VG 1m 5 0.1
let imax1=dc1.i(v1)
let imax2=dc2.i(v1)
let imax3=dc3.i(v1)
let imid1=dc1.i(v2)
let imid2=dc2.i(v2)
let imid3=dc3.i(v2)
let imin1=dc1.i(v3)
let imin2=dc2.i(v3)
let imin3=dc3.i(v3)
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog xlimit .6 2 ylimit 1n 100u
.endc
```

.model N1 NMOS

```

+ Level= 49          Tnom=27.0          version=3.24
+ mobmod=2          capmod=3          noimod=2
**-----Process-----
+ tox=160e-10      toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----V threshold-----
+ vth0=0.72        lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2         dvt1=0.53        dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06    ww=-9.525E-14     wwn=1.0
+ dvt0w=0          dvt1w=5.3e6      dvt2w=-1.E-01     dwg=0
+ k3=2.53          k3b=-5           dwb=0
*-----Bulk-----
+ k1=1.04          k2=-1.209E-01    kt2=-0.2916
+ cdscc=-2.4E-4    cdscc=-1.506E-04 cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678           ua=8.964e-10     ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09    ub1=-1.147E-17    ucl=-1.302E-01
+ vsat=86000       at=20380         elm=2
*-----Resistance-----
+ rsh=70           rdsw=375         prt=-3.287E+02
+ wr=0.7586        prwb=0           prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06     pclm=.19          pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39     pdiblc2=0.0086    drou=0.56
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04     voff=-7.862E-02   dsub=0.7
+ eta0=4.441e-16  etab=-2.E-01     dsu=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10   mjswg=0.2         pbswg=8.800e-01
+ cj=0.0002424     mj=0.3551         pb=0.5614
+ cjsw=2.73e-10    mjsw=0.3873       pbsw=0.8
+ cgso=9e-13       cgdo=9e-13        cgbo=7e-10
+ dlc=5e-08        dwc=1.5e-07       xpart=0
*-----BulkDiode-----
+ js=5.858e-08     jsw=1.25E-10     xti=2.000e+00     nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7           a1=1             a2=1               ags=0.05583
+ b0=6.305e-08     bi=6.579e-08     keta=-1.531E-02
*-----Noise????-----
+ af=1             kf=0             ef=1               em=4.1E+07
+ noia=1E+20       noib=50000       noic=-1.4E-12
*-----dLdW????-----
+ wl=0             wln=1            wwl=0
+ ll=0             lln=1            lw=0               lwn=1
+ lw1=0           llc=2E-13        lwc=0              lwlc=0
+ wlc=0           wwc=0            wwlc=0
*-----Bsim???-----
+ wk3=0           lk3=0            pk3=1.257
+ lk3b=0          wk3b=0           pk3b=0
+ pa0=0.0489      la0=-1.052       lags=0.01093
+ wags=0          pags=0.1573      lketa=0
+ wdwg=0          ldwb=0           wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07     ldif=0           lu0=0              ldwg=0
+ ucl=-1.098E-11   acm=13          wu0=1
+ wua=3.641E-11    lua=9.782E-10    pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20    pub=8.812E-19    pu0=1
+ wuc=1.177E-11    luc=-2.164E-10   puc=1.231E-10
*-----Flagged!!-----
+ ngsmo           lmlt=1.000e+00   wmlt=1.000e+00
+ tlev=0.000e+00  tlevc=0.000e+00
*-----

```

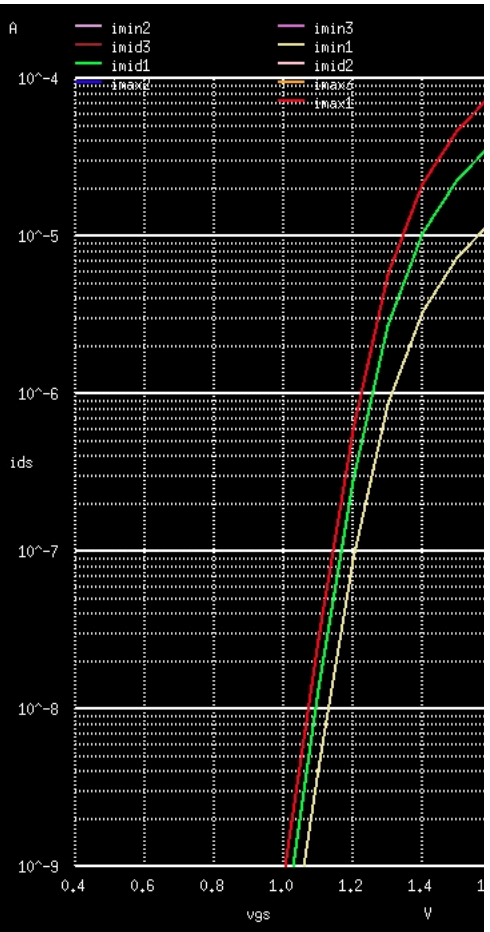
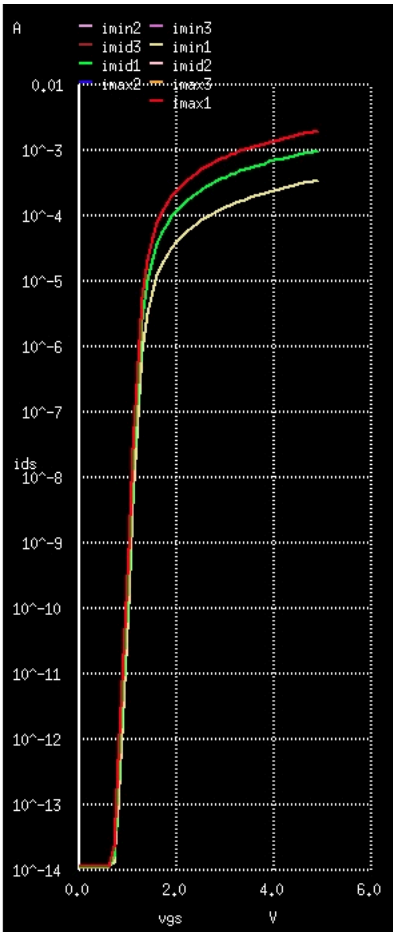
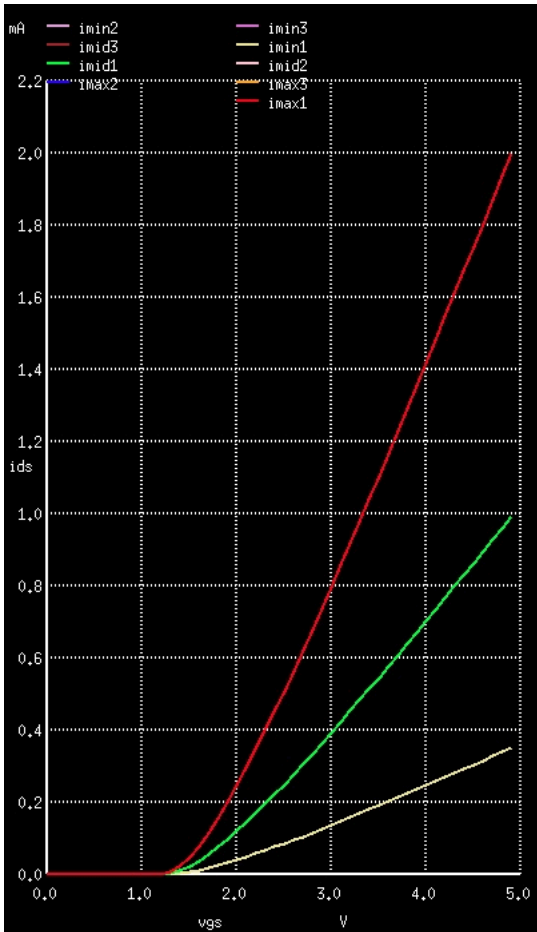
.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

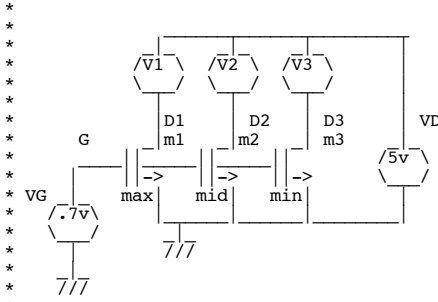
```

=====DVT2W=Body-biasCoefficientNarrowWidthSmallChannelLength=====
*-----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06    ww=-9.525E-14     wwn=1.0
+ dvt0w=0          dvt1w=5.3e6      dvt2w=-1.E-01     dwg=0
+ k3=2.53          k3b=-5           dwb=0
*-----

```



NMOS_DVT2W dvt2w=-1.E-02 -1.E-01 -1.0



```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*====
VD      D      0      dc      5v
VG      G      0      dc      5v
VB      B      0      dc     -5v
v1      D      1      dc      0v
v2      D      2      dc      0v
v3      D      3      dc      0v
m1      1      G      0      B      N1      W=6u   L=1u   AD=7p  AS=7p  PD=10u  PS=10u
m2      2      G      0      B      N1      W=3u   L=1u   AD=7p  AS=7p  PD=10u  PS=10u
m3      3      G      0      B      N1      W=1u   L=1u   AD=7p  AS=7p  PD=10u  PS=10u
```

```
.control
destroy all
altermod N1 dvt2w=-1.E-02
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc VG 1m 5 0.1
altermod N1 dvt2w=-1.E-01
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc VG 1m 5 0.1
altermod N1 dvt2w=-10.E-01
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc VG 1m 5 0.1
let imax1=dc1.i(v1)
let imax2=dc2.i(v1)
let imax3=dc3.i(v1)
let imid1=dc1.i(v2)
let imid2=dc2.i(v2)
let imid3=dc3.i(v2)
let imin1=dc1.i(v3)
let imin2=dc2.i(v3)
let imin3=dc3.i(v3)
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog
```

```
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog xlimit .6 2 ylimit 1n 100u
.endc
```

```
.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdscc=-2.4E-4 cdscd=-1.506E-04 cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ua1=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drou=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dLdW????-----
+ w1=0 wln=1 ww1=0
+ l1=0 lln=1 lw=0 lwn=1
+ lw1=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----Bsim???-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ nqsmod lmlt=1.000e+00 wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----
```

```
.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir
```

```
=====K3=NarrowWidthCoefficient=====
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----
```



```

let imid3=dc3.i(v2)
let imin1=dc1.i(v3)
let imin2=dc2.i(v3)
let imin3=dc3.i(v3)
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog xlimit .6 2 ylimit 1n 100u
.endc

```

```

.model
+ Level= 49 N1 Tnom=27.0 NMOS version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----
+ tox=160e-10 Process toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----
+ vth0=0.72 V threshold lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----
+ w0=2.6e-04 NarrowChannel wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----
+ k1=1.04 Bulk k2=-1.209E-01 kt2=-0.2916
+ cdscc=-2.4E-4 cdsd=-1.506E-04 cdsccb=-2.219E-04
*-----
+ u0=678 Mobility ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ua1=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----
+ rsh=70 Resistance rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----
+ lint=.12e-06 VAF pclm=.19 pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drou=0.56
*-----
+ nfactor=1.8 Subthreshold cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----
+ alpha0=1.61e-05 HotElectrons alpha1=8.276E-05 beta0=36.68
*-----
+ cjswg=2.73e-10 Capacitance mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----
+ js=5.858e-08 BulkDiode jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----
+ a0=0.7 BulkChargeEffect a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----
+ af=1 Noise???? kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----
+ wl=0 dLdW???? wln=1 ww1=0
+ ll=0 lln=1 lw=0 lwn=1
+ lw1=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----
+ wk3=0 Bsim??? lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----
+ hdif=2.7E-07 HspiceBSIM4?? ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----
+ nqsmod Flagged!! lmlt=1.000e+00 wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
*-----

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

```

=====K3B=BodyCoefficientofK3=====
*-----
+ w0=2.6e-04 NarrowChannel wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----

```



```

let imid3=dc3.i(v2)
let imin1=dc1.i(v3)
let imin2=dc2.i(v3)
let imin3=dc3.i(v3)
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog
plot imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog xlimit .6 2 ylimit 1n 100u
.endc

```

```

.model
+ Level= 49 N1 Tnom=27.0 NMOS version=3.24
+ mobmod=2 capmod=3 noimod=2
*-----
* Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----
* V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----
* NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----
* Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdscc=-2.4E-4 cdsccd=-1.506E-04 cdsccb=-2.219E-04
*-----
* Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ua1=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----
* Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----
* VAF-----
+ lint=.12e-06 pclm=.19 pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drou=0.56
*-----
* Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----
* HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----
* Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----
* BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----
* BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----
* Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----
* dLdW????-----
+ wl=0 wln=1 ww1=0
+ ll=0 lln=1 lw=0 lwn=1
+ lw1=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----
* Bsim???-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----
* HspiceBSIM4??-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----
* Flagged!!-----
+ nqsmod lmlt=1.000e+00 wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
*-----

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

```

=====DWB=CoefficientGateDependenceofWeff=====
*-----
* NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----

```



```

+ dvt0=2.2          dvt1=0.53          dvt2=-1.521E-01
*-----
+ w0=2.6e-04       wint=0.16e-06       ww=-9.525E-14      wwn=1.0
+ dvt0w=0          dvt1w=5.3e6        dvt2w=-1.E-01     dwg=0
+ k3=2.53          k3b=-5              dwb=0
*-----
+ k1=1.04          k2=-1.209E-01      kt2=-0.2916
+ cdsc=-2.4E-4     cdscd=-1.506E-04   cdscb=-2.219E-04
*-----
+ u0=678           ua=8.964e-10       ub=1.472e-18       uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09      ub1=-1.147E-17     ucl=-1.302E-01
+ vsat=86000       at=20380            elm=2
*-----
+ rsh=70           rdsw=375            prt=-3.287E+02
+ wr=0.7586        prwb=0              prwg=-4.441E-17
*-----
+ lint=.12e-06     pclm=.19            pscbe1=3.79e+08    pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39        pdiblc2=0.0086     drout=0.56
*-----
+ nfactor=1.8      cit=-5.0E-04        voff=-7.862E-02
+ eta0=4.441e-16   etab=-2.E-01        dsub=0.7
*-----
+ alpha0=1.61e-05  alpha1=8.276E-05    beta0=36.68
*-----
+ cjswg=2.73e-10   mjswg=0.2           pbswg=8.800e-01
+ cj=0.0002424     mj=0.3551           pb=0.5614
+ cjsw=2.73e-10   mjsw=0.3873         pbsw=0.8
+ cgso=9e-13       cgdo=9e-13          cgbo=7e-10
+ dlc=5e-08        dwc=1.5e-07         xpart=0
*-----
+ js=5.858e-08     jsw=1.25E-10        xti=2.000e+00      nj=1.08
*-----
+ a0=0.7           al=1                 a2=1                ags=0.05583
+ b0=6.305e-08     bl=6.579e-08        keta=-1.531E-02
*-----
+ af=1             kf=0                 ef=1                 em=4.1E+07
+ noia=1E+20       noib=50000           noic=-1.4E-12
*-----
+ w1=0             wln=1                wwl=0
+ l1=0             llm=1                lw=0                 lwn=1
+ lw1=0           llc=2E-13            lwc=0                 lwlc=0
+ wlc=0           wwc=0                wwlc=0
*-----
+ wk3=0           lk3=0                pk3=1.257
+ lk3b=0          wk3b=0               pk3b=0
+ pa0=0.0489      la0=-1.052           lags=0.01093
+ wags=0          pags=0.1573          lketa=0
+ wdwg=0          ldwb=0               wdwb=0
*-----
+ hdif=2.7E-07     ldif=0               lu0=0                ldwg=0
+ uc1=-1.098E-11  acm=13               wu0=1
+ wua=3.641E-11   lua=9.782E-10        pua=-4.46E-10       lub=-7.249E-19
+ wub=1.056E-20   pub=8.812E-19        pu0=1
+ wuc=1.177E-11   luc=-2.164E-10       puc=1.231E-10
*-----
+ nqsmod           lmlt=1.000e+00      wmlt=1.000e+00
+ tlev=0.000e+00  tlevc=0.000e+00
*-----

```

.end

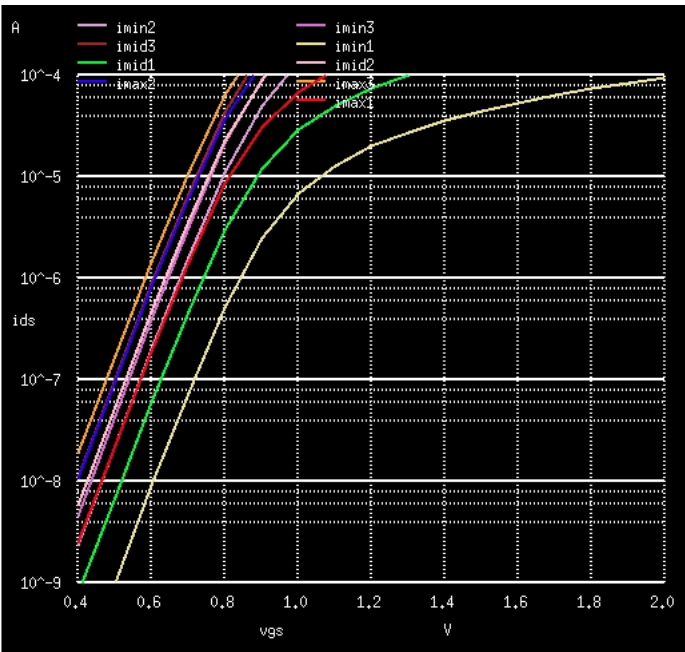
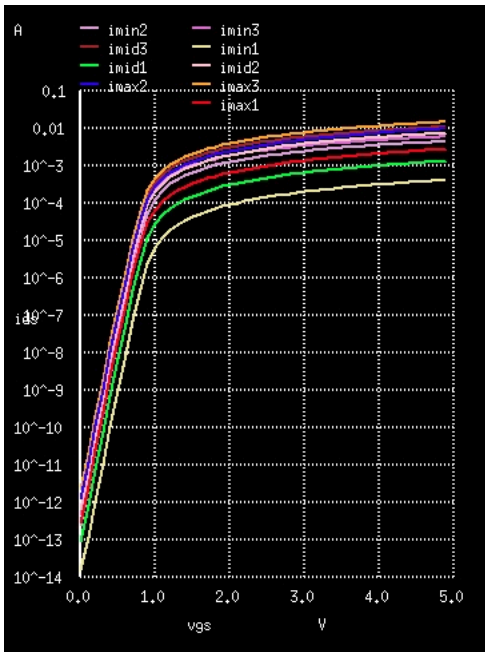
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Te

===== **DWB=CoefficientBodyDependenceofWeff** =====

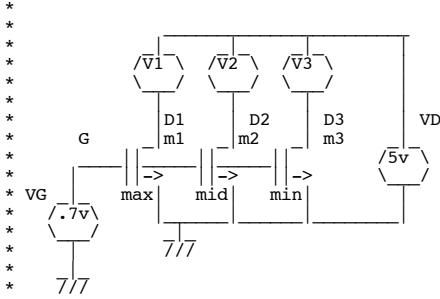
```

*-----
+ w0=2.6e-04       wint=0.16e-06       ww=-9.525E-14      wwn=1.0
+ dvt0w=0          dvt1w=5.3e6        dvt2w=-1.E-01     dwg=0
+ k3=2.53          k3b=-5              dwb=0
*-----

```



NMOS_DWB dwb= 0 .00003 dwg=.00006



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
VD      D      0      dc      5v
VG      G      0      dc      5v
VB      B      0      dc      1v
v1      D      1      dc      0v
v2      D      2      dc      0v
v3      D      3      dc      0v
m1      1      G      0      B      N1      W=6u    L=1u    AD=7p   AS=7p   PD=10u  PS=10u
m2      2      G      0      B      N1      W=3u    L=1u    AD=7p   AS=7p   PD=10u  PS=10u
m3      3      G      0      B      N1      W=1u    L=1u    AD=7p   AS=7p   PD=10u  PS=10u

.control
destroy all
altermod N1      dwb=0
*DC      SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc      VG      1m      5      0.1
altermod N1      dwb=.00003
*DC      SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc      VG      1m      5      0.1
altermod N1      dwb=.00006
*DC      SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc      VG      1m      5      0.1
let imax1=dc1.i(v1)
let imax2=dc2.i(v1)
let imax3=dc3.i(v1)
let imid1=dc1.i(v2)
let imid2=dc2.i(v2)
let imid3=dc3.i(v2)
let imin1=dc1.i(v3)
let imin2=dc2.i(v3)
let imin3=dc3.i(v3)
plot      imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs
plot      imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog
plot      imax1 imax2 imax3 imid1 imid2 imid3 imin1 imin2 imin3 ylabel ids xlabel vgs ylog xlimit .6 2 ylimit 1n 100u
.endc

.model      N1      NMOS
+ Level= 49      Tnom=27.0      version=3.24
+ mobmod=2      capmod=3      noimod=2
**-----Process-----
+ tox=160e-10      toxm=160e-10
+ ngate=8.000e+19      xj=0.25e-06      nch=0.5e+17
*-----V threshold-----
+ vth0=0.72      lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2      dvt1=0.53      dvt2=-1.521E-01
*-----NarrowChannel-----

```

```

+ w0=2.6e-04      wint=0.16e-06      ww=-9.525E-14      wwn=1.0
+ dvt0w=0         dvt1w=5.3e6        dvt2w=-1.E-01
+ k3=2.53         k3b=-5             dwg=0               dwb=0
*-----
+ k1=1.04         k2=-1.209E-01     kt2=-0.2916
+ cdsc=-2.4E-4   cdsd=-1.506E-04   cdscb=-2.219E-04
*-----
+ u0=678          ua=8.964e-10       ub=1.472e-18       uc=-4.441E-17
+ ute=-1.176     ual=5.705e-09      ubl=-1.147E-17     ucl=-1.302E-01
+ vsat=86000     at=20380           elm=2
*-----
+ rsh=70          rdsw=375           prt=-3.287E+02
+ wr=0.7586      prwb=0             prwg=-4.441E-17
*-----
+ lint=.12e-06   pclm=.19           pscbe1=3.79e+08    pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39       pdiblc2=0.0086     drou=0.56
*-----
+ nfactor=1.8    cit=-5.0E-04       voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01       dsub=0.7
*-----
+ alpha0=1.61e-05 alpha1=8.276E-05   beta0=36.68
*-----
+ cjswg=2.73e-10 mjswg=0.2          pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551         pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873       pbsw=0.8
+ cgso=9e-13     cgdo=9e-13        cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07       xpart=0
*-----
+ js=5.858e-08   jsw=1.25E-10      xti=2.000e+00      nj=1.08
*-----
+ a0=0.7         a1=1              a2=1                ags=0.05583
+ b0=6.305e-08  b1=6.579e-08     keta=-1.531E-02
*-----
+ af=1           kf=0              ef=1                 em=4.1E+07
+ noia=1E+20     noib=50000        noic=-1.4E-12
*-----
+ w1=0           wln=1             wwl=0                lwn=1
+ ll=0           lln=1             lw=0                 lwlc=0
+ lw1=0          llc=2E-13         lwc=0                wwlc=0
+ wl=0           wwc=0             wwlc=0
*-----
+ wk3=0          lk3=0             pk3=1.257
+ lk3b=0         wk3b=0            pk3b=0
+ pa0=0.0489    la0=-1.052        lags=0.01093
+ wags=0         pags=0.1573       lketa=0
+ wdwg=0         ldwb=0            wdwb=0
*-----
+ hdif=2.7E-07   ldif=0            lu0=0                ldwg=0
+ uc1=-1.098E-11 acm=13            wu0=1
+ wua=3.641E-11 lua=9.782E-10     pua=-4.46E-10       lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19     pu0=1
+ wuc=1.177E-11 luc=-2.164E-10   puc=1.231E-10
*-----
+ nqsmod         lmlt=1.000e+00    wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----

```

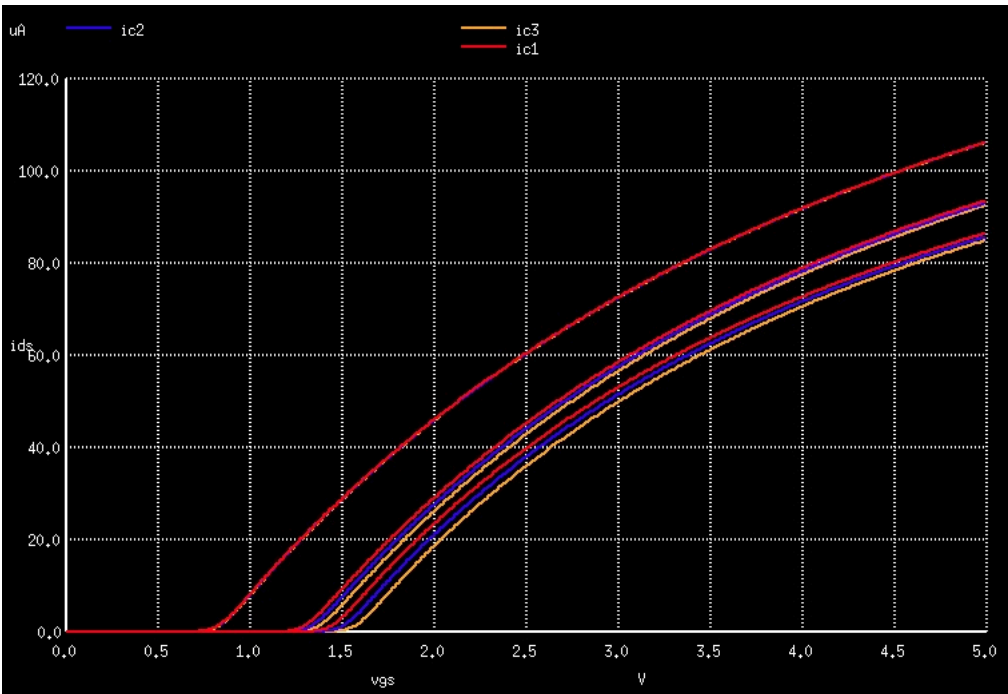
.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Te

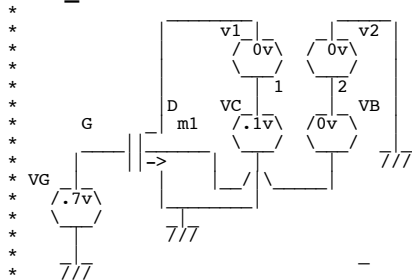
```

=====K1=First-orderBodyCoefficient=====
*-----
+ k1=1.04         k2=-1.209E-01     kt2=-0.2916
+ cdsc=-2.4E-4   cdsd=-1.506E-04   cdscb=-2.219E-04
*-----

```



NMOS_K1 **k1=1.00 1.04 1.08**



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds      D      0      dc      .1v
Vgs      G      0      dc      1.2v
Vbs      0      B      dc      0v
v1       D      1      dc      0v
m1       1      G      0      B      N1      W=3u  L=1u AD=7p AS=7p PD=10u PS=10u
.control
destroy all
altermod N1 k1=1.0
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs 1m 5 0.01 Vbs 0 5 2.5
altermod N1 k1=1.04
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs 1m 5 0.01 Vbs 0 5 2.5
altermod N1 k1=1.08
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs 1m 5 0.01 Vbs 0 5 2.5
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 ylabel IDS xlabel VGS
.endc

```

```

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----

```



```

*
*
*
*

```

```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*****
Vgs D 0 dc .1v
Vgs G 0 dc 1.2v
Vbs 0 B dc 0v
v1 D 1 dc 0v
m1 1 G 0 B N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u
.control
destroy all
altermod N1 cdsc=2.4E-3
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs lm 5 0.01 Vbs 0 5 2.5
altermod N1 cdsc=4.4E-3
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs lm 5 0.01 Vbs 0 5 2.5
altermod N1 cdsc=8.4E-3
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs lm 5 0.01 Vbs 0 5 2.5
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 ylabel IDS xlabel VGS
.endc

```

```

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V_threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ubl=-1.147E-17 ucl=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbel=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drou=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dLdW????-----
+ wl=0 wln=1 ww1=0
+ ll=0 lln=1 lw=0 lwn=1
+ lw1=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----Bsim??-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!-----
* nqsmod lmlt=1.000e+00 wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
*****

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

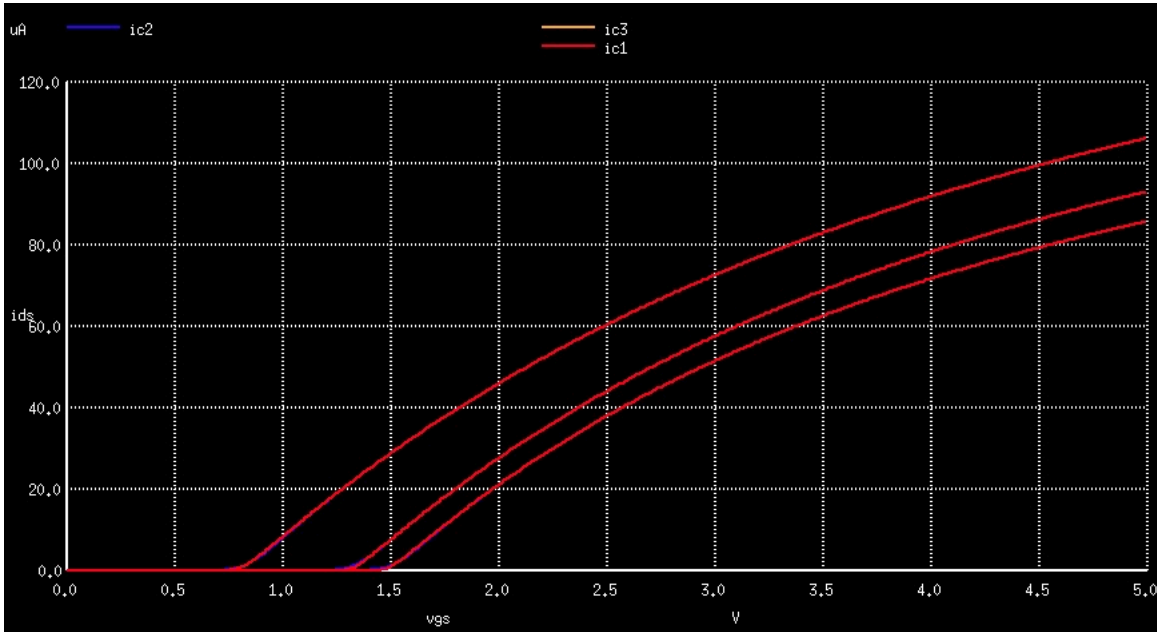
```

CDSCD=Drain-biasSensitivityCdsc

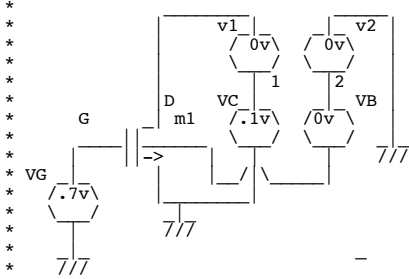
```

*-----Bulk-----
+ k1=1.04          k2=-1.209E-01      kt2=-0.2916
+ cdsc=-2.4E-4    cdscd=-1.506E-04    cdscb=-2.219E-04
*-----

```



NMOS_CDSCD **cdscd=-1.519E-01 -1.519E-04 -1.519E-06**



```

.OPTIONS  GMIN=1e-15  METHOD=gear  ABSTOL=1e-15
*-----
Vds      D      0      dc      .1v
Vgs      G      0      dc      1.2v
Vbs      0      B      dc      0v
v1       D      1      dc      0v
m1       1      G      0      B      N1      W=3u  L=1u  AD=7p  AS=7p  PD=10u  PS=10u
.control
destroy all
altermod N1      cdscd=-1.506E-01
*DC      SOURC1  VSTART  VSTOP  VSTEP  SOURC2  START2  STOP2  STEP2
dc       Vgs     1m      5      0.01  Vbs     0      5      2.5
altermod N1      cdscd=-1.506E-04
*DC      SOURC1  VSTART  VSTOP  VSTEP  SOURC2  START2  STOP2  STEP2
dc       Vgs     1m      5      0.01  Vbs     0      5      2.5
altermod N1      cdscd=-1.506E-06
*DC      SOURC1  VSTART  VSTOP  VSTEP  SOURC2  START2  STOP2  STEP2
dc       Vgs     1m      5      0.01  Vbs     0      5      2.5
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot    ic1 ic2 ic3      ylabel IDS xlabel VGS
.endc

```

```

.model      N1      NMOS
+ Level= 49      Tnom=27.0      version=3.24
+ mobmod=2      capmod=3      noimod=2
*-----Process-----
+ tox=160e-10    toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----V threshold-----
+ vth0=0.72      lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2       dvt1=0.53       dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04     wint=0.16e-06    ww=-9.525E-14     wwn=1.0
+ dvt0w=0       dvt1w=5.3e6     dvt2w=-1.E-01
+ k3=2.53       k3b=-5
*-----Bulk-----
+ k1=1.04        k2=-1.209E-01    kt2=-0.2916
+ cdsc=-2.4E-4  cdscd=-1.506E-04  cdscb=-2.219E-04
*-----Mobility-----
+ u0=678         ua=8.964e-10     ub=1.472e-18     uc=-4.441E-17
+ ute=-1.176    ual=5.705e-09    ub1=-1.147E-17  ucl=-1.302E-01

```

```

+ vsat=86000      at=20380      elm=2
* -----
+ rsh=70          rds=375          prt=-3.287E+02
+ wr=0.7586      prwb=0          prwg=-4.441E-17
* -----
+ lint=.12e-06   pclm=.19          pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39       pdiblc2=0.0086   drout=0.56
* -----
+ nfactor=1.8    cit=-5.0E-04       voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01       dsub=0.7
* -----
+ alpha0=1.61e-05 alpha1=8.276E-05   beta0=36.68
* -----
+ cjswg=2.73e-10 mjswg=0.2          pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551         pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873       pbsw=0.8
+ cgso=9e-13    cgdo=9e-13        cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07      xpart=0
* -----
+ js=5.858e-08  jsw=1.25E-10      xti=2.000e+00    nj=1.08
* -----
+ a0=0.7         a1=1              a2=1              ags=0.05583
+ b0=6.305e-08  b1=6.579e-08     keta=-1.531E-02
* -----
+ af=1           kf=0              ef=1              em=4.1E+07
+ noia=1E+20    noib=50000        noic=-1.4E-12
* -----
+ w1=0           wln=1             ww1=0
+ l1=0           lln=1             lw=0              lwn=1
+ lw1=0          llc=2E-13        lwc=0             lwlc=0
+ wlc=0          wwc=0             wwlc=0
* -----
+ wk3=0          lk3=0             pk3=1.257
+ lk3b=0         wk3b=0            pk3b=0
+ pa0=0.0489    la0=-1.052        lags=0.01093
+ wags=0         pags=0.1573       lketa=0
+ wdwg=0         ldwb=0            wdwb=0
* -----
+ hdif=2.7E-07  ldif=0            lu0=0             ldwg=0
+ uc1=-1.098E-11 acm=13            wu0=1
+ wua=3.641E-11 lua=9.782E-10   pua=-4.46E-10    lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19    pu0=1
+ wuc=1.177E-11 luc=-2.164E-10   puc=1.231E-10
* -----
+ nqsmod        lmlt=1.000e+00   wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
* -----

```

```

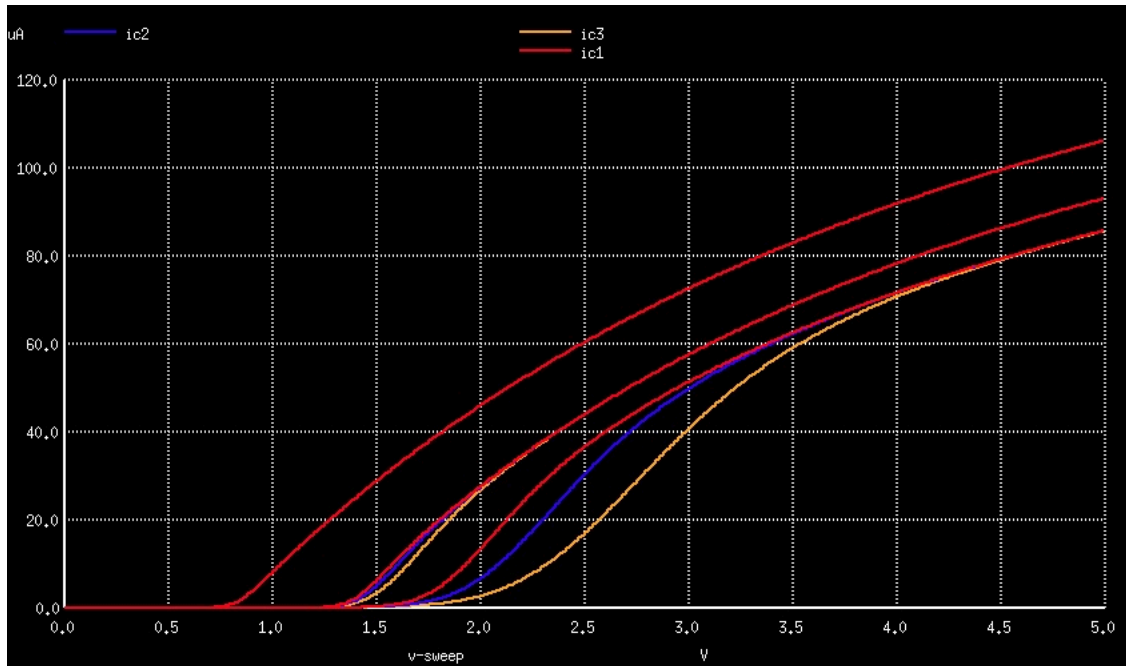
.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

```

=====CDSCB=Body-biasSensitivityCdsc=====
* -----
+ k1=1.04        k2=-1.209E-01     kt2=-0.2916
+ cdsc=-2.4E-4   cdsd=-1.506E-04  cdscb=-2.219E-04
* -----

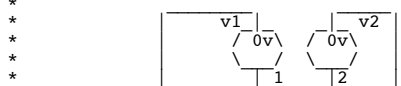
```

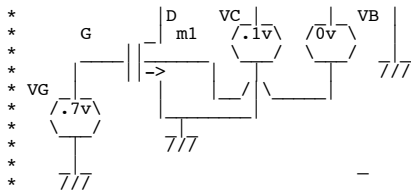


```

NMOS_CDSCB      cdscb=-1.519E-03  -2.219E-03  -3.219E-03

```





```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*****
Vds D 0 dc .1v
Vgs G 0 dc 1.2v
Vbs 0 B dc 0v
v1 D 1 dc 0v
m1 1 G 0 B N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u
```

```
.control
destroy all
altermod N1 cdscb=-1.519E-03
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs 1m 5 0.01 Vbs 0 5 2.5
altermod N1 cdscb=-2.219E-03
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs 1m 5 0.01 Vbs 0 5 2.5
altermod N1 cdscb=-3.219E-03
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vgs 1m 5 0.01 Vbs 0 5 2.5
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3
.endc
```

```
.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V_threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.1E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdsd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ubl=-1.147E-17 ucl=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbel=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drout=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dLdW????-----
+ wl=0 wln=1 wwl=0
+ ll=0 lln=1 lw=0 lwn=1
+ lw1=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----Bsim??-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ nqsmod lmlt=1.000e+00 wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----
```



```
let Reff3 = v(D)/(ic3 +1e-8)
plot Reff1 Reff2 Reff3 xlimit 0 1 ylimit .5k 2k xlabel VDS ylabel Rdseff
```

.endc

```
.model
+ Level= 49      N1      NMOS
+ mobmod=2      Tnom=27.0  version=3.24
+               capmod=3   noimod=2
**-----
+ tox=160e-10   toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06   nch=0.5e+17
*-----
+ vth0=0.72     lvth0=0.025   nlx=0.12e-06   kt1=-0.9821
+ dvt0=2.2      dvt1=0.53     dvt2=-1.521E-01
*-----
+ w0=2.6e-04    wint=0.16e-06 ww=-9.525E-14  wwn=1.0
+ dvt0w=0       dvt1w=5.3e6   dvt2w=-1.E-01
+ k3=2.53       k3b=-5        dwg=0          dwb=0
*-----
+ k1=1.04       k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4  cdscd=-1.506E-04 cdscb=-2.219E-04
*-----
+ u0=678        ua=8.964e-10  ub=1.472e-18   uc=-4.441E-17
+ ute=-1.176    ual=5.705e-09 ubl=-1.147E-17 uc1=-1.302E-01
+ vsat=86000    at=20380      elm=2
*-----
+ rsh=70        rdsw=375      prt=-3.287E+02
+ wr=0.7586     prwb=0        prwg=-4.441E-17
*-----
+ lint=.12e-06  pclm=.19      pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39  pdiblc2=0.0086  drout=0.56
*-----
+ nfactor=1.8   cit=-5.0E-04  voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01  dsub=0.7
*-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----
+ cjswg=2.73e-10 mjswg=0.2     pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551    pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873  pbsw=0.8
+ cgso=9e-13    cgdo=9e-13   cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07  xpart=0
*-----
+ js=5.858e-08  jsw=1.25E-10 xti=2.000e+00  nj=1.08
*-----
+ a0=0.7        a1=1          a2=1            ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----
+ af=1          kf=0          ef=1            em=4.1E+07
+ noia=1E+20    noib=50000    noic=-1.4E-12
*-----
+ w1=0          wln=1         wwl=0
+ l1=0          lln=1         lw=0            lwn=1
+ lw1=0         llc=2E-13    lwc=0           lwlc=0
+ wlc=0         wwc=0         wwlc=0
*-----
+ wk3=0         lk3=0         pk3=1.257
+ lk3b=0        wk3b=0        pk3b=0
+ pa0=0.0489    la0=-1.052    lags=0.01093
+ wags=0        pags=0.1573   lketa=0
+ wdwg=0        ldwb=0        wdwb=0
*-----
+ hdif=2.7E-07  ldif=0        lu0=0           ldwg=0
+ uc1=-1.098E-11 acm=13        wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10  lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----
+ nqsmod        lmlt=1.000e+00 wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----
```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```
=====ua=First-orderMobilityDegradationCoefficient=====
*-----
+ u0=678        ua=8.964e-10  ub=1.472e-18   uc=-4.441E-17
+ ute=-1.176    ual=5.705e-09 ubl=-1.147E-17 uc1=-1.302E-01
+ vsat=86000    at=20380      elm=2
*-----
```

Figure 78 Influence of Mobility Reduction


```

.model          N1          NMOS
+ Level= 49      Tnom=27.0   version=3.24
+ mobmod=2      capmod=3     noimod=2
**-----Process-----
+ tox=160e-10   toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06   nch=0.5e+17
*-----V threshold-----
+ vth0=0.72     lvth0=0.025   nlx=0.12e-06   kt1=-0.9821
+ dvt0=2.2      dvt1=0.53     dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04   wint=0.16e-06   ww=-9.525E-14   wwn=1.0
+ dvt0w=0      dvt1w=5.3e6    dvt2w=-1.E-01   dwg=0
+ k3=2.53      k3b=-5         dwb=0
*-----Bulk-----
+ k1=1.04      k2=-1.209E-01   kt2=-0.2916
+ cdsc=-2.4E-4   cdscd=-1.506E-04   cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678       ua=8.964e-10   ub=1.472e-18   uc=-4.441E-17
+ ute=-1.176   ual=5.705e-09   ub1=-1.147E-17   ucl=-1.302E-01
+ vsat=86000   at=20380       elm=2
*-----Resistance-----
+ rsh=70       rdsw=375       prt=-3.287E+02
+ wr=0.7586    prwb=0         prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06   pclm=.19       pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655   pdiblc1=0.39   pdiblc2=0.0086   drout=0.56
*-----Subthreshold-----
+ nfactor=1.8   cit=-5.0E-04   voff=-7.862E-02
+ eta0=4.441e-16   etab=-2.E-01   dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05   alpha1=8.276E-05   beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10   mjswg=0.2       pbswg=8.800e-01
+ cj=0.0002424    mj=0.3551       pb=0.5614
+ cjsw=2.73e-10   mjsw=0.3873    pbsw=0.8
+ cgso=9e-13      cgdo=9e-13      cgbo=7e-10
+ dlc=5e-08       dwc=1.5e-07     xpart=0
*-----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10   xti=2.000e+00   nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7         a1=1            a2=1             ags=0.05583
+ b0=6.305e-08   b1=6.579e-08   keta=-1.531E-02
*-----Noise????-----
+ af=1           kf=0            ef=1             em=4.1E+07
+ noia=1E+20     noib=50000      noic=-1.4E-12
*-----dLdW????-----
+ wl=0           wln=1           wwl=0
+ ll=0           lln=1           lw=0             lwn=1
+ lw1=0          llc=2E-13      lwc=0            lwlc=0
+ wlc=0          wwc=0           wwlc=0
*-----Bsim???-----
+ wk3=0          lk3=0           pk3=1.257
+ lk3b=0         wk3b=0          pk3b=0
+ pa0=0.0489    la0=-1.052     lags=0.01093
+ wags=0         pags=0.1573    lketa=0
+ wdwg=0         ldwb=0          wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0          lu0=0            ldwg=0
+ uc1=-1.098E-11   acm=13         wu0=1
+ wua=3.641E-11   lua=9.782E-10   pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20   pub=8.812E-19   pu0=1
+ wuc=1.177E-11   luc=-2.164E-10   puc=1.231E-10
*-----Flagged!!-----
+ nqsmod        lmlt=1.000e+00   wmlt=1.000e+00
+ tlev=0.000e+00   tlevc=0.000e+00
*-----

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

```

=====ub=Second-orderMobilityDegradationCoefficient=====
*-----mobility-----
+ u0=678       ua=8.964e-10   ub=1.472e-18   uc=-4.441E-17
+ ute=-1.176   ual=5.705e-09   ub1=-1.147E-17   ucl=-1.302E-01
+ vsat=86000   at=20380       elm=2
*-----

```



```

+ dvt0w=0          dvt1w=5.3e6          dvt2w=-1.E-01          dwg=0
+ k3=2.53          k3b=-5
* -----Bulk-----
+ k1=1.04          k2=-1.209E-01          kt2=-0.2916
+ cdsc=-2.4E-4    cdsd=-1.506E-04       cdscb=-2.219E-04
* -----Mobility-----
+ u0=678          ua=8.964e-10          ub=1.472e-18          uc=-4.441E-17
+ ute=-1.176      ual=5.705e-09         ub1=-1.147E-17       uc1=-1.302E-01
+ vsat=86000      at=20380              elm=2
* -----Resistance-----
+ rsh=70          rdsw=375              prt=-3.287E+02
+ wr=0.7586       prwb=0                prwg=-4.441E-17
* -----VAF-----
+ lint=.12e-06    pclm=.19              pscbe1=3.79e+08       pscbe2=9.4e-05
+ delta=0.01655   pdiblc1=0.39          pdiblc2=0.0086       drou=0.56
* -----Subthreshold-----
+ nfactor=1.8     cit=-5.0E-04          voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01          dsub=0.7
* -----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05      beta0=36.68
* -----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2             pbswg=8.800e-01
+ cj=0.0002424    mj=0.3551             pb=0.5614
+ cjsw=2.73e-10   mjsw=0.3873           pbsw=0.8
+ cgso=9e-13      cgdo=9e-13            cgbo=7e-10
+ dlc=5e-08       dwc=1.5e-07           xpart=0
* -----BulkDiode-----
+ js=5.858e-08    jsw=1.25E-10          xti=2.000e+00         nj=1.08
* -----BulkChargeEffect-----
+ a0=0.7          a1=1                   a2=1                   ags=0.05583
+ b0=6.305e-08    b1=6.579e-08          keta=-1.531E-02
* -----Noise????-----
+ af=1            kf=0                   ef=1                   em=4.1E+07
+ noia=1E+20      noib=50000            noic=-1.4E-12
* -----dLdW????-----
+ wl=0            wln=1                  ww1=0
+ ll=0            lln=1                  lw=0                   lwn=1
+ lw1=0           llc=2E-13             lwc=0                  lwlc=0
+ wlc=0           wwc=0                  wwlc=0
* -----Bsim???-----
+ wk3=0           lk3=0                  pk3=1.257
+ lk3b=0          wk3b=0                 pk3b=0
+ pa0=0.0489     la0=-1.052            lags=0.01093
+ wags=0          pags=0.1573           lketa=0
+ wdwg=0          ldwb=0                 wdwb=0
* -----HspiceBSIM4??-----
+ hdif=2.7E-07    ldif=0                 lu0=0                  ldwg=0
+ uc1=-1.098E-11  acm=13                 wu0=1
+ wua=3.641E-11   lua=9.782E-10          pua=-4.46E-10         lub=-7.249E-19
+ wub=1.056E-20   pub=8.812E-19          pu0=1
+ wuc=1.177E-11   luc=-2.164E-10         puc=1.231E-10
* -----Flagged!!-----
+ nqsmod          lmlt=1.000e+00        wmlt=1.000e+00
+ tlev=0.000e+00  tlevc=0.000e+00
* -----

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

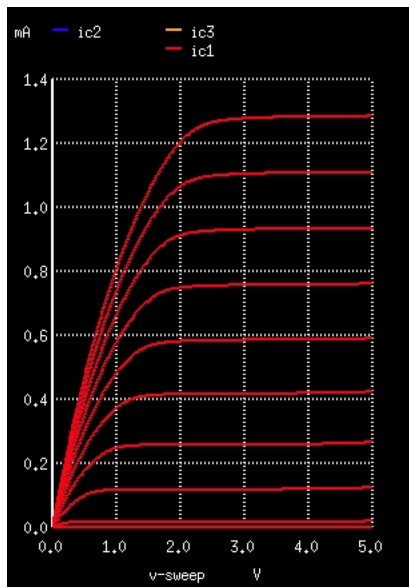
```

=====uc=Third-orderMobilityDegradationCoefficient=====

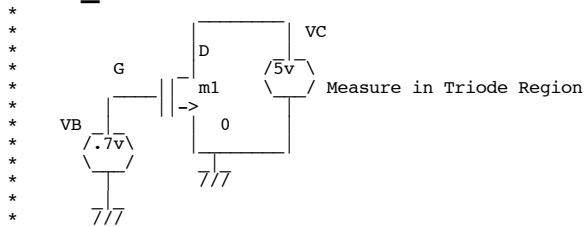
```

* -----mobility-----
+ u0=678          ua=8.964e-10          ub=1.472e-18          uc=-4.441E-17
+ ute=-1.176      ual=5.705e-09         ub1=-1.147E-17       uc1=-1.302E-01
+ vsat=86000      at=20380              elm=2
* -----

```



NMOS_UC uc=-4.441E-16 -4.441E-17 -4.441E-18



```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds      D      0      dc      5v
Vgs      G      0      dc      1.2v
v1       D      1      dc      0v
m1       1      G      0      0      N1      W=3u    L=1u    AD=7p    AS=7p    PD=10u    PS=10u

.control
destroy all
altermod N1      uc=-4.441E-16
*DC      SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc       Vds      lm      5      0.01  vgs      0      5      .5
altermod N1      uc=-4.441E-17
*DC      SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc       Vds      lm      5      0.01  vgs      0      5      .5
altermod N1      uc=-4.441E-18
*DC      SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc       Vds      lm      5      0.01  vgs      0      5      .5
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot    ic1 ic2 ic3
.endc
```

```
.model      N1      NMOS
+ Level= 49      Tnom=27.0      version=3.24
+ mobmod=2      capmod=3      noimod=2
**-----Process-----
+ tox=160e-10    toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06      nch=0.5e+17
*-----V threshold-----
+ vth0=0.72      lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2      dvt1=0.53      dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04      wint=0.16e-06      ww=-9.525E-14      wwn=1.0
+ dvt0w=0      dvt1w=5.3e6      dvt2w=-1.1E-01
+ k3=2.53      k3b=-5      dwg=0      dwb=0
*-----Bulk-----
+ k1=1.04      k2=-1.209E-01      kt2=-0.2916
+ cdscc=-2.4E-4      cdscc=-1.506E-04      cdscc=-2.219E-04
*-----Mobility-----
+ u0=678      ua=8.964e-10      ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176      ua1=5.705e-09      ub1=-1.147E-17      uc1=-1.302E-01
+ vsat=86000      at=20380      elm=2
*-----Resistance-----
+ rsh=70      rdsw=375      prt=-3.287E+02
+ wr=0.7586      prwb=0      prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06      pclm=.19      pscbe1=3.79e+08      pscbe2=9.4e-05
+ delta=0.01655      pdiblc1=0.39      pdiblc2=0.0086      drout=0.56
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04      voff=-7.862E-02
+ eta0=4.441e-16      etab=-2.E-01      dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05      alpha1=8.276E-05      beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10      mjswg=0.2      pbswg=8.800e-01
+ cj=0.0002424      mj=0.3551      pb=0.5614
+ cjsw=2.73e-10      mjsw=0.3873      pbsw=0.8
+ cgso=9e-13      cgdo=9e-13      cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07      xpart=0
*-----BulkDiode-----
+ js=5.858e-08      jsw=1.25E-10      xt1=2.000e+00      nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7      a1=1      a2=1      ags=0.05583
+ b0=6.305e-08      b1=6.579e-08      keta=-1.531E-02
*-----Noise????-----
+ af=1      kf=0      ef=1      em=4.1E+07
+ noia=1E+20      noib=50000      noic=-1.4E-12
*-----dLdW????-----
+ wl=0      wln=1      ww1=0
+ ll=0      lln=1      lw=0      lwn=1
+ lw1=0      llc=2E-13      lwc=0      lwlc=0
+ wlc=0      wwc=0      wwlc=0
*-----Bsim??-----
+ wk3=0      lk3=0      pk3=1.257
+ lk3b=0      wk3b=0      pk3b=0
+ pa0=0.0489      la0=-1.052      lags=0.01093
+ wags=0      pags=0.1573      lketa=0
+ wdwg=0      ldwb=0      wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07      ldif=0      lu0=0      ldwg=0
+ uc1=-1.098E-11      acm=13      wu0=1
+ wua=3.641E-11      lua=9.782E-10      pua=-4.46E-10      lub=-7.249E-19
+ wub=1.056E-20      pub=8.812E-19      pu0=1
+ wuc=1.177E-11      luc=-2.164E-10      puc=1.231E-10
*-----Flagged!!-----
+ nqsmod      lmlt=1.000e+00      wmlt=1.000e+00
+ tlev=0.000e+00      tlevc=0.000e+00
```

-----*

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

=====ute=MobilityTemperatureExponent=====

*-----mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ua1=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----

Figure 129 Temperature Dependence of Carrier Mobility U0: Influence on Drain Current

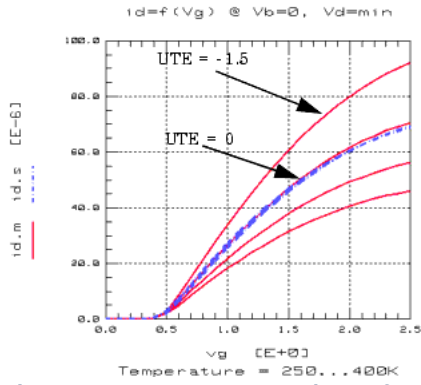
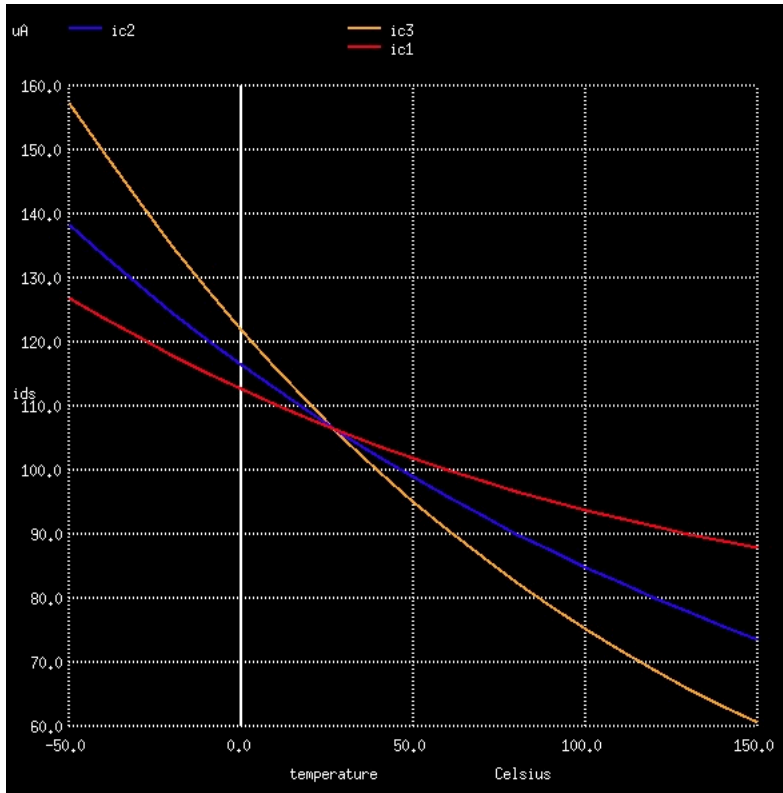
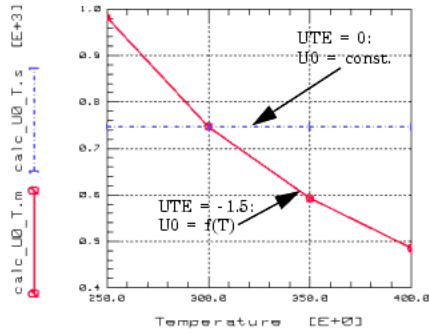
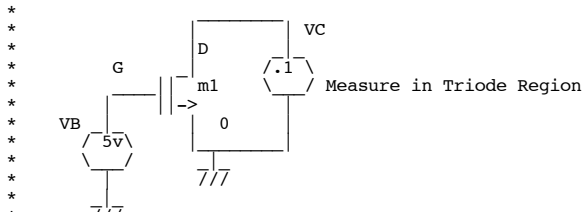


Figure 130 Temperature Dependence of Carrier Mobility U0: Dependence from UTE



NMOS_UTE ute=-1.076 -1.176 -1.276



```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*****
Vds      D      0      dc      .1v
Vgs      G      0      dc      2v
v1       D      1      dc      0v
m1       1      G      0      0      N1      W=3u  L=1u  AD=7p  AS=7p  PD=10u  PS=10u
```

```
.control
destroy all
altermod N1 ute=-1.076
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc TEMP -50 150 10
altermod N1 ute=-1.176
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc TEMP -50 150 10
altermod N1 ute=-1.276
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc TEMP -50 150 10
```

```
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 ylabel IDS xlabel temperature
```

```
.endc

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAR-----
+ lint=.12e-06 pclm=.19 pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 dROUT=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dIdW????-----
+ wl=0 wln=1 ww1=0
+ ll=0 lln=1 lw=0 lwn=1
+ lwl=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 ww1c=0
*-----Bsim??-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
```



```

**-----Process-----
+ tox=160e-10      toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----V threshold-----
+ vth0=0.72        lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2         dvt1=0.53        dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06    ww=-9.525E-14     wwn=1.0
+ dvt0w=0          dvt1w=5.3e6      dvt2w=-1.E-01     dwg=0
+ k3=2.53          k3b=-5           dwb=0
*-----Bulk-----
+ k1=1.04          k2=-1.209E-01    kt2=-0.2916
+ cdscc=-2.4E-4    cdscd=-1.506E-04  cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678           ua=8.964e-10     ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09    ub1=-1.147E-17    ucl=-1.302E-01
+ vsat=86000       at=20380         elm=2
*-----Resistance-----
+ rsh=70           rdsw=375         prt=-3.287E+02
+ wr=0.7586        prwb=0           prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06     pclm=.19         pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39     pdiblc2=0.0086    drout=0.56
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04     voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01     dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05  beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10   mjswg=0.2         pbswg=8.800e-01
+ cj=0.0002424     mj=0.3551         pb=0.5614
+ cjsw=2.73e-10   mjsw=0.3873      pbsw=0.8
+ cgso=9e-13       cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08        dwc=1.5e-07      xpart=0
*-----BulkDiode-----
+ js=5.858e-08     jsw=1.25E-10     xti=2.000e+00     nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7           al=1             a2=1               ags=0.05583
+ b0=6.305e-08     bl=6.579e-08     keta=-1.531E-02
*-----Noise????-----
+ af=1             kf=0             ef=1               em=4.1E+07
+ noia=1E+20       noib=50000       noic=-1.4E-12
*-----dLdW????-----
+ wl=0            wln=1            wwl=0
+ ll=0            lln=1            lw=0               lwn=1
+ lw1=0           llc=2E-13       lwc=0              lwlc=0
+ wlc=0           wwc=0            wwlc=0
*-----Bsim???-----
+ wk3=0           lk3=0            pk3=1.257
+ lk3b=0          wk3b=0           pk3b=0
+ pa0=0.0489      la0=-1.052       lags=0.01093
+ wags=0           pags=0.1573      lketa=0
+ wdwg=0          ldwb=0           wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07     ldif=0           lu0=0              ldwg=0
+ uc1=-1.098E-11   acm=13           wu0=1
+ wua=3.641E-11    lua=9.782E-10    pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20    pub=8.812E-19    pu0=1
+ wuc=1.177E-11    luc=-2.164E-10   puc=1.231E-10
*-----Flagged!-----
+ nqsmod          lmlt=1.000e+00   wmlt=1.000e+00
+ tlev=0.000e+00  tlevc=0.000e+00

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

=====ub1=TemperatureCoefficientUb=====
*-----mobility-----
+ u0=678           ua=8.964e-10     ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09    ub1=-1.147E-17    ucl=-1.302E-01
+ vsat=86000       at=20380         elm=2
*-----

```



```

+ rsh=70          rdsw=375          prt=-3.287E+02
+ wr=0.7586      prwb=0            prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06   pclm=.19          pscbel=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39      pdiblc2=0.0086   drou=0.56
*-----Subthreshold-----
+ nfactor=1.8    cit=-5.0E-04      voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01      dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05  beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2         pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551        pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873      pbsw=0.8
+ cgso=9e-13    cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07      xpart=0
*-----BulkDiode-----
+ js=5.858e-08  jsw=1.25E-10     xti=2.000e+00    nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7        al=1             a2=1             ags=0.05583
+ b0=6.305e-08 bl=6.579e-08    keta=-1.531E-02
*-----Noise????-----
+ af=1          kf=0             ef=1             em=4.1E+07
+ noia=1E+20    noib=50000      noic=-1.4E-12
*-----dLdW????-----
+ wl=0          wln=1           wwl=0
+ ll=0          lln=1           lw=0             lwn=1
+ lwl=0         llc=2E-13      lwc=0            lwlc=0
+ wlc=0         wwc=0           wwlc=0
*-----Bsim??-----
+ wk3=0         lk3=0           pk3=1.257
+ lk3b=0        wk3b=0          pk3b=0
+ pa0=0.0489   la0=-1.052      lags=0.01093
+ wags=0        pags=0.1573     lketa=0
+ wdwg=0        ldwb=0          wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07  ldif=0           lu0=0            ldwg=0
+ uc1=-1.098E-11 acm=13           wu0=1
+ wua=3.641E-11 lua=9.782E-10  pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19    pu0=1
+ wuc=1.177E-11 luc=-2.164E-10  puc=1.231E-10
*-----Flagged!!-----
+ nqsmod        lmlt=1.000e+00  wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----

```

```

.end
* source /Users/don_sauer/Downloads/stable/SI_Lib/Tests.cir

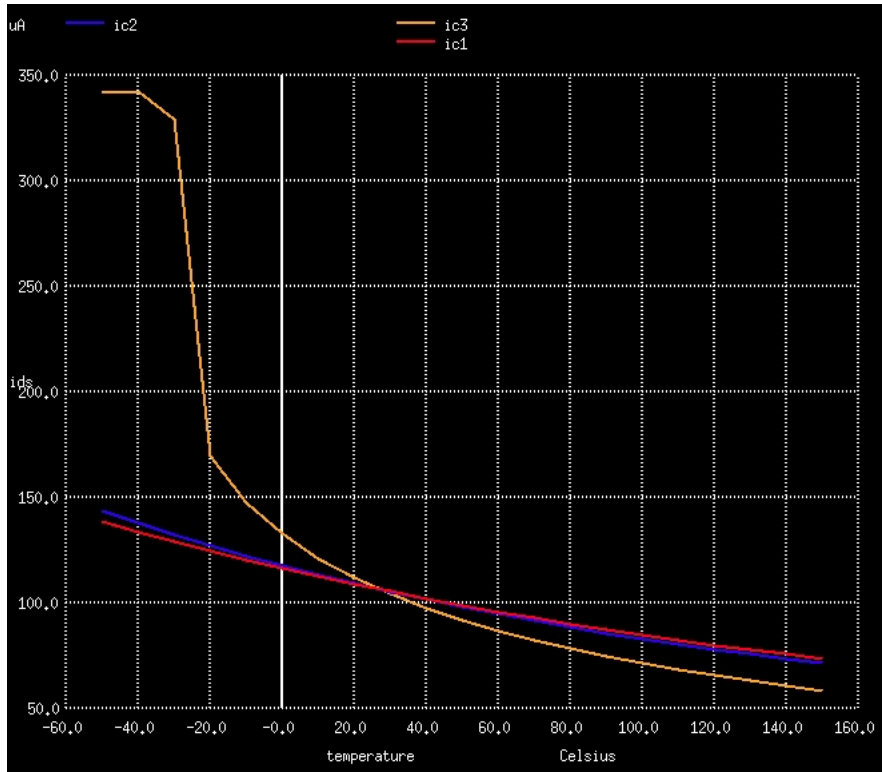
```

=====uc1=TemperatureCoefficientUc=====

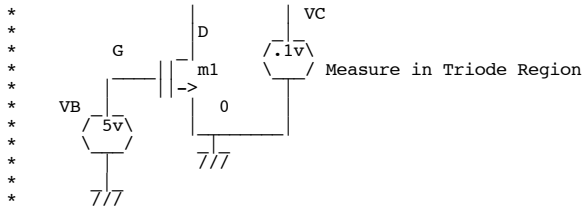
```

*-----mobility-----
+ u0=678        ua=8.964e-10    ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176   ual=5.705e-09   ubl=-1.147E-17  uc1=-1.302E-01
+ vsat=86000   at=20380        elm=2
*-----

```



NMOS_UC1 uc1=-1.302E-09 -1.302E-06 -1.302E-05



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds D 0 dc .1v
Vgs G 0 dc 5v
v1 D 1 dc 0v
m1 1 G 0 0 N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u

```

```

.control
destroy all
altermod N1 ucl=-1.302E-09
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc TEMP -50 150 10
altermod N1 ucl=-1.302E-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc TEMP -50 150 10
altermod N1 ucl=-1.302E-05
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc TEMP -50 150 10

```

```

let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 ylabel iDS xlabel temperature

```

.endc

```

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drou=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 bl=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dLdW????-----
+ wl=0 wln=1 wwl=0
+ ll=0 lln=1 lw=0 lwn=1
+ lw1=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----Bsim??-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!-----
* nqsmod lmlt=1.000e+00 wmlt=1.000e+00

```



```

dc      Vds      lm      5      0.01  vgs      0      5      .5
altermod N1      vsat=86000
*DC     SOURC1  VSTART  VSTOP  VSTEP  SOURC2  START2  STOP2  STEP2
dc      Vds      lm      5      0.01  vgs      0      5      .5
altermod N1      vsat=96000
*DC     SOURC1  VSTART  VSTOP  VSTEP  SOURC2  START2  STOP2  STEP2
dc      Vds      lm      5      0.01  vgs      0      5      .5
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot    ic1 ic2 ic3

let Reff1 = v(D)/(ic1 +1e-8)
let Reff2 = v(D)/(ic2 +1e-8)
let Reff3 = v(D)/(ic3 +1e-8)

plot Reff1 Reff2 Reff3 xlimit 0 1 ylimit .5k 2k xlabel VDS ylabel Rchan

```

```

.endc

.model          N1          NMOS
+ Level= 49      Tnom=27.0   version=3.24
+ mobmod=2      capmod=3     noimod=2
**-----Process-----
+ tox=160e-10   toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06   nch=0.5e+17
*-----V threshold-----
+ vth0=0.72     lvth0=0.025   nlx=0.12e-06   kt1=-0.9821
+ dvt0=2.2      dvt1=0.53     dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04    wint=0.16e-06 ww=-9.525E-14  wwn=1.0
+ dvt0w=0       dvt1w=5.3e6   dvt2w=-1.E-01  dwg=0
+ k3=2.53       k3b=-5        dwb=0
*-----Bulk-----
+ k1=1.04       k2=-1.209E-01 kt2=-0.2916
+ cdscc=-2.4E-4 cdsccb=-1.506E-04 cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678        ua=8.964e-10  ub=1.472e-18   uc=-4.441E-17
+ ute=-1.176    ua1=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000    at=20380      elm=2
*-----Resistance-----
+ rsh=70        rdsw=375      prt=-3.287E+02
+ wr=0.7586     prwb=0        prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06  pclm=.19      pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086  drou=0.56
*-----Subthreshold-----
+ nfactor=1.8   cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01  dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2      pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551     pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873   pbsw=0.8
+ cgso=9e-13     cgdo=9e-13    cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07   xpart=0
*-----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10  xti=2.000e+00  nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7         a1=1          a2=1            ags=0.05583
+ b0=6.305e-08   b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1           kf=0          ef=1            em=4.1E+07
+ noia=1E+20     noib=50000    noic=-1.4E-12
*-----dLdW????-----
+ wl=0           wln=1         wwl=0
+ ll=0           lln=1         lw=0            lwn=1
+ lw1=0          llc=2E-13    lwc=0           lwlc=0
+ wlc=0          wwc=0         wwlc=0
*-----Bsim???-----
+ wk3=0          lk3=0         pk3=1.257
+ lk3b=0         wk3b=0        pk3b=0
+ pa0=0.0489     la0=-1.052    lags=0.01093
+ wags=0         pags=0.1573   lketa=0
+ wdwg=0         ldwb=0        wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0        lu0=0           ldwg=0
+ uc1=-1.098E-11 acm=13        wu0=1
+ wua=3.641E-11  lua=9.782E-10 pua=-4.46E-10  lub=-7.249E-19
+ wub=1.056E-20  pub=8.812E-19 pu0=1
+ wuc=1.177E-11  luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ ngsmod         lmlt=1.000e+00 wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----

```

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

=====at=TemperatureCoefficientSaturationVelocity=====
*-----mobility-----
+ u0=678        ua=8.964e-10  ub=1.472e-18   uc=-4.441E-17
+ ute=-1.176    ua1=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000    at=20380      elm=2
*-----

```

Figure 131 Output Characteristic Id=f(Vd,T)


```
Vgs      G      0      dc      2v
v1       D      1      dc      0v
m1       1      G      0      0      N1      W=3u    L=1u    AD=7p  AS=7p  PD=10u PS=10u
```

```
.control
destroy all
altermod N1 at=1380
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc TEMP -50 150 10
altermod N1 at=20380
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc TEMP -50 150 10
altermod N1 at=130380
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc TEMP -50 150 10
```

```
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel VDS ylabel temperature
```

```
.endc
```

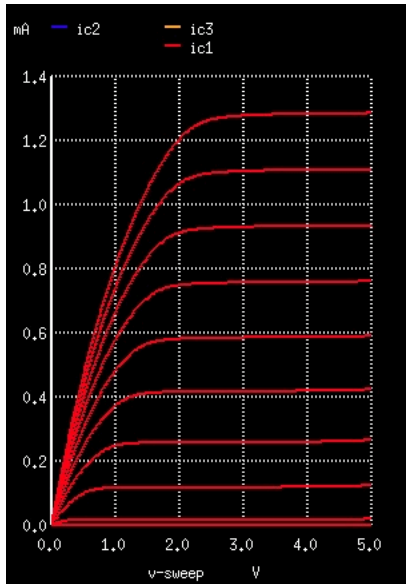
```
.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
*-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdscc=-2.4E-4 cdscc=-1.506E-04 cdscc=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ua1=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drout=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dLdW????-----
+ wl=0 wln=1 wwl=0
+ ll=0 lln=1 lw=0 lwn=1
+ lw=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----Bsim??-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!-----
* ngsmod lmlt=1.000e+00 wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
*-----
```

```
.end
```

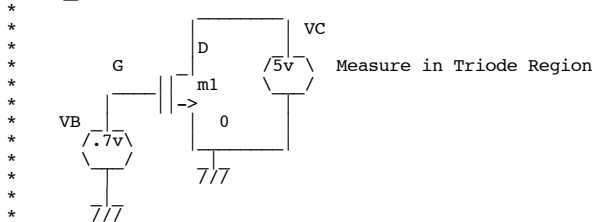
```
* source /Users/don_sauer/Downloads/stable/SI_Lib/Tests.cir
```

```
=====elm=ElmoreChannelConstant=====
*-----mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ua1=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
```

+ vsat=86000 at=20380 elm=2



NMOS_ELM elm=1 2 4



```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds      D      0      dc      5v
Vgs      G      0      dc      1.2v
v1       D      1      dc      0v
m1       1      G      0      0      N1      W=3u  L=1u  AD=7p  AS=7p  PD=10u  PS=10u
.control
destroy all
altermod N1 elm=1
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds lm 5 0.01 vgs 0 5 .5
altermod N1 elm=2
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds lm 5 0.01 vgs 0 5 .5
altermod N1 elm=4
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds lm 5 0.01 vgs 0 5 .5
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3
.endc
```

```
.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 k3bw=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdscc=-2.4E-4 cdscc=-1.506E-04 cdscc=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ua1=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbel1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drout=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
```

```

*-----Capacitance-----
+ cjswg=2.73e-10      mjswg=0.2           pbswg=8.800e-01
+ cj=0.0002424      mj=0.3551          pb=0.5614
+ cjsw=2.73e-10      mjsw=0.3873        pbsw=0.8
+ cgso=9e-13         cgdo=9e-13         cgbo=7e-10
+ dlc=5e-08          dwc=1.5e-07        xpart=0
*-----BulkDiode-----
+ js=5.858e-08       jsw=1.25E-10       xti=2.000e+00     nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7             a1=1                a2=1              ags=0.05583
+ b0=6.305e-08      b1=6.579e-08       keta=-1.531E-02
*-----Noise????-----
+ af=1              kf=0                ef=1              em=4.1E+07
+ noia=1E+20        noib=50000          noic=-1.4E-12
*-----dIdW????-----
+ wl=0              wln=1              ww1=0
+ ll=0              lln=1              lw=0              lwn=1
+ lw1=0             llc=2E-13          lwc=0             lwlc=0
+ wlc=0             wwc=0              wwlc=0
*-----Bsim??-----
+ wk3=0             lk3=0              pk3=1.257
+ lk3b=0            wk3b=0             pk3b=0
+ pa0=0.0489        la0=-1.052         lags=0.01093
+ wags=0            pags=0.1573        lketa=0
+ wdwg=0            ldwb=0             wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07      ldif=0             lu0=0             ldwg=0
+ uc1=-1.098E-11    acm=13             wu0=1
+ wua=3.641E-11     lua=9.782E-10      pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20     pub=8.812E-19      pu0=1
+ wuc=1.177E-11     luc=-2.164E-10     puc=1.231E-10
*-----Flagged!!-----
+ ngsmod            lmlt=1.000e+00     wmlt=1.000e+00
+ tlev=0.000e+00    tlevc=0.000e+00
*

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

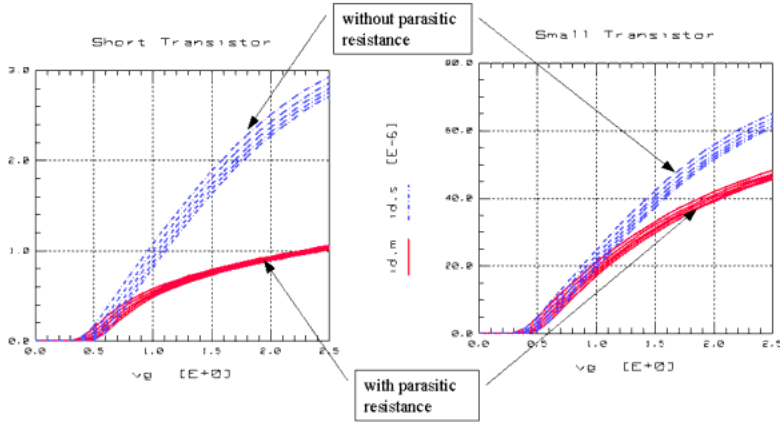
===== **rsh_SourceDrainOhmPerSquare** =====

```

*-----Resistance-----
+ rsh=70            rdsw=375           prt=-3.287E+02
+ wr=0.7586        prwb=0             prwg=-4.441E-17
*

```

Figure 92 Influence of Drain Source Resistance on Drain Current




```

+ rsh=70          rdsw=375          prt=-3.287E+02
+ wr=0.7586      prwb=0            prwg=-4.441E-17
*-----
+ lint=.12e-06   pclm=.19          pscbel=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39      pdiblc2=0.0086   drou=0.56
*-----
+ nfactor=1.8    Subthreshold      cit=-5.0E-04     voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01      dsub=0.7
*-----
+ alpha0=1.61e-05 alpha1=8.276E-05  beta0=36.68
*-----
+ cjswg=2.73e-10 mjswg=0.2         pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551        pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873      pbsw=0.8
+ cgso=9e-13    cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07      xpart=0
*-----
+ js=5.858e-08  jsw=1.25E-10     xti=2.000e+00    nj=1.08
*-----
+ a0=0.7         BulkChargeEffect  a1=1             a2=1
+ b0=6.305e-08  bl=6.579e-08     keta=-1.531E-02 ags=0.05583
*-----
+ af=1           Noise????         kf=0             ef=1             em=4.1E+07
+ noia=1E+20    noib=50000        noic=-1.4E-12
*-----
+ wl=0          dLdW????         wln=1           wwl=0
+ ll=0          lln=1            lwn=1
+ lwl=0         llc=2E-13        lwc=0           lwlc=0
+ wlc=0         wwc=0            wwlc=0
*-----
+ wk3=0         Bsim???          lk3=0           pk3=1.257
+ lk3b=0        wk3b=0           pk3b=0
+ pa0=0.0489   pags=0.1573      lags=0.01093
+ wags=0        ldwb=0           lketa=0
+ wdwg=0        wdwb=0
*-----
+ hdif=2.7E-07  HspiceBSIM4???  ldif=0          lu0=0           ldwg=0
+ uc1=-1.098E-11 acm=13          wu0=1
+ wua=3.641E-11 lua=9.782E-10   pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19   pu0=1
+ wuc=1.177E-11 luc=-2.164E-10  puc=1.231E-10
*-----
+ nqsmod        Flagged!!        lmlt=1.000e+00  wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----
.end
* source /Users/don_sauer/Downloads/stable/SI_Lib/Tests.cir

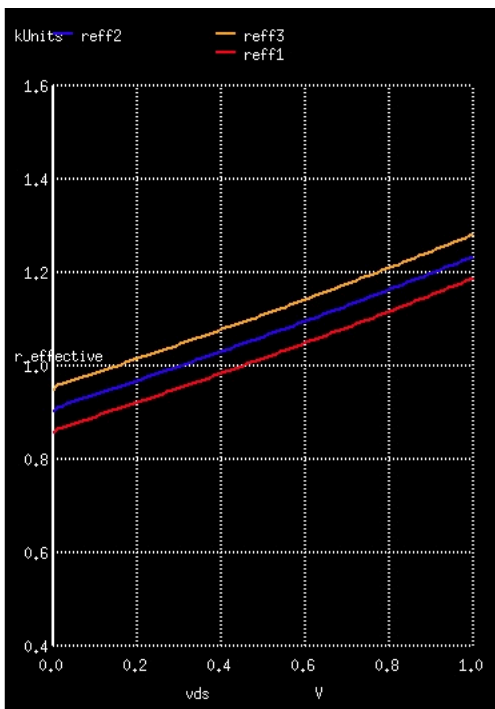
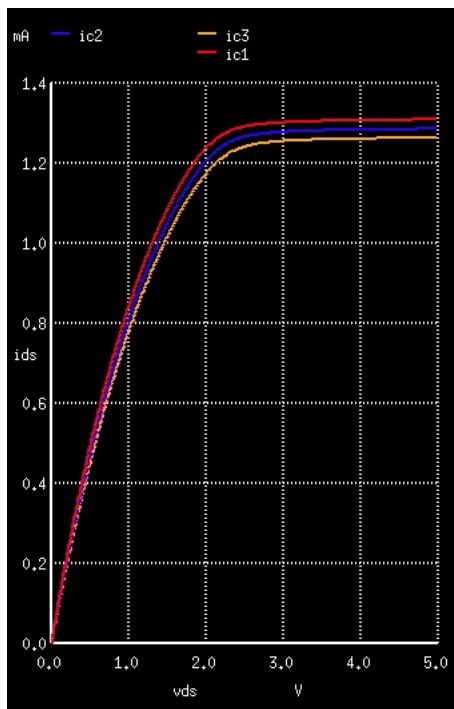
```

=====**rdsw=ParasiticResistancePerUnitWidth**=====

```

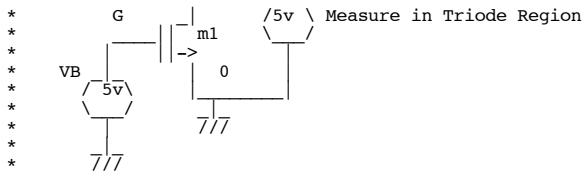
*-----
+ rsh=70          Resistance
+ wr=0.7586      rdsw=375          prt=-3.287E+02
+ wr=0.7586      prwb=0            prwg=-4.441E-17
*-----

```



NMOS_RDSW rdsw=275 375 475





```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds D 0 dc 5v
Vgs G 0 dc 5v
v1 D 1 dc 0v
m1 1 G 0 0 N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u
.control
destroy all
altermod N1 rds=275
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 5 5 5
altermod N1 rds=375
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 5 5 5
altermod N1 rds=475
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 5 5 5
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel VDS ylabel Ids
let Reff1 = v(D)/(ic1 +1e-8)
let Reff2 = v(D)/(ic2 +1e-8)
let Reff3 = v(D)/(ic3 +1e-8)
plot Reff1 Reff2 Reff3 xlimit 0 1 ylimit .5k 1.5k xlabel VDS ylabel R_effective
.endc

```

```

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ub1=-1.147E-17 ucl=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rds=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAR-----
+ lint=.12e-06 pclm=.19 pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drout=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dIdW????-----
+ w1=0 wln=1 ww1=0
+ l1=0 lln=1 lw=0 lwn=1
+ lwl=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----Bsim???-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----

```



```
let Reff3 = v(d)/dc3.i(v1)
plot Reff1 Reff2 Reff3 ylabel Rchan
```

```
.endc
```

```
.model
+ Level= 49          N1          NMOS
+ mobmod=2          Tnom=27.0      version=3.24
+ ngate=8.000e+19  capmod=3          noimod=2
**-----Process-----
+ tox=160e-10       toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----V_threshold-----
+ vth0=0.72        lvth0=0.025      nlx=0.12e-06    kt1=-0.9821
+ dvt0=2.2         dvt1=0.53        dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06    ww=-9.525E-14   wwn=1.0
+ dvt0w=0         dvt1w=5.3e6     dvt2w=-1.E-01
+ k3=2.53         k3b=-5          dwg=0           dwb=0
*-----Bulk-----
+ k1=1.04          k2=-1.209E-01    kt2=-0.2916
+ cdscc=-2.4E-4    cdsd=-1.506E-04  cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678           ua=8.964e-10     ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09    ubl=-1.147E-17  ucl=-1.302E-01
+ vsat=86000       at=20380         elm=2
*-----Resistance-----
+ rsh=70           rdsw=375         prt=-3.287E+02
+ wr=0.7586        prwb=0           prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06     pclm=.19         pscbel=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39     pdiblc2=0.0086  drou=0.56
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04     voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01    dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2        pbswg=8.800e-01
+ cj=0.0002424    mj=0.3551        pb=.5614
+ cjsw=2.73e-10  mjsw=0.3873      pbsw=0.8
+ cgso=9e-13      cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08       dwc=1.5e-07      xpart=0
*-----BulkDiode-----
+ js=5.858e-08    jsw=1.25E-10     xti=2.000e+00   nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7           a1=1             a2=1
+ b0=6.305e-08    b1=6.579e-08    keta=-1.531E-02  ags=0.05583
*-----Noise????-----
+ af=1             kf=0             ef=1             em=4.1E+07
+ noia=1E+20       noib=50000       noic=-1.4E-12
*-----dLdW????-----
+ wl=0             wln=1            wl=0
+ ll=0             lln=1            lw=0             lwn=1
+ lw1=0           llc=2E-13        lwc=0            lwlc=0
+ wlc=0           wwc=0            wwlc=0
*-----Bsim???-----
+ wk3=0           lk3=0            pk3=1.257
+ lk3b=0          wk3b=0           pk3b=0
+ pa0=0.0489      la0=-1.052       lags=0.01093
+ wags=0           pags=0.1573     lketa=0
+ wdwg=0          ldwb=0           wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07    ldif=0           lu0=0            ldwg=0
+ uc1=-1.098E-11  acm=13           wu0=1
+ wua=3.641E-11  lua=9.782E-10    pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20  pub=8.812E-19    pu0=1
+ wuc=1.177E-11  luc=-2.164E-10  puc=1.231E-10
*-----Flagged!!-----
* ngsmod          lmlt=1.000e+00  wmlt=1.000e+00
* tlev=0.000e+00  tlevc=0.000e+00
*-----
```

```
.end
```

```
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir
```

```
=====wr=WidthOffsetFromWeff=====
```

```
*-----Resistance-----
+ rsh=70           rdsw=375         prt=-3.287E+02
+ wr=0.7586       prwb=0           prwg=-4.441E-17
*-----
```



```

+ vsat=86000      at=20380      elm=2
*-----
+ rsh=70          rdsw=375          prt=-3.287E+02
+ wr=0.7586      prwb=0           prwg=-4.441E-17
*-----
+ lint=.12e-06   pclm=.19         pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39     pdiblc2=0.0086    drou=0.56
*-----
+ nfactor=1.8    cit=-5.0E-04     voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01     dsub=0.7
*-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----
+ cjswg=2.73e-10 mjswg=0.2        pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551        pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873      pbsw=0.8
+ cgso=9e-13    cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07      xpart=0
*-----
+ js=5.858e-08  jsw=1.25E-10     xti=2.000e+00     nj=1.08
*-----
+ a0=0.7         a1=1              a2=1               ags=0.05583
+ b0=6.305e-08  b1=6.579e-08     keta=-1.531E-02
*-----
+ af=1           kf=0              ef=1               em=4.1E+07
+ noia=1E+20     noib=50000        noic=-1.4E-12
*-----
+ w1=0           wln=1             ww1=0
+ l1=0           lln=1             lw=0               lwn=1
+ lw1=0          llc=2E-13         lwc=0              lwlc=0
+ wlc=0          wwc=0             wwlc=0
*-----
+ wk3=0          lk3=0             pk3=1.257
+ lk3b=0         wk3b=0            pk3b=0
+ pa0=0.0489    la0=-1.052        lags=0.01093
+ wags=0         pags=0.1573       lketa=0
+ wdwg=0         ldwb=0            wdwb=0
*-----
+ hdif=2.7E-07  ldif=0            lu0=0              ldwg=0
+ uc1=-1.098E-11 acm=13            wu0=1
+ wua=3.641E-11 lua=9.782E-10     pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19     pu0=1
+ wuc=1.177E-11 luc=-2.164E-10    puc=1.231E-10
*-----
+ nqsmod         lmlt=1.000e+00    wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
*-----

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

=====PRWB=Body-biasDependenceLDDResistance=====
*-----
+ rsh=70          rdsw=375          prt=-3.287E+02
+ wr=0.7586      prwb=0           prwg=-4.441E-17
*-----

```



```

+ k1=1.04          k2=-1.209E-01      kt2=-0.2916
+ cdsc=-2.4E-4    cdscd=-1.506E-04     cdscb=-2.219E-04
*-----Mobility-----
+ u0=678          ua=8.964e-10        ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176     ual=5.705e-09        ub1=-1.147E-17   ucl=-1.302E-01
+ vsat=86000     at=20380             elm=2
*-----Resistance-----
+ rsh=70          rdsw=375             prt=-3.287E+02
+ wr=0.7586      prwb=0               prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06   pclm=.19             pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39        pdiblc2=0.0086    drout=0.56
*-----Subthreshold-----
+ nfactor=1.8    cit=-5.0E-04        voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01        dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05     beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2           pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551          pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873        pbsw=0.8
+ cgso=9e-13     cgdo=9e-13         cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07        xpart=0
*-----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10       xti=2.000e+00     nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7          al=1                 a2=1               ags=0.05583
+ b0=6.305e-08   bl=6.579e-08       keta=-1.531E-02
*-----Noise????-----
+ af=1            kf=0                 ef=1               em=4.1E+07
+ noia=1E+20     noib=50000          noic=-1.4E-12
*-----dLdW????-----
+ wl=0            wln=1                wwl=0
+ ll=0            lln=1                lw=0               lwn=1
+ lw1=0           llc=2E-13           lwc=0              lwlc=0
+ wlc=0           wwc=0                wwlc=0
*-----Bsim???-----
+ wk3=0           lk3=0                pk3=1.257
+ lk3b=0          wk3b=0               pk3b=0
+ pa0=0.0489     la0=-1.052           lags=0.01093
+ wags=0          pags=0.1573          lketa=0
+ wdwg=0          ldwb=0               wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0               lu0=0              ldwg=0
+ uc1=-1.098E-11 acm=13                wu0=1
+ wua=3.641E-11  lua=9.782E-10        pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20  pub=8.812E-19        pu0=1
+ wuc=1.177E-11  luc=-2.164E-10       puc=1.231E-10
*-----Flagged!!-----
+ nqsmod          lmlt=1.000e+00      wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

=====**PRWG=Gate-biasDependenceLDDResistance**=====

```

*-----Resistance-----
+ rsh=70          rdsw=375             prt=-3.287E+02
+ wr=0.7586      prwb=0               prwg=-4.441E-17
*-----

```



```

+ dvt0w=0          dvt1w=5.3e6          dvt2w=-1.E-01          dwg=0
+ k3=2.53          k3b=-5
* -----Bulk-----
+ k1=1.04          k2=-1.209E-01          kt2=-0.2916
+ cdsc=-2.4E-4    cdscd=-1.506E-04      cdscb=-2.219E-04
* -----Mobility-----
+ u0=678           ua=8.964e-10          ub=1.472e-18          uc=-4.441E-17
+ ute=-1.176      ual=5.705e-09         ub1=-1.147E-17       uc1=-1.302E-01
+ vsat=86000      at=20380              elm=2
* -----Resistance-----
+ rsh=70           rdsw=375              prt=-3.287E+02
+ wr=0.7586       prwb=0                prwg=-4.441E-17
* -----VAR-----
+ lint=.12e-06    pclm=.19              pscbe1=3.79e+08       pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39          pdiblc2=0.0086       dROUT=0.56
* -----Subthreshold-----
+ nfactor=1.8     cit=-5.0E-04          voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01          dsub=0.7
* -----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05      beta0=36.68
* -----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2             pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551             pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873           pbsw=0.8
+ cgso=9e-13     cgdo=9e-13            cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07           xpart=0
* -----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10          xti=2.000e+00         nj=1.08
* -----BulkChargeEffect-----
+ a0=0.7          a1=1                   a2=1                   ags=0.05583
+ b0=6.305e-08   b1=6.579e-08          keta=-1.531E-02
* -----Noise????-----
+ af=1            kf=0                   ef=1                   em=4.1E+07
+ noia=1E+20     noib=50000            noic=-1.4E-12
* -----dLdW????-----
+ wl=0            wln=1                  ww1=0
+ ll=0            lln=1                  lw=0                   lwn=1
+ lw1=0           llc=2E-13             lwc=0                  lwlc=0
+ wlc=0           wwc=0                  wwlc=0
* -----Bsim???-----
+ wk3=0           lk3=0                  pk3=1.257
+ lk3b=0          wk3b=0                 pk3b=0
+ pa0=0.0489     la0=-1.052             lags=0.01093
+ wags=0          pags=0.1573            lketa=0
+ wdwg=0          ldwb=0                 wdwb=0
* -----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0                 lu0=0                  ldwg=0
+ uc1=-1.098E-11 acm=13                 wu0=1
+ wua=3.641E-11  lua=9.782E-10          pua=-4.46E-10         lub=-7.249E-19
+ wub=1.056E-20  pub=8.812E-19          pu0=1
+ wuc=1.177E-11  luc=-2.164E-10         puc=1.231E-10
* -----Flagged!!-----
+ nqsmod          lmlt=1.000e+00        wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
* -----

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

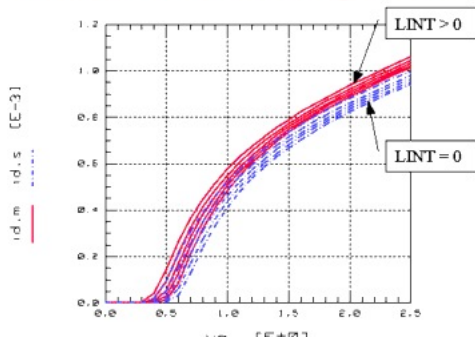
```

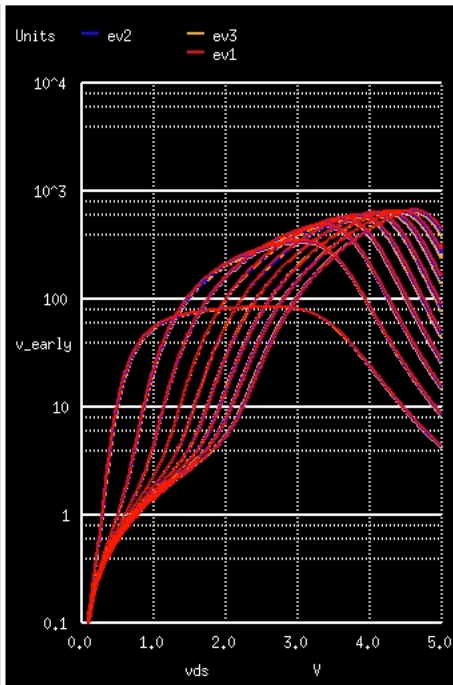
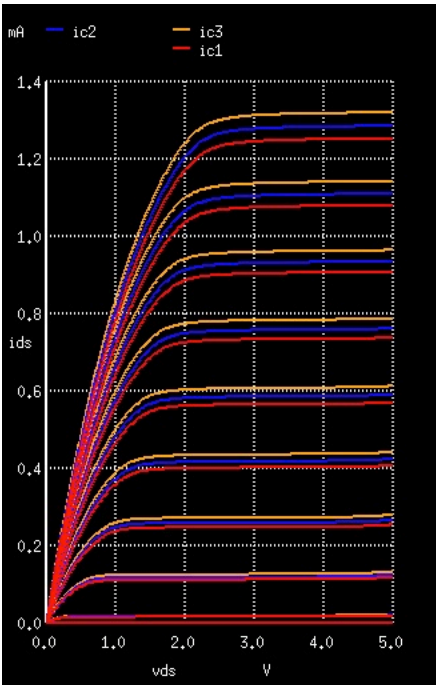
```

=====lint=LengthOffsetFittingParameter=====
* -----VAR-----
+ lint=.12e-06    pclm=.19              pscbe1=3.79e+08       pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39          pdiblc2=0.0086       dROUT=0.56
* -----

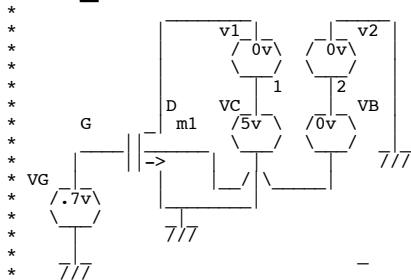
```

Figure 80 Influence of Channel Length Reduction on the Drain Current





NMOS_LINT lint=.10e-06 .12e-06 .14e-06



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds D 0 dc .1v
Vgs G 0 dc 1.2v
Vbs 2 B dc 0v
v1 D 1 dc 0v
v2 0 2 dc 0v
m1 1 G 0 B N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u

```

```

.control
destroy all
altermod N1 lint=.10e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 lint=.12e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 lint=.14e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5

let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel VDS ylabel IDS

let ev1 = mag(ic1/(deriv(ic1)+1e-7))
let ev2 = mag(ic2/(deriv(ic2)+1e-7))
let ev3 = mag(ic3/(deriv(ic3)+1e-7))
plot ev1 ev2 ev3 ylog ylimit .1 10k xlabel VDS ylabel V_early
.endc

```

```

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
*-----
* Process
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----
* V threshold
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----
* NarrowChannel
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----
* Bulk
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdsd=-1.506E-04 cdsb=-2.219E-04

```



```

*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ubl=-1.147E-17 ucl=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drout=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dLdW????-----
+ wl=0 wln=1 wwl=0
+ ll=0 lln=1 lw=0 lwn=1
+ lw1=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----Bsim???-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
+ wags=0 pags=0.1573 lketa=0
+ wdwg=0 ldwb=0 wdwb=0
*-----HspiceBSIM4???-----
+ hdif=2.7E-07 ldif=0 lu0=0 ldwg=0
+ uc1=-1.098E-11 acm=13 wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ nqsmod lmlt=1.000e+00 wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

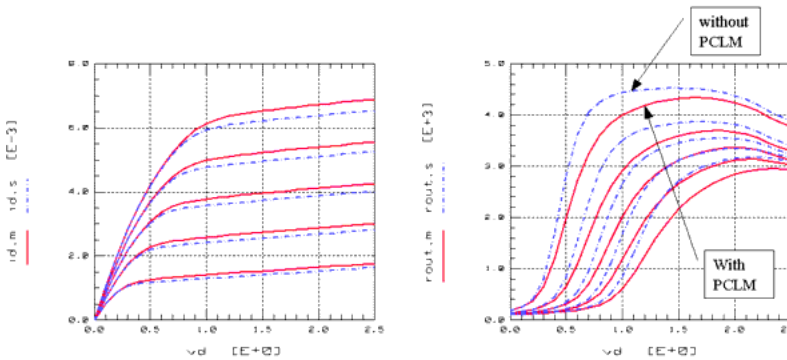
=====**pclm=ChannelLengthModulationParameter**=====

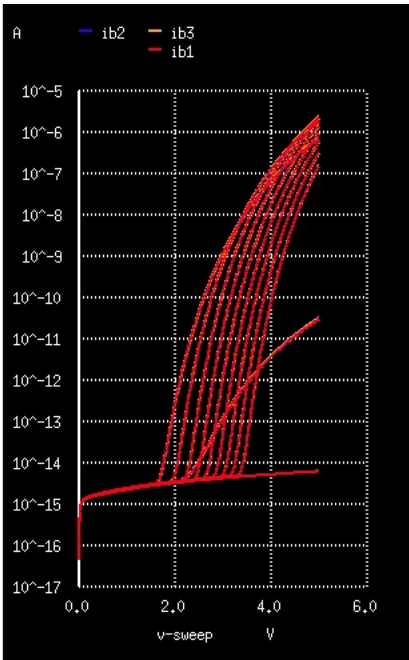
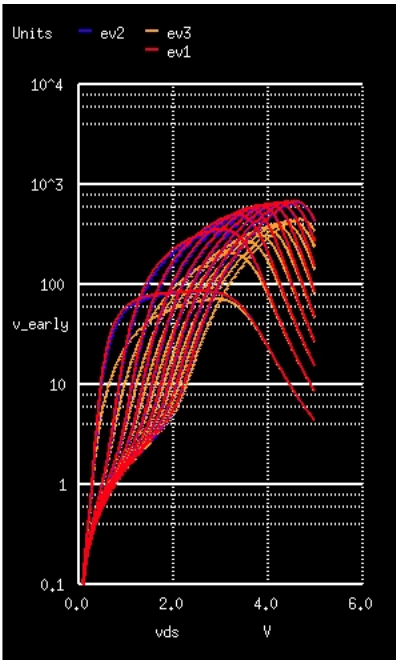
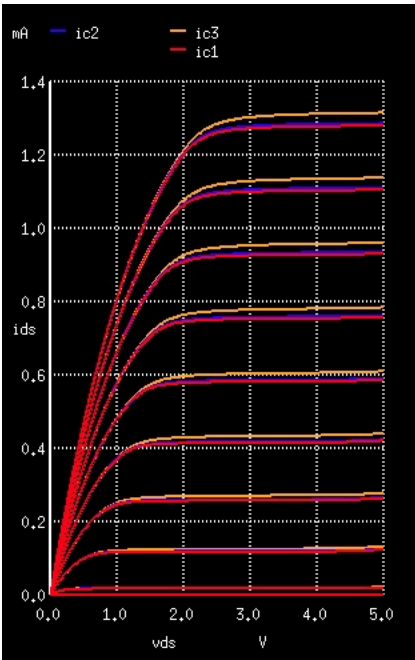
```

*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drout=0.56
*-----

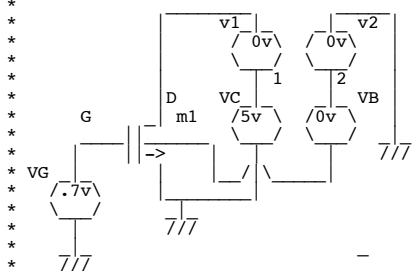
```

Figure 94 Channel Length Modulation (CLM)





NMOS_PCLM **pclm=.05 .19 .89**



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds D 0 dc .1v
Vgs G 0 dc 1.2v
Vbs 2 B dc 0v
v1 D 1 dc 0v
v2 0 2 dc 0v
m1 1 G 0 B N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u
.control
destroy all
altermod N1 pclm=.05
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 pclm=.19
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 pclm=.89
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5

let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel VDS ylabel IDS

let ev1 = mag(ic1/(deriv(ic1)+1e-7))
let ev2 = mag(ic2/(deriv(ic2)+1e-7))
let ev3 = mag(ic3/(deriv(ic3)+1e-7))
plot ev1 ev2 ev3 ylog ylimit .1 10k xlabel VDS ylabel V_early

let ib1 = mag(dc1.i(v2))
let ib2 = mag(dc2.i(v2))
let ib3 = mag(dc3.i(v2))
plot ib1 ib2 ib3 ylog xlabel VDS ylabel BulkCurrent
.endc

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----

```

```

+ k1=1.04          k2=-1.209E-01      kt2=-0.2916
+ cdsc=-2.4E-4    cdscd=-1.506E-04      cdscb=-2.219E-04
* -----Mobility-----
+ u0=678          ua=8.964e-10        ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176     ual=5.705e-09         ub1=-1.147E-17   uc1=-1.302E-01
+ vsat=86000     at=20380              elm=2
* -----Resistance-----
+ rsh=70         rdsw=375              prt=-3.287E+02
+ wr=0.7586     prwb=0                prwg=-4.441E-17
* -----VAF-----
+ lint=.12e-06   pclm=.19              pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39          pdiblc2=0.0086    dROUT=0.56
* -----Subthreshold-----
+ nfactor=1.8    cit=-5.0E-04          voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01          dsub=0.7
* -----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05      beta0=36.68
* -----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2            pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551            pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873          pbsw=0.8
+ cgso=9e-13     cgdo=9e-13           cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07          xpart=0
* -----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10         xti=2.000e+00     nj=1.08
* -----BulkChargeEffect-----
+ a0=0.7         al=1                  a2=1               ags=0.05583
+ b0=6.305e-08  bl=6.579e-08         keta=-1.531E-02
* -----Noise????-----
+ af=1          kf=0                  ef=1               em=4.1E+07
+ noia=1E+20    noib=50000           noic=-1.4E-12
* -----dIdW????-----
+ wl=0          wln=1                 wwl=0
+ ll=0          lln=1                 lw=0               lwn=1
+ lwl=0         llc=2E-13            lwc=0              lwlc=0
+ wlc=0         wwc=0                 wwlc=0
* -----Bsim???-----
+ wk3=0         lk3=0                 pk3=1.257
+ lk3b=0        wk3b=0                pk3b=0
+ pa0=0.0489   la0=-1.052            lags=0.01093
+ wags=0        pags=0.1573           lketa=0
+ wdwg=0        ldwb=0                wdwb=0
* -----HspiceBSIM4???-----
+ hdif=2.7E-07  ldif=0                lu0=0              ldwg=0
+ uc1=-1.098E-11 acm=13                wu0=1
+ wua=3.641E-11 lua=9.782E-10       pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19       pu0=1
+ wuc=1.177E-11 luc=-2.164E-10      puc=1.231E-10
* -----Flagged!!-----
+ nqsmod        lmlt=1.000e+00       wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
* -----

```

.end

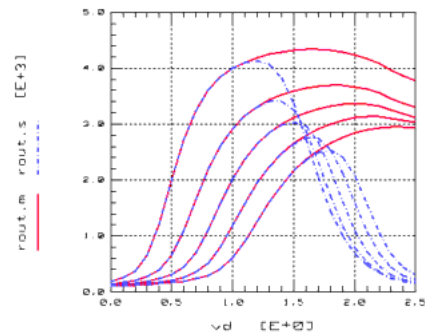
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

=====pscbe1=FirstSubstrateCurrentBodyeffectParameter=====
* -----VAF-----
+ lint=.12e-06   pclm=.19              pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39          pdiblc2=0.0086    dROUT=0.56
* -----

```

Figure 97 Substrate Current Body Effect (SCBE)




```

*-----Mobility-----
+ u0=678          ua=8.964e-10      ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176     ual=5.705e-09      ubl=-1.147E-17   uc1=-1.302E-01
+ vsat=86000     at=20380           elm=2
*-----Resistance-----
+ rsh=70         rdsw=375           prt=-3.287E+02
+ wr=0.7586     prwb=0             prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06   pclm=.19           pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39       pdiblc2=0.0086    drout=0.56
*-----Subthreshold-----
+ nfactor=1.8    cit=-5.0E-04       voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01       dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05   beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2          pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551          pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873        pbsw=0.8
+ cgso=9e-13    cgdo=9e-13         cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07        xpart=0
*-----BulkDiode-----
+ js=5.858e-08  jsw=1.25E-10       xti=2.000e+00     nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7         a1=1                a2=1                ags=0.05583
+ b0=6.305e-08  b1=6.579e-08       keta=-1.531E-02
*-----Noise????-----
+ af=1           kf=0                ef=1                em=4.1E+07
+ noia=1E+20     noib=50000          noic=-1.4E-12
*-----dLdW????-----
+ wl=0           wln=1               ww1=0
+ ll=0           lln=1               lw=0                lwn=1
+ lw1=0          llc=2E-13           lwc=0               lwlc=0
+ wlc=0          wwc=0               wwlc=0
*-----Bsim???-----
+ wk3=0          lk3=0               pk3=1.257
+ lk3b=0         wk3b=0              pk3b=0
+ pa0=0.0489    la0=-1.052          lags=0.01093
+ wags=0         pags=0.1573         lketa=0
+ wdwg=0         ldwb=0              wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07  ldif=0              lu0=0               ldwg=0
+ uc1=-1.098E-11 acm=13              wu0=1
+ wua=3.641E-11 lua=9.782E-10       pua=-4.46E-10      lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19       pu0=1
+ wuc=1.177E-11 luc=-2.164E-10     puc=1.231E-10
*-----Flagged!-----
+ nqsmod         lmlt=1.000e+00     wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----

```

```

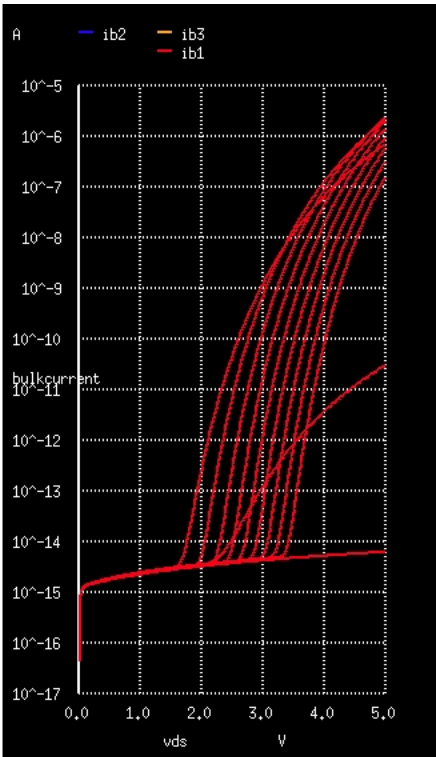
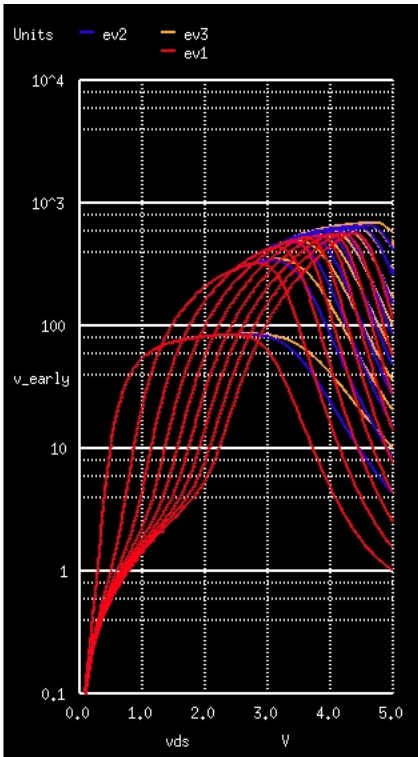
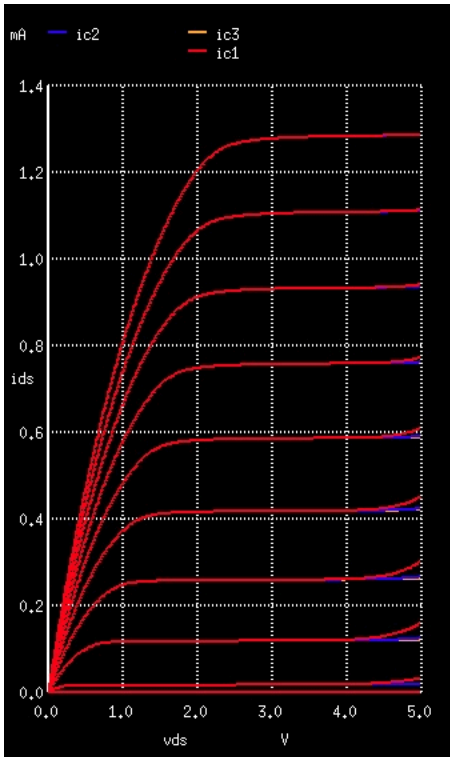
.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

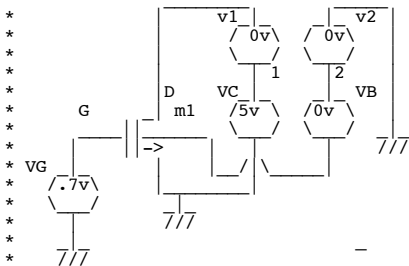
```

=====pscbe2=SecondSubstrateCurrentBodyeffectParamete=====
*-----VAF-----
+ lint=.12e-06   pclm=.19           pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39       pdiblc2=0.0086    drout=0.56
*-----

```



NMOS_PSCBE2 **pscbe2=9.4e-04 9.4e-05 9.4e-06**



```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*****
Vds D 0 dc .1v
Vgs G 0 dc 1.2v
Vbs 2 B dc 0v
v1 D 1 dc 0v
v2 0 2 dc 0v
m1 1 G 0 B N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u
```

```
.control
destroy all
altermod N1 pscbe2=9.4e-04
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 pscbe2=9.4e-05
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 pscbe2=9.4e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
```

```
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel VDS ylabel IDS

let ev1 = mag(ic1/(deriv(ic1)+1e-7))
let ev2 = mag(ic2/(deriv(ic2)+1e-7))
let ev3 = mag(ic3/(deriv(ic3)+1e-7))
plot ev1 ev2 ev3 ylog ylimit .1 10k xlabel VDS ylabel V_early
```

```
let ib1 = mag(dc1.i(v2))
let ib2 = mag(dc2.i(v2))
let ib3 = mag(dc3.i(v2))
plot ib1 ib2 ib3 ylog xlabel VDS ylabel BulkCurrent
```

```
.endc

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V_threshold-----
```

```

+ vth0=0.72      lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2      dvt1=0.53      dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04    wint=0.16e-06   ww=-9.525E-14    wwn=1.0
+ dvt0w=0      dvt1w=5.3e6    dvt2w=-1.E-01
+ k3=2.53      k3b=-5         dwg=0            dwb=0
*-----Bulk-----
+ k1=1.04      k2=-1.209E-01  kt2=-0.2916
+ cdsc=-2.4E-4  cdscd=-1.506E-04  cdscb=-2.219E-04
*-----Mobility-----
+ u0=678      ua=8.964e-10   ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176  ual=5.705e-09  ubl=-1.147E-17  ucl=-1.302E-01
+ vsat=86000  at=20380      elm=2
*-----Resistance-----
+ rsh=70      rdsw=375      prt=-3.287E+02
+ wr=0.7586   prwb=0        prwg=-4.441E-17
*-----VAR-----
+ lint=.12e-06  pclm=.19      pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39  pdiblc2=0.0086  drout=0.56
*-----Subthreshold-----
+ nfactor=1.8  cit=-5.0E-04  voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01  dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05  beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2     pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551    pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873  pbsw=0.8
+ cgso=9e-13    cgdo=9e-13   cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07  xpart=0
*-----BulkDiode-----
+ js=5.858e-08  jsw=1.25E-10  xti=2.000e+00   nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7      a1=1          a2=1            ags=0.05583
+ b0=6.305e-08  b1=6.579e-08  keta=-1.531E-02
*-----Noise????-----
+ af=1      kf=0          ef=1            em=4.1E+07
+ noia=1E+20  noib=50000   noic=-1.4E-12
*-----dIdW????-----
+ wl=0      wln=1        ww1=0
+ ll=0      lln=1        lw=0            lwn=1
+ lw1=0     llc=2E-13   lwc=0           lwlc=0
+ wlc=0     wwc=0       wwlc=0
*-----Bsim??-----
+ wk3=0      lk3=0        pk3=1.257
+ lk3b=0     wk3b=0       pk3b=0
+ pa0=0.0489  la0=-1.052   lags=0.01093
+ wags=0     pags=0.1573  lketa=0
+ wdwg=0     ldwb=0       wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07  ldif=0       lu0=0           ldwg=0
+ uc1=-1.098E-11  acm=13      wu0=1
+ wua=3.641E-11  lua=9.782E-10  pua=-4.46E-10  lub=-7.249E-19
+ wub=1.056E-20  pub=8.812E-19  pu0=1
+ wuc=1.177E-11  luc=-2.164E-10  puc=1.231E-10
*-----Flagged!!-----
+ nqsmod      lmlt=1.000e+00  wmlt=1.000e+00
* tlev=0.000e+00  tlevc=0.000e+00
*-----

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

=====delta=EffectiveVdsParameter=====
*-----VAR-----
+ lint=.12e-06  pclm=.19      pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39  pdiblc2=0.0086  drout=0.56
*-----

```



```

*-----NarrowChannel-----
+ w0=2.6e-04      wint=0.16e-06      ww=-9.525E-14      wwn=1.0
+ dvt0w=0         dvt1w=5.3e6        dvt2w=-1.E-01     dwb=0
+ k3=2.53         k3b=-5             dwg=0
*-----Bulk-----
+ k1=1.04         k2=-1.209E-01      kt2=-0.2916
+ cdscc=-2.4E-4  cdsd=-1.506E-04    cdscb=-2.219E-04
*-----Mobility-----
+ u0=678          ua=8.964e-10       ub=1.472e-18       uc=-4.441E-17
+ ute=-1.176      ual=5.705e-09      ubl=-1.147E-17     ucl=-1.302E-01
+ vsat=86000      at=20380           elm=2
*-----Resistance-----
+ rsh=70          rdsw=375           prt=-3.287E+02
+ wr=0.7586       prwb=0             prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06    pclm=.19           pscbe1=3.79e+08    pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39       pdiblc2=0.0086     drout=0.56
*-----Subthreshold-----
+ nfactor=1.8     cit=-5.0E-04       voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01       dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05   beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2          pbswg=8.800e-01
+ cj=0.0002424    mj=0.3551          pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873        pbsw=0.8
+ cgso=9e-13      cgdo=9e-13         cgbo=7e-10
+ dlc=5e-08       dwc=1.5e-07        xpart=0
*-----BulkDiode-----
+ js=5.858e-08    jsw=1.25E-10       xti=2.000e+00      nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7          a1=1               a2=1                ags=0.05583
+ b0=6.305e-08   bl=6.579e-08       keta=-1.531E-02
*-----Noise????-----
+ af=1            kf=0               ef=1                em=4.1E+07
+ noia=1E+20      noib=50000         noic=-1.4E-12
*-----dLdW????-----
+ wl=0            wln=1              wwl=0
+ ll=0            lln=1              lw=0                lwn=1
+ lwl=0           llc=2E-13          lwc=0               lwlc=0
+ wlc=0           wwc=0              wwlc=0
*-----Bsim???-----
+ wk3=0           lk3=0              pk3=1.257
+ lk3b=0          wk3b=0             pk3b=0
+ pa0=0.0489      la0=-1.052         lags=0.01093
+ wags=0           pags=0.1573        lketa=0
+ wdwg=0           ldwb=0             wdwb=0
*-----HspiceBSIM4???-----
+ hdif=2.7E-07    ldif=0             lu0=0               ldwg=0
+ uc1=-1.098E-11 acm=13             wu0=1
+ wua=3.641E-11  lua=9.782E-10     pua=-4.46E-10      lub=-7.249E-19
+ wub=1.056E-20  pub=8.812E-19     pu0=1
+ wuc=1.177E-11  luc=-2.164E-10    puc=1.231E-10
*-----Flagged!!-----
+ ngsmod          lmlt=1.000e+00     wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00

```

```

.end
* source /Users/don_sauer/Downloads/stable/SI_Lib/Tests.cir

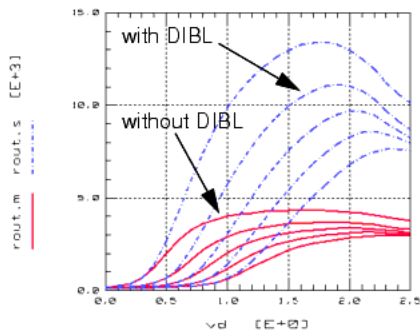
```

```

=====PDIBLC1=DIBL_effect_Rout=====
*-----VAF-----
+ lint=.12e-06    pclm=.19           pscbe1=3.79e+08    pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39       pdiblc2=0.0086     drout=0.56
*

```

Figure 96 Influence of Drain Induced Barrier Lowering (DIBL) effect on output resistance




```

*-----NarrowChannel-----
+ w0=2.6e-04      wint=0.16e-06      ww=-9.525E-14      wwn=1.0
+ dvt0w=0         dvt1w=5.3e6       dvt2w=-1.E-01
+ k3=2.53         k3b=-5            dwg=0               dwb=0
*-----Bulk-----
+ k1=1.04         k2=-1.209E-01     kt2=-0.2916
+ cdsc=-2.4E-4   cdscd=-1.506E-04  cdscb=-2.219E-04
*-----Mobility-----
+ u0=678          ua=8.964e-10      ub=1.472e-18       uc=-4.441E-17
+ ute=-1.176     ual=5.705e-09     ubl=-1.147E-17     ucl=-1.302E-01
+ vsat=86000     at=20380           elm=2
*-----Resistance-----
+ rsh=70          rdsw=375          prt=-3.287E+02
+ wr=0.7586      prwb=0            prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06   pclm=.19          pscbel=3.79e+08     pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39      pdiblc2=0.0086     drout=0.56
*-----Subthreshold-----
+ nfactor=1.8    cit=-5.0E-04     voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01     dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05  beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2         pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551         pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873       pbsw=0.8
+ cgso=9e-13     cgdo=9e-13        cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07       xpart=0
*-----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10      xti=2.000e+00      nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7          a1=1              a2=1                ags=0.05583
+ b0=6.305e-08   bl=6.579e-08     keta=-1.531E-02
*-----Noise????-----
+ af=1            kf=0              ef=1                em=4.1E+07
+ noia=1E+20      noib=50000        noic=-1.4E-12
*-----dLdW????-----
+ wl=0            wln=1             wwl=0
+ ll=0            lln=1             lw=0                lwn=1
+ lwl=0           llc=2E-13         lwc=0               lwlc=0
+ wlc=0           wwc=0             wwlc=0
*-----Bsim???-----
+ wk3=0           lk3=0             pk3=1.257
+ lk3b=0          wk3b=0            pk3b=0
+ pa0=0.0489     la0=-1.052        lags=0.01093
+ wags=0          pags=0.1573       lketa=0
+ wdwg=0          ldwb=0            wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0            lu0=0               ldwg=0
+ uc1=-1.098E-11 acm=13            wu0=1
+ wua=3.641E-11 lua=9.782E-10     pua=-4.46E-10      lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19     pu0=1
+ wuc=1.177E-11 luc=-2.164E-10    puc=1.231E-10
*-----Flagged!!-----
+ ngsmod          lmlt=1.000e+00    wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00

```

```

.end
* source /Users/don_sauer/Downloads/stable/SI_Lib/Tests.cir

```

=====**PDIBLC2=DIBL_effect_Rout**=====

```

*-----VAF-----
+ lint=.12e-06   pclm=.19          pscbel=3.79e+08     pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39      pdiblc2=0.0086     drout=0.56
*-----

```



```

+ dvt0w=0          dvt1w=5.3e6          dvt2w=-1.E-01
+ k3=2.53          k3b=-5                    dwg=0          dwb=0
*-----Bulk-----
+ k1=1.04          k2=-1.209E-01           kt2=-0.2916
+ cdsc=-2.4E-4    cdsd=-1.506E-04        cdscb=-2.219E-04
*-----Mobility-----
+ u0=678          ua=8.964e-10           ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176     ual=5.705e-09          ub1=-1.147E-17  uc1=-1.302E-01
+ vsat=86000     at=20380                elm=2
*-----Resistance-----
+ rsh=70          rdsw=375                prt=-3.287E+02
+ wr=0.7586      prwb=0                  prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06    pclm=.19                pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39           pdiblc2=0.0086  drout=0.56
*-----Subthreshold-----
+ nfactor=1.8     cit=-5.0E-04           voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01           dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05       beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2              pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551              pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873           pbsw=0.8
+ cgso=9e-13     cgdo=9e-13            cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07           xpart=0
*-----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10          xti=2.000e+00    nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7          a1=1                    a2=1              ags=0.05583
+ b0=6.305e-08   b1=6.579e-08          keta=-1.531E-02
*-----Noise????-----
+ af=1            kf=0                    ef=1              em=4.1E+07
+ noia=1E+20     noib=50000             noic=-1.4E-12
*-----dLdW????-----
+ w1=0            wln=1                   ww1=0
+ l1=0            lln=1                    lw=0              lwn=1
+ lw1=0           llc=2E-13               lwc=0             lwlc=0
+ wlc=0           wwc=0                   wwlc=0
*-----Bsim???-----
+ wk3=0           lk3=0                   pk3=1.257
+ lk3b=0          wk3b=0                  pk3b=0
+ pa0=0.0489     la0=-1.052              lags=0.01093
+ wags=0          pags=0.1573             lketa=0
+ wdwg=0          ldwb=0                   wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0                  lu0=0             ldwg=0
+ uc1=-1.098E-11 acm=13                  wu0=1
+ wua=3.641E-11 lua=9.782E-10         pua=-4.46E-10    lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19          pu0=1
+ wuc=1.177E-11 luc=-2.164E-10        puc=1.231E-10
*-----Flagged!!-----
+ nqsmod          lmlt=1.000e+00         wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----

```

```

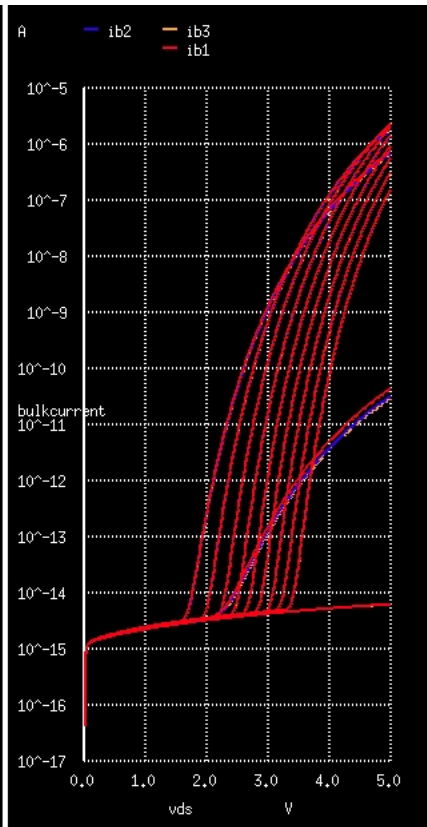
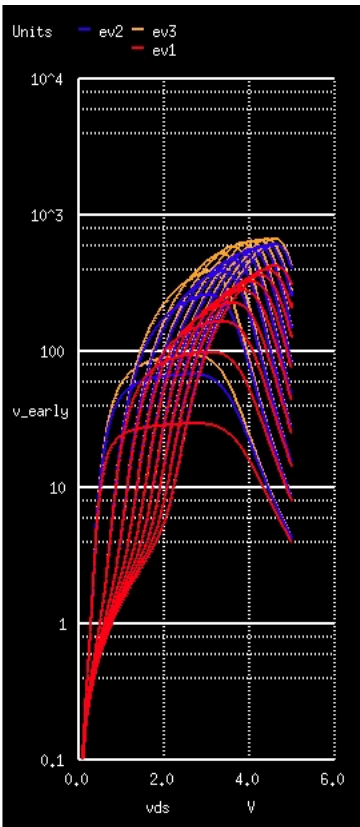
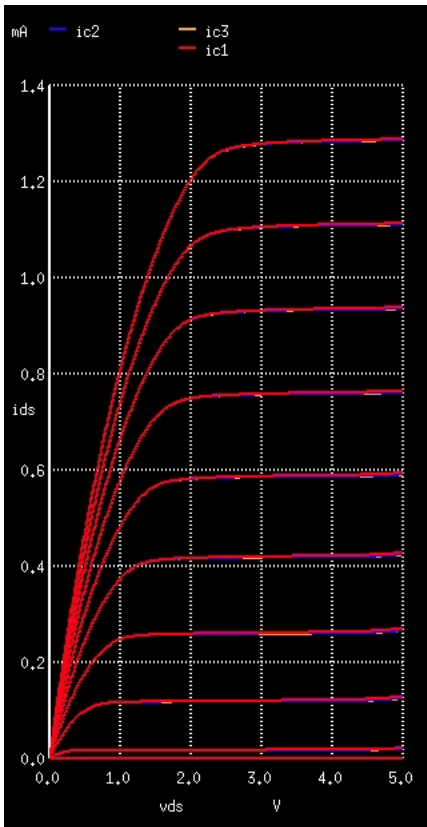
.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

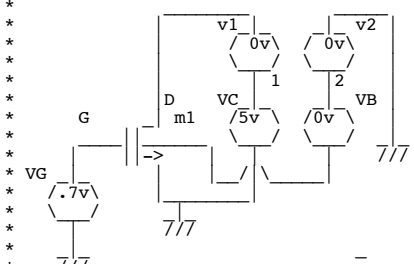
```

=====DROUT=Channel-lengthDependenceOfDIBLonRout=====
*-----VAF-----
+ lint=.12e-06    pclm=.19                pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39           pdiblc2=0.0086  drout=0.56
*-----

```



NMOS_DROUT **d**rout=0.26 0.56 0.96



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds D 0 dc .1v
Vgs G 0 dc 1.2v
Vbs 2 B dc 0v
v1 D 1 dc 0v
v2 0 2 dc 0v
m1 1 G 0 B N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u

```

```

.control
destroy all
altermod N1 drout=0.26
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 drout=0.56
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 drout=0.96
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5

```

```

let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel VDS ylabel IDS

let ev1 = mag(ic1/(deriv(ic1)+1e-7))
let ev2 = mag(ic2/(deriv(ic2)+1e-7))
let ev3 = mag(ic3/(deriv(ic3)+1e-7))
plot ev1 ev2 ev3 ylog ylimit .1 10k xlabel VDS ylabel V_early

let ib1 = mag(dc1.i(v2))
let ib2 = mag(dc2.i(v2))
let ib3 = mag(dc3.i(v2))
plot ib1 ib2 ib3 ylog xlabel VDS ylabel BulkCurrent

```

```

.endc

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----

```

```

+ tox=160e-10      toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----V threshold-----
+ vth0=0.72        lvth0=0.025        nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2         dvt1=0.53          dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06      ww=-9.525E-14     wwn=1.0
+ dvt0w=0          dvt1w=5.3e6        dvt2w=-1.E-01     dwb=0
+ k3=2.53          k3b=-5             dwg=0
*-----Bulk-----
+ k1=1.04          k2=-1.209E-01      kt2=-0.2916
+ cdscc=-2.4E-4    cdscc=-1.506E-04   cdscc=-2.219E-04
*-----Mobility-----
+ u0=678           ua=8.964e-10       ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09      ubl=-1.147E-17    ucl=-1.302E-01
+ vsat=86000       at=20380            elm=2
*-----Resistance-----
+ rsh=70           rdsw=375           prt=-3.287E+02
+ wr=0.7586        prwb=0             prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06     pclm=.19           pscbel=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39       pdiblc2=0.0086    drout=0.56
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04       voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01       dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05   beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10   mjswg=0.2          pbswg=8.800e-01
+ cj=0.0002424     mj=0.3551          pb=0.5614
+ cjsw=2.73e-10    mjsw=0.3873        pbsw=0.8
+ cgso=9e-13       cgdo=9e-13         cgbo=7e-10
+ dlc=5e-08        dwc=1.5e-07        xpart=0
*-----BulkDiode-----
+ js=5.858e-08     jsw=1.25E-10       xti=2.000e+00     nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7           a1=1               a2=1              ags=0.05583
+ b0=6.305e-08     bl=6.579e-08       keta=-1.531E-02
*-----Noise????-----
+ af=1             kf=0               ef=1              em=4.1E+07
+ noia=1E+20       noib=50000         noic=-1.4E-12
*-----dLdW????-----
+ wl=0             wln=1              wwl=0
+ ll=0             lln=1              lw=0              lwn=1
+ lwl=0            llc=2E-13          lwc=0              lwlc=0
+ wlc=0            wwc=0              wwlc=0
*-----Bsim??-----
+ wk3=0            lk3=0              pk3=1.257
+ lk3b=0           wk3b=0             pk3b=0
+ pa0=0.0489       la0=-1.052         lags=0.01093
+ wags=0           pags=0.1573        lketa=0
+ wdwg=0           ldwb=0             wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07     ldif=0             lu0=0             ldwg=0
+ uc1=-1.098E-11   acm=13             wu0=1
+ wua=3.641E-11    lua=9.782E-10      pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20    pub=8.812E-19      pu0=1
+ wuc=1.177E-11    luc=-2.164E-10     puc=1.231E-10
*-----Flagged!!-----
+ ngsmod           lmlt=1.000e+00     wmlt=1.000e+00
+ tlev=0.000e+00  tlevc=0.000e+00
*-----

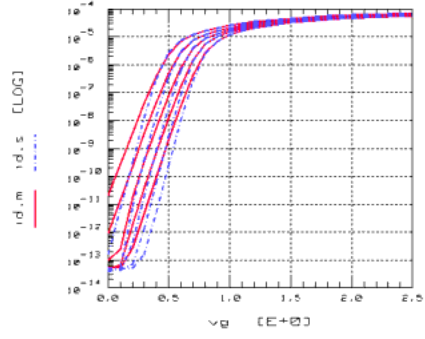
```

```

=====NFACTOR=Subthreshold_NFactor=====
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04       voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01       dsub=0.7
*-----

```

Figure 89 Influence of VOFF and NFACTOR on Drain Current in the Subthreshold Region



.endc

```
.model          N1          NMOS
+ Level= 49      Tnom=27.0    version=3.24
+ mobmod=2      capmod=3    noimod=2
**-----Process-----
+ tox=160e-10   toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06    nch=0.5e+17
*-----V threshold-----
+ vth0=0.72     lvth0=0.025   nlx=0.12e-06    kt1=-0.9821
+ dvt0=2.2      dvt1=0.53     dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04    wint=0.16e-06 ww=-9.525E-14   wwn=1.0
+ dvt0w=0       dvt1w=5.3e6   dvt2w=-1.E-01   dwg=0
+ k3=2.53       k3b=-5        dwb=0
*-----Bulk-----
+ k1=1.04       k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4  cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678        ua=8.964e-10  ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176    ual=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000    at=20380      elm=2
*-----Resistance-----
+ rsh=70        rdsw=375      prt=-3.287E+02
+ wr=0.7586     prwb=0        prwg=-4.441E-17
*-----VAR-----
+ lint=.12e-06  pclm=.19      pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39  pdiblc2=0.0086   drout=0.56
*-----Subthreshold-----
+ nfactor=1.8   cit=-5.0E-04  voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01  dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2     pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551    pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873  pbsw=0.8
+ cgso=9e-13    cgdo=9e-13   cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07  xpart=0
*-----BulkDiode-----
+ js=5.858e-08  jsw=1.25E-10 xti=2.000e+00   nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7        a1=1          a2=1             ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1          kf=0          ef=1             em=4.1E+07
+ noia=1E+20    noib=50000    noic=-1.4E-12
*-----dLdW????-----
+ w1=0          wln=1         ww1=0
+ l1=0          lln=1         lw=0             lwn=1
+ lwl=0         llc=2E-13    lwc=0            lwlc=0
+ wlc=0         wwc=0         wwlc=0
*-----Bsim??-----
+ wk3=0         lk3=0         pk3=1.257
+ lk3b=0        wk3b=0        pk3b=0
+ pa0=0.0489    la0=-1.052    lags=0.01093
+ wags=0         pags=0.1573   lketa=0
+ wdwg=0         ldwb=0        wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07  ldif=0        lu0=0            ldwg=0
+ uc1=-1.098E-11 acm=13        wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pbu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
* nqsmod        lmlt=1.000e+00 wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
*-----
```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```
===== CIT=InterfaceTrapCapacitance =====
*-----Subthreshold-----
+ nfactor=1.8   cit=-5.0E-04  voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01  dsub=0.7
*-----
```



```

.model
+ Level= 49      N1      NMOS
+ mobmod=2      Tnom=27.0  version=3.24
+-----+-----+-----+
** Process-----
+ tox=160e-10   toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06   nch=0.5e+17
*-----+-----+-----+
* V threshold-----
+ vth0=0.72     lvth0=0.025   nlx=0.12e-06   kt1=-0.9821
+ dvt0=2.2      dvt1=0.53     dvt2=-1.521E-01
*-----+-----+-----+
* NarrowChannel-----
+ w0=2.6e-04    wint=0.16e-06  ww=-9.525E-14  wwn=1.0
+ dvt0w=0       dvt1w=5.3e6   dvt2w=-1.E-01  dwg=0
+ k3=2.53       k3b=-5        dwb=0
*-----+-----+-----+
* Bulk-----
+ k1=1.04       k2=-1.209E-01  kt2=-0.2916
+ cdsc=-2.4E-4  cdscd=-1.506E-04  cdscc=-2.219E-04
*-----+-----+-----+
* Mobility-----
+ u0=678        ua=8.964e-10   ub=1.472e-18   uc=-4.441E-17
+ ute=-1.176    ual=5.705e-09  ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000    at=20380       elm=2
*-----+-----+-----+
* Resistance-----
+ rsh=70        rdsw=375       prt=-3.287E+02
+ wr=0.7586     prwb=0         prwg=-4.441E-17
*-----+-----+-----+
* VAF-----
+ lint=.12e-06  pclm=.19       pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39   pdiblc2=0.0086   drout=0.56
*-----+-----+-----+
* Subthreshold-----
+ nfactor=1.8   cit=-5.0E-04   voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01   dsub=0.7
*-----+-----+-----+
* HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----+-----+-----+
* Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2      pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551     pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873   pbsw=0.8
+ cgso=9e-13    cgdo=9e-13    cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07   xpart=0
*-----+-----+-----+
* BulkDiode-----
+ js=5.858e-08  jsw=1.25E-10  xti=2.000e+00   nj=1.08
*-----+-----+-----+
* BulkChargeEffect-----
+ a0=0.7        a1=1           a2=1             ags=0.05583
+ b0=6.305e-08 b1=6.579e-08  keta=-1.531E-02
*-----+-----+-----+
* Noise????-----
+ af=1          kf=0           ef=1             em=4.1E+07
+ noia=1E+20    noib=50000     noic=-1.4E-12
*-----+-----+-----+
* dLdW????-----
+ wl=0          wln=1          wwl=0
+ ll=0          lln=1          lw=0             lwn=1
+ wl=0          llc=2E-13     lwc=0            lwlc=0
+ wlc=0          wwc=0          wwlc=0
*-----+-----+-----+
* Bsim???-----
+ wk3=0         lk3=0          pk3=1.257
+ lk3b=0        wk3b=0         pk3b=0
+ pa0=0.0489    la0=-1.052     lags=0.01093
+ wags=0         pags=0.1573    lketa=0
+ wdwg=0        ldwb=0         wdwb=0
*-----+-----+-----+
* HspiceBSIM4??-----
+ hdif=2.7E-07  ldif=0         lu0=0            ldwg=0
+ uc1=-1.098E-11 acm=13         wu0=1
+ wua=3.641E-11 lua=9.782E-10  pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19  pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----+-----+-----+
* Flagged!!-----
+ nqsmod        lmlt=1.000e+00  wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----+-----+-----+

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

```

=====VOFF=SubthresholdOffsetVoltage=====
*-----+-----+-----+
* Subthreshold-----
+ nfactor=1.8   cit=-5.0E-04   voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01   dsub=0.7
*-----+-----+-----+

```


plot ev1 ev2 ev3 loglog xlabel VDS ylabel V_early

.endc

```
.model          N1          NMOS
+ Level= 49      Tnom=27.0    version=3.24
+ mobmod=2      capmod=3      noimod=2
**-----Process-----
+ tox=160e-10   toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06    nch=0.5e+17
*-----V threshold-----
+ vth0=0.72     lvth0=0.025    nlx=0.12e-06    kt1=-0.9821
+ dvt0=2.2      dvt1=0.53      dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04    wint=0.16e-06  ww=-9.525E-14   wwn=1.0
+ dvt0w=0       dvt1w=5.3e6    dvt2w=-1.E-01   dwg=0
+ k3=2.53       k3b=-5         dwg=0            dwb=0
*-----Bulk-----
+ k1=1.04       k2=-1.209E-01  kt2=-0.2916
+ cdscc=-2.4E-4 cdscc=-1.506E-04 cdscc=-2.219E-04
*-----Mobility-----
+ u0=678        ua=8.964e-10   ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176    ua1=5.705e-09  ub1=-1.147E-17  uc1=-1.302E-01
+ vsat=86000    at=20380       elm=2
*-----Resistance-----
+ rsh=70        rdsw=375       prt=-3.287E+02
+ wr=0.7586     prwb=0         prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06  pclm=.19       pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39   pdiblc2=0.0086   drout=0.56
*-----Subthreshold-----
+ nfactor=1.8   cit=-5.0E-04   voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01   dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2      pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551      pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873   pbsw=0.8
+ cgso=9e-13    cgdo=9e-13    cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07    xpart=0
*-----BulkDiode-----
+ js=5.858e-08  jsw=1.25E-10   xti=2.000e+00    nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7         a1=1           a2=1              ags=0.05583
+ b0=6.305e-08  b1=6.579e-08  keta=-1.531E-02
*-----Noise????-----
+ af=1           kf=0           ef=1              em=4.1E+07
+ noia=1E+20     noib=50000     noic=-1.4E-12
*-----dLdW????-----
+ wl=0           wln=1          wwl=0
+ ll=0           lln=1          lw=0              lwn=1
+ wl=0           llc=2E-13      lwc=0             lwlc=0
+ wlc=0          wwc=0          wwlc=0
*-----Bsim???-----
+ wk3=0          lk3=0          pk3=1.257
+ lk3b=0         wk3b=0         pk3b=0
+ pa0=0.0489     la0=-1.052     lags=0.01093
+ wags=0         pags=0.1573    lketa=0
+ wdwg=0         ldwb=0         wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0         lu0=0             ldwg=0
+ uc1=-1.098E-11 acm=13         wu0=1
+ wua=3.641E-11 lua=9.782E-10  pua=-4.46E-10    lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19  pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ ngsmod         lmlt=1.000e+00 wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
**-----
```

.end

* source /Users/don_sauer/Downloads/stable/SI_Lib/Tests.cir

```
=====ETA0=DIBLCoefficientSubthresholdRegion=====
*-----Subthreshold-----
+ nfactor=1.8   cit=-5.0E-04   voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01   dsub=0.7
**-----
```



```

+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----
* V_threshold
+ vth0=0.72        lvth0=0.025      nlx=0.12e-06    kt1=-0.9821
+ dvt0=2.2         dvt1=0.53       dvt2=-1.521E-01
*-----
* NarrowChannel
+ w0=2.6e-04      wint=0.16e-06   ww=-9.525E-14   wwn=1.0
+ dvt0w=0         dvt1w=5.3e6    dvt2w=-1.E-01
+ k3=2.53        k3b=-5        dwg=0           dwb=0
*-----
* Bulk
+ k1=1.04         k2=-1.209E-01   kt2=-0.2916
+ cdscc=-2.4E-4   cdscc=-1.506E-04 cdsccb=-2.219E-04
*-----
* Mobility
+ u0=678          ua=8.964e-10    ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176     ua1=5.705e-09   ub1=-1.147E-17  uc1=-1.302E-01
+ vsat=86000     at=20380        elm=2
*-----
* Resistance
+ rsh=70          rdsw=375        prt=-3.287E+02
+ wr=0.7586      prwb=0          prwg=-4.441E-17
*-----
* VAF
+ lint=.12e-06   pclm=.19        pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39    pdiblc2=0.0086  drout=0.56
*-----
* Subthreshold
+ nfactor=1.8    cit=-5.0E-04    voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01  dsub=0.7
*-----
* HotElectrons
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----
* Capacitance
+ cjswg=2.73e-10 mjswg=0.2       pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551      pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873    pbsw=0.8
+ cgso=9e-13     cgdo=9e-13     cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07    xpart=0
*-----
* BulkDiode
+ js=5.858e-08   jsw=1.25E-10   xti=2.000e+00   nj=1.08
*-----
* BulkChargeEffect
+ a0=0.7         a1=1            a2=1            ags=0.05583
+ b0=6.305e-08  b1=6.579e-08  keta=-1.531E-02
*-----
* Noise???
+ af=1           kf=0            ef=1            em=4.1E+07
+ noia=1E+20    noib=50000     noic=-1.4E-12
*-----
* dLdW????
+ wl=0          wln=1          ww1=0
+ ll=0          lln=1          lw=0           lwn=1
+ lw1=0         llc=2E-13     lwc=0          lwlc=0
+ wlc=0         wwc=0          wwlc=0
*-----
* Bsim???
+ wk3=0         lk3=0          pk3=1.257
+ lk3b=0        wk3b=0         pk3b=0
+ pa0=0.0489   la0=-1.052     lags=0.01093
+ wags=0        pags=0.1573   lketa=0
+ wdwg=0        ldwb=0         wdwb=0
*-----
* HspiceBSIM4??
+ hdif=2.7E-07  ldif=0         lu0=0          ldwg=0
+ uc1=-1.098E-11 acm=13         wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----
* Flagged!!
* nqsmod        lmlt=1.000e+00  wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
*-----

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

===== **ETAB=BodybiasCoefficientSubthresholdDIBLEffect** =====

```

*-----
* Subthreshold
+ nfactor=1.8    cit=-5.0E-04    voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01  dsub=0.7
*-----

```



```

+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----V_threshold-----
+ vth0=0.72        lvth0=0.025      nlx=0.12e-06    kt1=-0.9821
+ dvt0=2.2         dvt1=0.53        dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06   ww=-9.525E-14   wwn=1.0
+ dvt0w=0          dvt1w=5.3e6     dvt2w=-1.E-01
+ k3=2.53          k3b=-5          dwg=0           dwb=0
*-----Bulk-----
+ k1=1.04          k2=-1.209E-01   kt2=-0.2916
+ cdscc=-2.4E-4    cdsccd=-1.506E-04  cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678           ua=8.964e-10    ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176       ua1=5.705e-09   ub1=-1.147E-17  uc1=-1.302E-01
+ vsat=86000       at=20380        elm=2
*-----Resistance-----
+ rsh=70           rdsw=375        prt=-3.287E+02
+ wr=0.7586        prwb=0          prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06     pclm=.19         pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39    pdiblc2=0.0086  drout=0.56
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04    voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01    dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05  beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10   mjswg=0.2        pbswg=8.800e-01
+ cj=0.0002424     mj=0.3551        pb=0.5614
+ cjsw=2.73e-10    mjsw=0.3873     pbsw=0.8
+ cgso=9e-13       cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08        dwc=1.5e-07      xpart=0
*-----BulkDiode-----
+ js=5.858e-08     jsw=1.25E-10     xti=2.000e+00    nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7            a1=1             a2=1             ags=0.05583
+ b0=6.305e-08     b1=6.579e-08    keta=-1.531E-02
*-----Noise????-----
+ af=1              kf=0             ef=1             em=4.1E+07
+ noia=1E+20        noib=50000       noic=-1.4E-12
*-----dLdW????-----
+ wl=0              wln=1            wl=0             lwn=1
+ ll=0              lln=1            lw=0             lwlc=0
+ lw1=0             llc=2E-13        lwc=0
+ wlc=0             wwc=0            wwlc=0
*-----Bsim??-----
+ wk3=0             lk3=0            pk3=1.257
+ lk3b=0            wk3b=0           pk3b=0
+ pa0=0.0489        la0=-1.052       lags=0.01093
+ wags=0            pags=0.1573     lketa=0
+ wdwg=0            ldwb=0           wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07      ldif=0           lu0=0            ldwg=0
+ uc1=-1.098E-11    acm=13           wu0=1
+ wua=3.641E-11     lua=9.782E-10    pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20     pub=8.812E-19    pu0=1
+ wuc=1.177E-11     luc=-2.164E-10  puc=1.231E-10
*-----Flagged!!-----
* ngsmod           lmlt=1.000e+00  wmlt=1.000e+00
* tlev=0.000e+00   tlevc=0.000e+00
*-----

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

=====DSUB=DIBLCoefficientExponentSubthresholdRegion=====
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04    voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01    dsub=0.7
*-----

```



```

+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----
* V_threshold
+ vth0=0.72        lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2         dvt1=0.53        dvt2=-1.521E-01
*-----
* NarrowChannel
+ w0=2.6e-04       wint=0.16e-06    ww=-9.525E-14    wwn=1.0
+ dvt0w=0         dvt1w=5.3e6     dvt2w=-1.E-01
+ k3=2.53         k3b=-5          dwg=0             dwb=0
*-----
* Bulk
+ k1=1.04          k2=-1.209E-01    kt2=-0.2916
+ cdsc=-2.4E-4     cdscd=-1.506E-04  cdscb=-2.219E-04
*-----
* Mobility
+ u0=678           ua=8.964e-10     ub=1.472e-18     uc=-4.441E-17
+ ute=-1.176       ua1=5.705e-09    ub1=-1.147E-17  uc1=-1.302E-01
+ vsat=86000       at=20380         elm=2
*-----
* Resistance
+ rsh=70           rdsw=375         prt=-3.287E+02
+ wr=0.7586        prwb=0          prwg=-4.441E-17
*-----
* VAF
+ lint=.12e-06     pclm=.19         pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39     pdiblc2=0.0086   drou=0.56
*-----
* Subthreshold
+ nfactor=1.8      cit=-5.0E-04     voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01    dsub=0.7
*-----
* HotElectrons
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----
* Capacitance
+ cjswg=2.73e-10  mjswg=0.2        pbswg=8.800e-01
+ cj=0.0002424    mj=0.3551        pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873      pbsw=0.8
+ cgso=9e-13      cgdo=9e-13       cgbo=7e-10
+ dlc=5e-08        dwc=1.5e-07      xpart=0
*-----
* BulkDiode
+ js=5.858e-08    jsw=1.25E-10     xti=2.000e+00   nj=1.08
*-----
* BulkChargeEffect
+ a0=0.7           a1=1            a2=1              ags=0.05583
+ b0=6.305e-08    b1=6.579e-08    keta=-1.531E-02
*-----
* Noise???
+ af=1             kf=0              ef=1              em=4.1E+07
+ noia=1E+20       noib=50000        noic=-1.4E-12
*-----
* dLdw???
+ wl=0             wln=1             ww1=0
+ ll=0             lln=1             lw=0              lwn=1
+ lw1=0           llc=2E-13         lwc=0             lwlc=0
+ wlc=0           wwc=0             wwlc=0
*-----
* Bsim???
+ wk3=0            lk3=0             pk3=1.257
+ lk3b=0           wk3b=0            pk3b=0
+ pa0=0.0489       la0=-1.052        lags=0.01093
+ wags=0           pags=0.1573       lketa=0
+ wdwg=0           ldwb=0            wdwb=0
*-----
* HspiceBSIM4??
+ hdif=2.7E-07     ldif=0            lu0=0             ldwg=0
+ uc1=-1.098E-11   acm=13            wu0=1
+ wua=3.641E-11    lua=9.782E-10     pua=-4.46E-10    lub=-7.249E-19
+ wub=1.056E-20    pub=8.812E-19     pu0=1
+ wuc=1.177E-11    luc=-2.164E-10    puc=1.231E-10
*-----
* Flagged!!
+ nqsmod           lmlt=1.000e+00    wmlt=1.000e+00
* tlev=0.000e+00  tlevc=0.000e+00
*-----

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

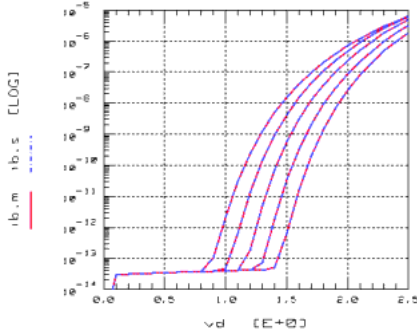
=====**ALPHA0=FirstParameterImpactIonization**=====

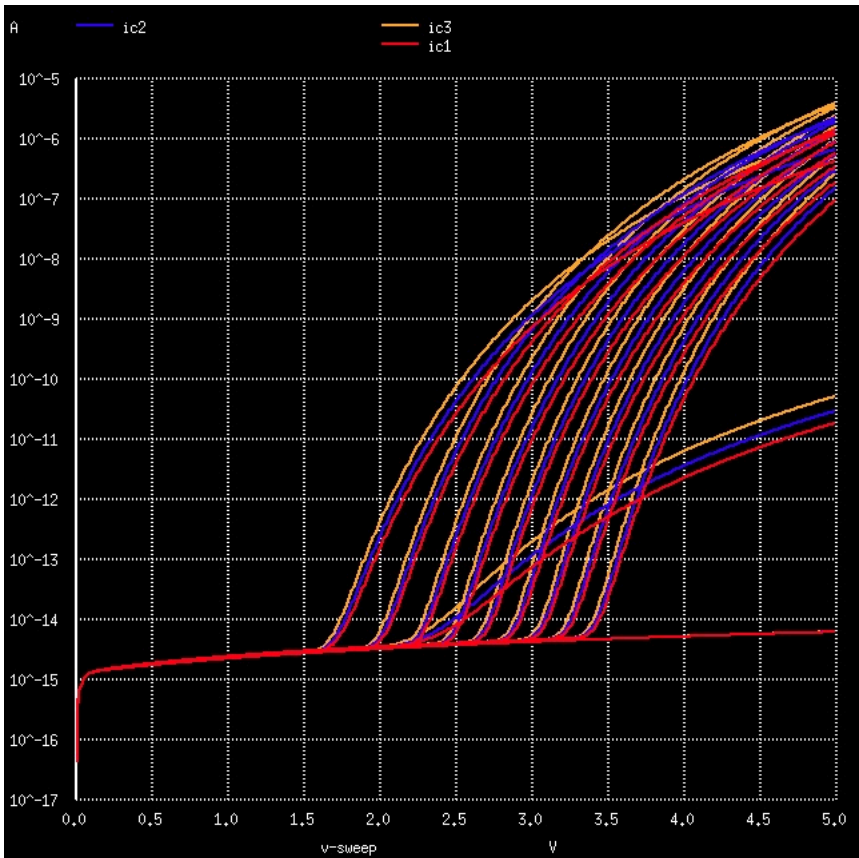
```

*-----
* HotElectrons
+ alpha0=1.61e-05  alpha1=8.276E-05  beta0=36.68
*-----

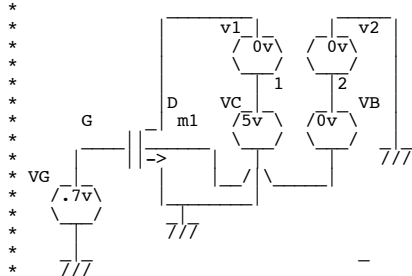
```

Figure 99 Substrate Current $I_{b,s}$ parameterized by V_g





NMOS_ALPHA0 alpha0=1.01e-05 1.61e-05 2.861e-05



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds D 0 dc .1v
Vgs G 0 dc 1.2v
Vbs 2 B dc 0v
v1 D 1 dc 0v
v2 0 2 dc 0v
m1 1 G 0 B N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u

.control
destroy all
altermod N1 alpha0=1.01e-05
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 alpha0=1.61e-05
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 alpha0=2.81e-05
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5

let ic1 = mag(dc1.i(v2))
let ic2 = mag(dc2.i(v2))
let ic3 = mag(dc3.i(v2))
plot ic1 ic2 ic3 ylog

.endc

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0

```

```

+ dvt0w=0          dvt1w=5.3e6          dvt2w=-1.E-01
+ k3=2.53          k3b=-5                dwg=0          dwb=0
*-----Bulk-----
+ k1=1.04          k2=-1.209E-01        kt2=-0.2916
+ cdsc=-2.4E-4    cdsd=-1.506E-04      cdscb=-2.219E-04
*-----Mobility-----
+ u0=678           ua=8.964e-10         ub=1.472e-18    uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09        ub1=-1.147E-17  uc1=-1.302E-01
+ vsat=86000       at=20380             elm=2
*-----Resistance-----
+ rsh=70           rdsw=375             prt=-3.287E+02
+ wr=0.7586        prwb=0               prwg=-4.441E-17
*-----VAR-----
+ lint=.12e-06     pclm=.19             pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39         pdiblc2=0.0086  drout=0.56
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04         voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01         dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05    beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10   mjswg=0.2           pbswg=8.800e-01
+ cj=0.0002424     mj=0.3551           pb=0.5614
+ cjsw=2.73e-10   mjsw=0.3873         pbsw=0.8
+ cgso=9e-13       cgdo=9e-13          cgbo=7e-10
+ dlc=5e-08        dwc=1.5e-07         xpart=0
*-----BulkDiode-----
+ js=5.858e-08     jsw=1.25E-10        xti=2.000e+00    nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7           a1=1                 a2=1             ags=0.05583
+ b0=6.305e-08     b1=6.579e-08        keta=-1.531E-02
*-----Noise????-----
+ af=1             kf=0                 ef=1             em=4.1E+07
+ noia=1E+20       noib=50000          noic=-1.4E-12
*-----dLdW????-----
+ wl=0             wln=1               ww1=0
+ ll=0             llm=1               lw=0             lwn=1
+ lw1=0            llc=2E-13           lwc=0            lwlc=0
+ wlc=0            wwc=0               wwlc=0
*-----Bsim???-----
+ wk3=0            lk3=0               pk3=1.257
+ lk3b=0           wk3b=0              pk3b=0
+ pa0=0.0489       la0=-1.052          lags=0.01093
+ wags=0           pags=0.1573         lketa=0
+ wdwg=0           ldwb=0              wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07     ldif=0              lu0=0            ldwg=0
+ uc1=-1.098E-11   acm=13              wu0=1
+ wua=3.641E-11    lua=9.782E-10       pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20    pub=8.812E-19       pu0=1
+ wuc=1.177E-11    luc=-2.164E-10     puc=1.231E-10
*-----Flagged!!-----
+ nqsmod           lmlt=1.000e+00      wmlt=1.000e+00
+ tlev=0.000e+00   tlevc=0.000e+00
*-----

```

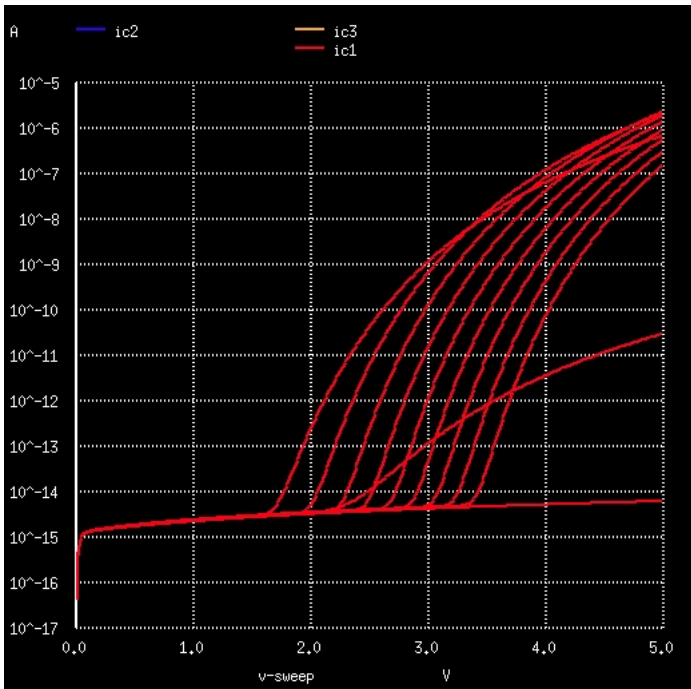
.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

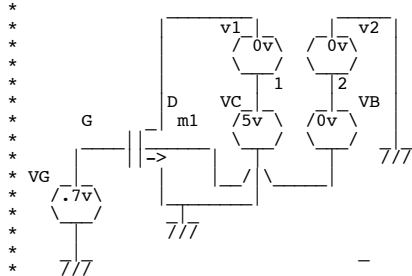
```

=====ALPHA1=ChannelLengthScalingImpactIonizationCurrent=====
*-----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05    beta0=36.68
*-----

```



NMOS_ALPHA1 alpha=8.276E-04 8.276E-05 8.276E-06



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds D 0 dc .1v
Vgs G 0 dc 1.2v
Vbs 2 B dc 0v
v1 D 1 dc 0v
v2 0 2 dc 0v
m1 1 G 0 B N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u
.control
destroy all
altermod N1 alpha=8.276E-04
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 alpha=8.276E-05
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5
altermod N1 alpha=8.276E-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 0 5 .5

let ic1 = mag(dc1.i(v2))
let ic2 = mag(dc2.i(v2))
let ic3 = mag(dc3.i(v2))
plot ic1 ic2 ic3 ylog

.endc

```

```

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdscd=-1.506E-04 cdscb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----

```

```

+ rsh=70          rdsw=375          prt=-3.287E+02
+ wr=0.7586      prwb=0          prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06   pclm=.19       pscbel=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39   pdiblc2=0.0086   drout=0.56
*-----Subthreshold-----
+ nfactor=1.8    cit=-5.0E-04   voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01   dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2      pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551     pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873   pbsw=0.8
+ cgso=9e-13    cgdo=9e-13    cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07   xpart=0
*-----BulkDiode-----
+ js=5.858e-08  jsw=1.25E-10  xti=2.000e+00    nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7         a1=1          a2=1             ags=0.05583
+ b0=6.305e-08  b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1          kf=0          ef=1             em=4.1E+07
+ noia=1E+20    noib=50000    noic=-1.4E-12
*-----dldw????-----
+ wl=0          wln=1         wwl=0
+ ll=0          lln=1         lw=0             lwn=1
+ lwl=0         llc=2E-13     lwc=0            lwlc=0
+ wlc=0         wwc=0         wwlc=0
*-----Bsim???-----
+ wk3=0         lk3=0         pk3=1.257
+ lk3b=0        wk3b=0        pk3b=0
+ pa0=0.0489    la0=-1.052    lags=0.01093
+ wags=0        pags=0.1573   lketa=0
+ wdwg=0        ldwb=0        wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07  ldif=0        lu0=0            ldwg=0
+ uc1=-1.098E-11 acm=13        wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ ngsmod        lmlt=1.000e+00 wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

=====BETA0=FirstVdsDependentImpactIonizationCurrent=====

```

*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----

```



```

+ dvt0w=0          dvt1w=5.3e6          dvt2w=-1.E-01
+ k3=2.53          k3b=-5                    dwg=0          dwb=0
*-----Bulk-----
+ k1=1.04          k2=-1.209E-01           kt2=-0.2916
+ cdscc=-2.4E-4   cdscc=-1.506E-04       cdscc=-2.219E-04
*-----Mobility-----
+ u0=678           ua=8.964e-10           ub=1.472e-18   uc=-4.441E-17
+ ute=-1.176      ual=5.705e-09          ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000      at=20380               elm=2
*-----Resistance-----
+ rsh=70           rdsw=375                prt=-3.287E+02
+ wr=0.7586       prwb=0                  prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06    pclm=.19                pscbe1=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39           pdiblc2=0.0086  drout=0.56
*-----Subthreshold-----
+ nfactor=1.8     cit=-5.0E-04           voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01           dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05       beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2              pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551              pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873           pbsw=0.8
+ cgso=9e-13     cgdo=9e-13            cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07           xpart=0
*-----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10          xti=2.000e+00   nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7          a1=1                    a2=1             ags=0.05583
+ b0=6.305e-08   b1=6.579e-08          keta=-1.531E-02
*-----Noise????-----
+ af=1            kf=0                    ef=1             em=4.1E+07
+ noia=1E+20     noib=50000             noic=-1.4E-12
*-----dLdW????-----
+ wl=0            wln=1                   ww1=0
+ ll=0            lln=1                   lw=0             lwn=1
+ lw1=0           llc=2E-13              lwc=0            lwlc=0
+ wlc=0           wwc=0                   wwlc=0
*-----Bsim???-----
+ wk3=0           lk3=0                   pk3=1.257
+ lk3b=0          wk3b=0                  pk3b=0
+ pa0=0.0489     la0=-1.052              lags=0.01093
+ wags=0          pags=0.1573            lketa=0
+ wdwg=0          ldwb=0                  wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0                  lu0=0            ldwg=0
+ uc1=-1.098E-11 acm=13                  wu0=1
+ wua=3.641E-11  lua=9.782E-10          pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20  pub=8.812E-19          pu0=1
+ wuc=1.177E-11  luc=-2.164E-10         puc=1.231E-10
*-----Flagged!!-----
+ nqsmod          lmlt=1.000e+00         wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
*-----

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

=====**CJSWG=GateEedgSdewalCapacitancePerUnitLength (typ=5e-10F/m) t**=====

```

*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2              pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551              pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873           pbsw=0.8
+ cgso=9e-13     cgdo=9e-13            cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07           xpart=0
*-----

```

Do these values match what an AC simulation measures?
See below??

=====**CJ=BottomJunctionCapacitancePerUnitArea (typ=5e-4F/m^2)**=====

```

*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2              pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551              pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873           pbsw=0.8
+ cgso=9e-13     cgdo=9e-13            cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07           xpart=0
*-----

```

=====**CJSW=IsolationEdgeSidewallJunctionCapacitancePerUnitWidth (typ=5e-10F/m)**=====

```

*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2              pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551              pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873           pbsw=0.8
+ cgso=9e-13     cgdo=9e-13            cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07           xpart=0
*-----

```

=====**CGSO=SourceGateOverlapCapacitancePerUnitChannelWidth (F/m)**=====

```

*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2              pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551              pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873           pbsw=0.8
+ cgso=9e-13     cgdo=9e-13            cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07           xpart=0
*-----

```

=====**CGBO=GateBulkOverlapCapacitancePerUnitChannelWidth (F/m)**=====

```

*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2              pbswg=8.800e-01

```


*

```
.OPTIONS GMIN=1e-18 METHOD=gear ABSTOL=1e-15 temp=27
VIN      IN      0      DC      OV      AC      1V
R1       IN      V1      100k
R2       IN      V2      100k
R3       IN      V3      100k
R4       IN      V4      100k
m1       V1      V1      V1      0      N1      W=3u    L=1u    AD=7p   AS=7p   PD=10u  PS=10u
m2       0      V2      V2      0      N1      W=3u    L=1u    AD=7p   AS=7p   PD=10u  PS=10u
m3       0      V3      0      0      N1      W=3u    L=1u    AD=7p   AS=7p   PD=10u  PS=10u
m4       0      V4      0      V4     N1      W=3u    L=1u    AD=7p   AS=7p   PD=10u  PS=10u
```

```
.control
run
ac dec 10 1000k 1000Meghz
plot db(v(V1)) db(v(V2)) db(v(V3)) db(v(V4)) ylimit -3 0 title Find_R_C_3db
echo "For EACH 100K 3db point"
meas ac freq_3d_V1 WHEN vdb(V1) =-3
meas ac freq_3d_V2 WHEN vdb(V2) =-3
meas ac freq_3d_V3 WHEN vdb(V3) =-3
meas ac freq_3d_V4 WHEN vdb(V4) =-3
```

```
let f1 =freq_3d_V1
let f2 =freq_3d_V2
let f3 =freq_3d_V3
let f4 =freq_3d_V4
let C1 = 1/(2*3.14*f1*100k)
let C2 = 1/(2*3.14*f2*100k)
let C3 = 1/(2*3.14*f3*100k)
let C4 = 1/(2*3.14*f4*100k)
echo "C1 = $&C1 C2 = $&C2 C3 = $&C3 C4 = $&C4 "
echo "C1=CDB+CSB+CGB,C2=CSB+CGB,Cdb=csb,C4=Cdb+Csb+Cdg+Csg,Cdb=Csb,Cdb=csb"
let CDB = C1 - C2
let CGB = C2 - CDB
let CDg = ( C4 - 2*CDB )/2
*echo "Therefore CDB/CSB = $&CDB and Cdg/Csg = $&CDg CGB = $&CGB "
let Csbexpect = 7p*0.0002424 + 10u*2.73e-10
echo "Csbexpect = (AD*cj+ PD*cjsw) = $&Csbexpect and get CDB/CSB = $&CDB "
let Cdgexpect = 3u*9e-13
echo "Cdgexpect = (w*cgso) = $&Cdgexpect and get Cdg/Csg = $&CDg "
let Cgbexpect = 7p*7e-10 + 3u*2.73e-10
echo "Cgbexpect = (AD*cgbo + w*cjswg) = $&Cgbexpect and get CGB = $&CGB "
.endc
```

```
.model
+ Level= 49
+ mobmod=2
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----
+ k1=1.04 k2=-1.209E-01 kt2=-0.2916
+ cdsc=-2.4E-4 cdsd=-1.506E-04 cdsb=-2.219E-04
*-----Mobility-----
+ u0=678 ua=8.964e-10 ub=1.472e-18 uc=-4.441E-17
+ ute=-1.176 ual=5.705e-09 ub1=-1.147E-17 uc1=-1.302E-01
+ vsat=86000 at=20380 elm=2
*-----Resistance-----
+ rsh=70 rdsw=375 prt=-3.287E+02
+ wr=0.7586 prwb=0 prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06 pclm=.19 pscbel=3.79e+08 pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39 pdiblc2=0.0086 drou=0.56
*-----Subthreshold-----
+ nfactor=1.8 cit=-5.0E-04 voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01 dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2 pbswg=8.800e-01
+ cj=0.0002424 mj=0.3551 pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873 pbsw=0.8
+ cgso=9e-13 cgdo=9e-13 cgbo=7e-10
+ dlc=5e-08 dwc=1.5e-07 xpart=0
*-----BulkDiode-----
+ js=5.858e-08 jsw=1.25E-10 xti=2.000e+00 nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7 a1=1 a2=1 ags=0.05583
+ b0=6.305e-08 b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1 kf=0 ef=1 em=4.1E+07
+ noia=1E+20 noib=50000 noic=-1.4E-12
*-----dLdW????-----
+ wl=0 wln=1 wwl=0
+ ll=0 lln=1 lw=0 lwn=1
+ lw1=0 llc=2E-13 lwc=0 lwlc=0
+ wlc=0 wwc=0 wwlc=0
*-----Bsim???-----
+ wk3=0 lk3=0 pk3=1.257
+ lk3b=0 wk3b=0 pk3b=0
+ pa0=0.0489 la0=-1.052 lags=0.01093
```

```

+ wags=0          pags=0.1573      lketa=0
+ wdwg=0          ldwb=0            wdwb=0
* -----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0            lu0=0      ldwg=0
+ ucl=-1.098E-11 acm=13           wu0=1
+ wua=3.641E-11 lua=9.782E-10     pua=-4.46E-10 lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19     pu0=1
+ wuc=1.177E-11 luc=-2.164E-10    puc=1.231E-10
* -----Flagged!!-----
* ngsmo          lmlt=1.000e+00    wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
* -----

```

```

.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

```

=====DLC=ChannelLengthOffsetForCVModel=====
* -----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2          pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551     pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873       pbsw=0.8
+ cgso=9e-13     cgdo=9e-13   cgbo=7e-10
+ dlc=5e-08    dwc=1.5e-07    xpart=0
* -----

```

Figure 109 Different Components of the Extrinsic Capacitance

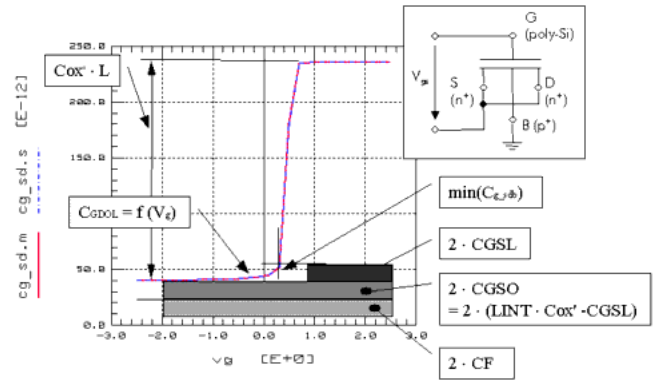
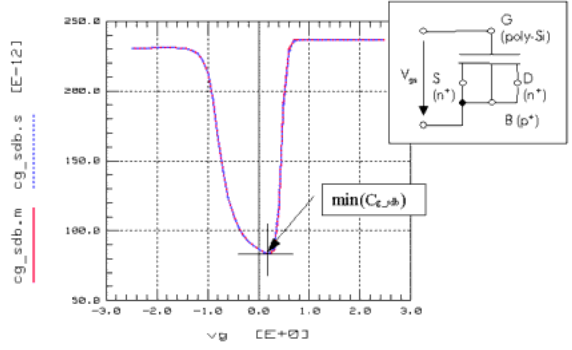
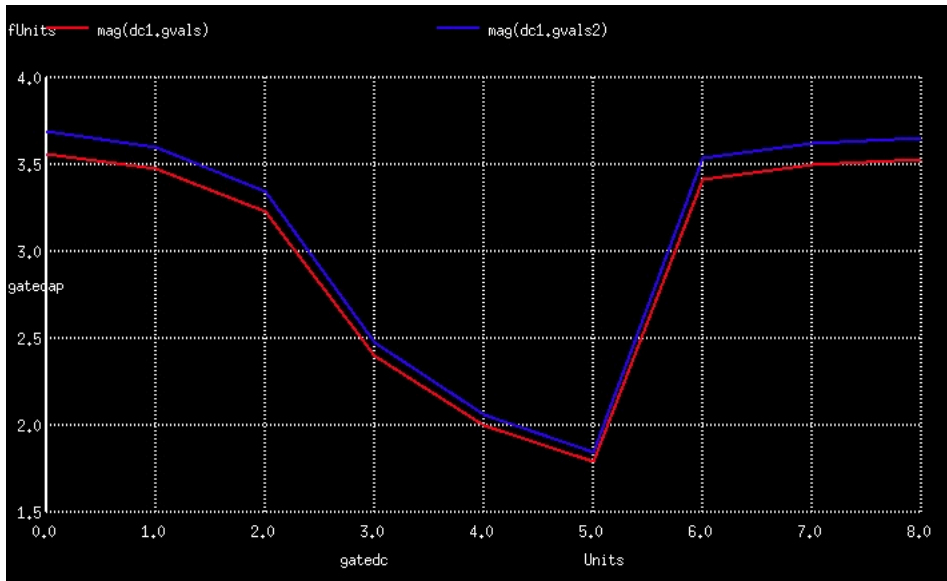
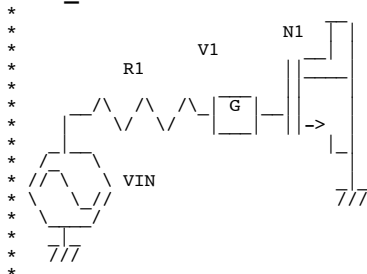


Figure 110 Overlap Capacitance Between Gate and Drain/Source/Bulk





NMOS_DLC dlc=5e-08 4e-08



```

.OPTIONS GMIN=1e-18 METHOD=gear ABSTOL=1e-15 temp=27
VIN      IN      0      DC      0V      AC      1V
R1       IN      V1     100k
R2       IN      0      1k
m1       0       V1     0       0       N1     W=3u L=1u AD=7p AS=7p PD=10u PS=10u

```

.control

```
altermod N1 dlc=5e-08
```

```

destroy all
dc VIN 0 1m 1m
let gvals = vector(9)
let gvals2 = vector(9)
let nindex = vector(9)

foreach vg -2 -1.5 -1 -.5 0 .5 1 1.5 2
alter VIN dc = $vg
echo " VG = $VG "
ac dec 10 1000k 1000Meghz
meas ac freq_3d_V1 WHEN vdb(V1) ==-3
let C1 = 1/(2*3.14*freq_3d_V1*100k)
echo "C1 = $&C1 "
end

```

```

let dcl.gvals[0]=ac1.C1
let dcl.gvals[1]=ac2.C1
let dcl.gvals[2]=ac3.C1
let dcl.gvals[3]=ac4.C1
let dcl.gvals[4]=ac5.C1
let dcl.gvals[5]=ac6.C1
let dcl.gvals[6]=ac7.C1
let dcl.gvals[7]=ac8.C1
let dcl.gvals[8]=ac9.C1

```

plot mag(dcl.gvals) vs dcl.nindex

```
altermod N1 dlc=4e-08
```

```

foreach vg -2 -1.5 -1 -.5 0 .5 1 1.5 2
alter VIN dc = $vg
echo " VG = $VG "
ac dec 10 1000k 1000Meghz
meas ac freq_3d_V1 WHEN vdb(V1) ==-3
let C1 = 1/(2*3.14*freq_3d_V1*100k)
echo "C1 = $&C1 "
end

```

```

let dcl.gvals2[0]=ac10.C1
let dcl.gvals2[1]=ac11.C1
let dcl.gvals2[2]=ac12.C1
let dcl.gvals2[3]=ac13.C1
let dcl.gvals2[4]=ac14.C1
let dcl.gvals2[5]=ac15.C1
let dcl.gvals2[6]=ac16.C1
let dcl.gvals2[7]=ac17.C1

```

```

let dcl.gvals2[8]=ac18.C1
plot mag(dcl.gvals) mag(dcl.gvals2) vs dcl.nindex ylabel GateCap xlabel GateDC
.endc

.model
+ Level= 49      N1      NMOS
+ mobmod=2      Tnom=27.0  version=3.24
**-----Process-----
+ tox=160e-10   toxm=160e-10  nch=0.5e+17
+ ngate=8.000e+19 xj=0.25e-06
*-----V threshold-----
+ vth0=0.72     lvth0=0.025   nlx=0.12e-06   kt1=-0.9821
+ dvt0=2.2      dvt1=0.53     dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04    wint=0.16e-06  ww=-9.525E-14  wwn=1.0
+ dvt0w=0       dvt1w=5.3e6   dvt2w=-1.E-01  dwb=0
+ k3=2.53       k3b=-5        dwg=0
*-----Bulk-----
+ k1=1.04       k2=-1.209E-01  kt2=-0.2916
+ cdscc=-2.4E-4 cdsccd=-1.506E-04 cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678        ua=8.964e-10  ub=1.472e-18   uc=-4.441E-17
+ ute=-1.176    ual=5.705e-09 ubl=-1.147E-17 ucl=-1.302E-01
+ vsat=86000    at=20380      elm=2
*-----Resistance-----
+ rsh=70        rdsw=375      prt=-3.287E+02
+ wr=0.7586     prwb=0        prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06  pclm=.19      pscbel=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39  pdiblc2=0.0086  drout=0.56
*-----Subthreshold-----
+ nfactor=1.8   cit=-5.0E-04  voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01  dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2     pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551    pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873  pbsw=0.8
+ cgso=9e-13     cgdo=9e-13   cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07  xpart=0
*-----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10  xti=2.000e+00   nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7         a1=1          a2=1             ags=0.05583
+ b0=6.305e-08  b1=6.579e-08 keta=-1.531E-02
*-----Noise????-----
+ af=1           kf=0          ef=1             em=4.1E+07
+ noia=1E+20     noib=50000    noic=-1.4E-12
*-----dLdW????-----
+ wl=0           wln=1         wwl=0
+ ll=0           lln=1         llw=0            lwn=1
+ lwl=0          llc=2E-13    lwc=0            lwlc=0
+ wlc=0          wwc=0         wwlc=0
*-----Bsim???-----
+ wk3=0          lk3=0         pk3=1.257
+ lk3b=0         wk3b=0        pk3b=0
+ pa0=0.0489    la0=-1.052    lags=0.01093
+ wags=0         pags=0.1573   lketa=0
+ wdwg=0         ldwb=0        wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07   ldif=0        lu0=0            ldwg=0
+ uc1=-1.098E-11 acm=13        wu0=1
+ wua=3.641E-11 lua=9.782E-10 pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19 pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ ngsmod         lmlt=1.000e+00 wmlt=1.000e+00
* tlev=0.000e+00 tlevc=0.000e+00
**-----

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

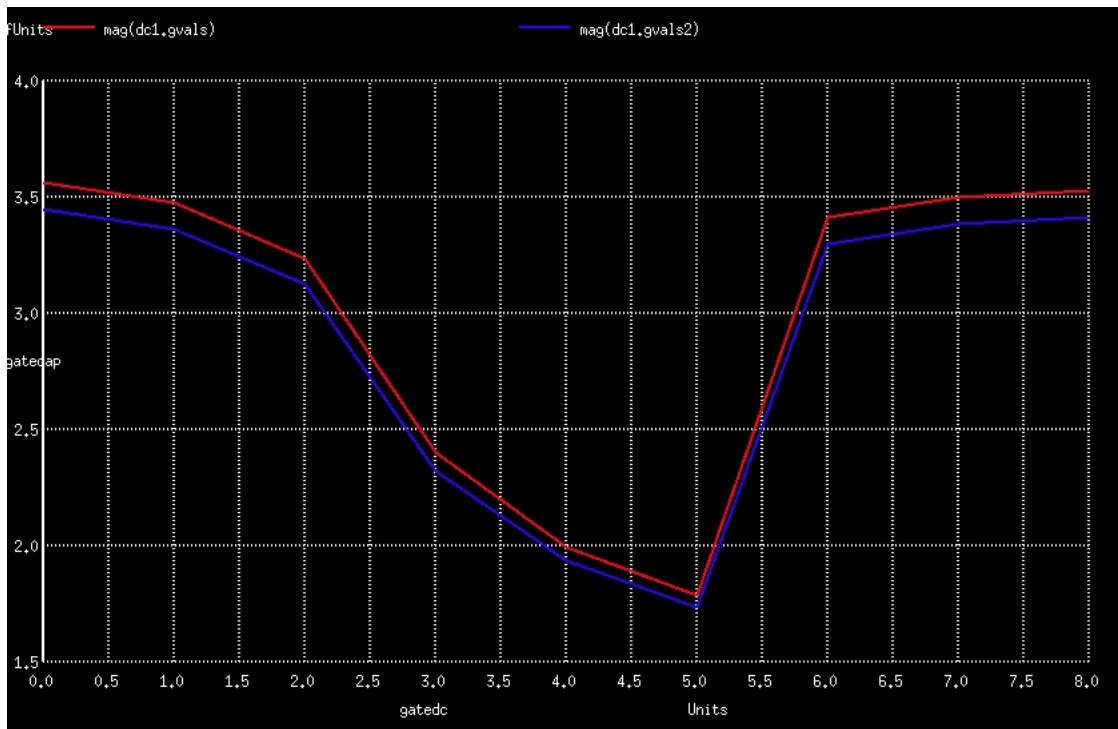
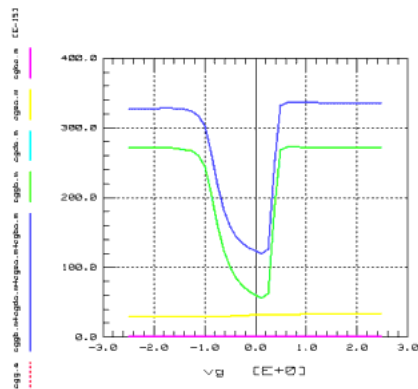
```

```

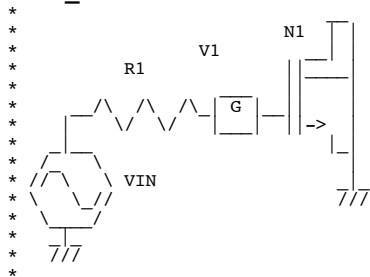
=====DWC=ChannelWidthOffsetForCVModel=====
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2     pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551    pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873  pbsw=0.8
+ cgso=9e-13     cgdo=9e-13   cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07  xpart=0
*-----

```

Figure 115 Different Parts of Overlap Capacitance C_Gate_SDB



NMOS_DWC dwc=1.5e-07 2.0e-07



```
.OPTIONS GMIN=1e-18 METHOD=gear ABSTOL=1e-15 temp=27
VIN      IN      0      DC      0V      AC      1V
R1       IN      V1      100k
R2       IN      0       1k
m1       0       V1      0       0       N1      W=3u  L=1u AD=7p AS=7p PD=10u PS=10u
```

.control

```
altermod N1 dwc=1.5e-07
destroy all
dc VIN 0 1m 1m
let gvals = vector(9)
let gvals2 = vector(9)
let nindex = vector(9)
```

```
foreach vg -2 -1.5 -1 -.5 0 .5 1 1.5 2
alter VIN dc = $vg
echo " VG = $VG "
ac dec 10 1000k 1000Meghz
meas ac freq_3d_V1 WHEN vdb(V1) ==-3
let C1 = 1/(2*3.14*freq_3d_V1*100k)
echo "C1 = $&C1 "
end
```

```

let dc1.gvals[0]=ac1.C1
let dc1.gvals[1]=ac2.C1
let dc1.gvals[2]=ac3.C1
let dc1.gvals[3]=ac4.C1
let dc1.gvals[4]=ac5.C1
let dc1.gvals[5]=ac6.C1
let dc1.gvals[6]=ac7.C1
let dc1.gvals[7]=ac8.C1
let dc1.gvals[8]=ac9.C1

plot mag(dc1.gvals) vs dc1.nindex

altermod N1 dmc=2.0e-07
foreach vg -2 -1.5 -1 -.5 0 .5 1 1.5 2
alter VIN dc = $vg
echo " VG = $VG "
ac dec 10 1000k 1000Meghz
meas ac freq_3d_V1 WHEN vdb(V1) =-3
let C1 = 1/(2*3.14*freq_3d_V1*100k)
echo "C1 = $C1 "
end

let dc1.gvals2[0]=ac10.C1
let dc1.gvals2[1]=ac11.C1
let dc1.gvals2[2]=ac12.C1
let dc1.gvals2[3]=ac13.C1
let dc1.gvals2[4]=ac14.C1
let dc1.gvals2[5]=ac15.C1
let dc1.gvals2[6]=ac16.C1
let dc1.gvals2[7]=ac17.C1
let dc1.gvals2[8]=ac18.C1

plot mag(dc1.gvals) mag(dc1.gvals2) vs dc1.nindex ylabel GateCap xlabel GateDC
.endc

.model
+ Level= 49
+ mobmod=2
*-----
+ tox=160e-10
+ ngate=8.000e+19
*-----
+ vth0=0.72
+ dvt0=2.2
*-----
+ w0=2.6e-04
+ dvt0w=0
+ k3=2.53
*-----
+ k1=1.04
+ cdscc=-2.4E-4
*-----
+ u0=678
+ ute=-1.176
+ vsat=86000
*-----
+ rsh=70
+ wr=0.7586
*-----
+ lint=.12e-06
+ delta=0.01655
*-----
+ nfactor=1.8
+ eta0=4.441e-16
*-----
+ alpha0=1.61e-05
*-----
+ cjswg=2.73e-10
+ cj=0.0002424
+ cjsw=2.73e-10
+ cgso=9e-13
+ dlc=5e-08
*-----
+ js=5.858e-08
+ a0=0.7
+ b0=6.305e-08
*-----
+ af=1
+ noia=1E+20
*-----
+ wl=0
+ ll=0
+ lw=0
+ wlc=0
*-----
+ wk3=0
+ lk3b=0
+ pa0=0.0489
+ wags=0
+ wdwg=0
*-----
+ hdif=2.7E-07
+ uc1=-1.098E-11
+ wua=3.641E-11
+ wub=1.056E-20
+ wuc=1.177E-11
*-----
+ ngsmod
+ tlev=0.000e+00

```

N1		NMOS	
Tnom=27.0	capmod=3	version=3.24	noimod=2
Process			
toxm=160e-10	xj=0.25e-06	nch=0.5e+17	
V threshold			
lvth0=0.025	dvt1=0.53	nlx=0.12e-06	kt1=-0.9821
NarrowChannel			
wint=0.16e-06	dvt1w=5.3e6	ww=-9.525E-14	wwn=1.0
k3b=-5	dwg=0	dvt2w=-1.E-01	dwb=0
Bulk			
k2=-1.209E-01	cdscd=-1.506E-04	kt2=-0.2916	cdscb=-2.219E-04
Mobility			
ua=8.964e-10	ua1=5.705e-09	ub=1.472e-18	uc=-4.441E-17
at=20380	elm=2	ubl=-1.147E-17	ucl=-1.302E-01
Resistance			
rdsw=375	prwb=0	prt=-3.287E+02	prwg=-4.441E-17
VAF			
pclm=.19	pdiblc1=0.39	pscbel=3.79e+08	pscbe2=9.4e-05
Subthreshold			
cit=-5.0E-04	etab=-2.E-01	voff=-7.862E-02	dsub=0.7
HotElectrons			
alpha1=8.276E-05	beta0=36.68		
Capacitance			
mjswg=0.2	mj=0.3551	pbswg=8.800e-01	pb=0.5614
mjsw=0.3873	cgdo=9e-13	pbsw=0.8	cgbo=7e-10
dwc=1.5e-07	xpart=0		
BulkDiode			
jsw=1.25E-10	xti=2.000e+00	nj=1.08	
BulkChargeEffect			
a1=1	a2=1	ags=0.05583	
b1=6.579e-08	keta=-1.531E-02		
Noise???			
kf=0	ef=1	em=4.1E+07	
noib=50000	noic=-1.4E-12		
dLdW???			
wln=1	wl=0	wl=0	lwn=1
lln=1	lwc=0	lwc=0	lwlc=0
llc=2E-13	wwc=0	wwlc=0	
Bsim??			
lk3=0	pk3=1.257		
wk3b=0	pk3b=0		
la0=-1.052	lags=0.01093		
pag=0.1573	lketa=0		
ldwb=0	wdwb=0		
HspiceBSIM4??			
ldif=0	lu0=0	ldwg=0	
acm=13	wu0=1		
lua=9.782E-10	pua=-4.46E-10	lub=-7.249E-19	
pub=8.812E-19	pu0=1		
luc=-2.164E-10	puc=1.231E-10		
Flagged!!			
lmlt=1.000e+00	wmlt=1.000e+00		
tlevc=0.000e+00			


```

*-----
.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

=====XPART=ChargePartitionParameter=====
*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2      pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551      pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873      pbsw=0.8
+ cgso=9e-13     cgdo=9e-13      cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07      xpart=0
*-----

```

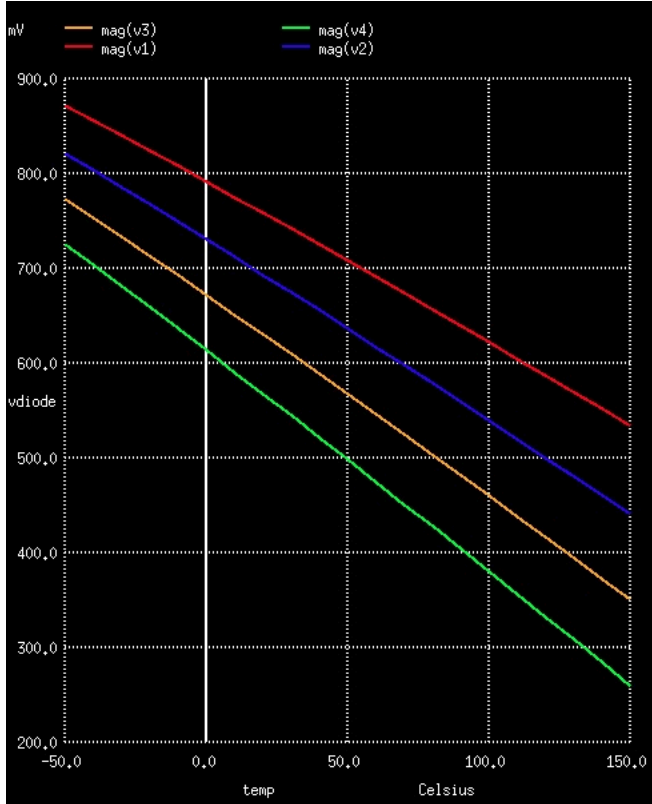
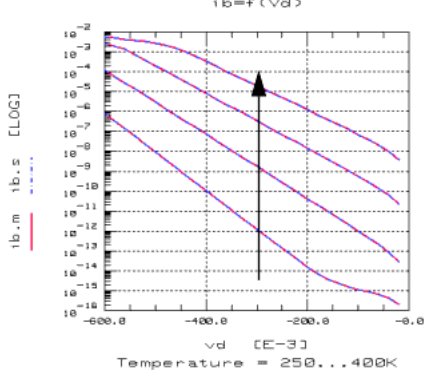
How to do it????

```

=====BULK DIODE=====
*-----Bulk diode-----
+ js=5.858e-08   jsw=1.25E-10    xti=2.000e+00   nj=1.08
*-----

```

Figure 134 Saturation Current as Function of Temperature

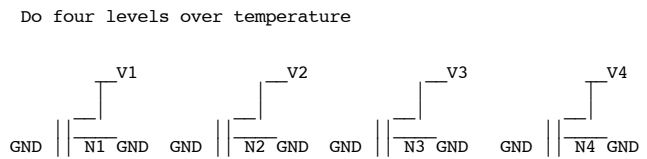


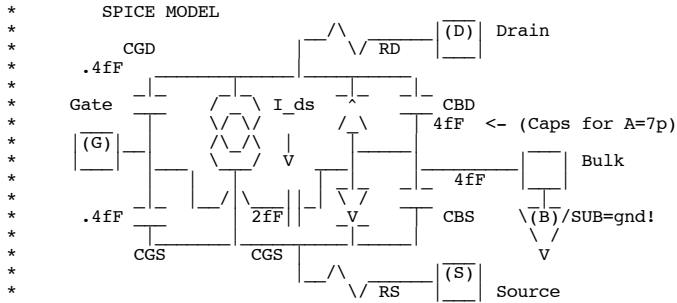
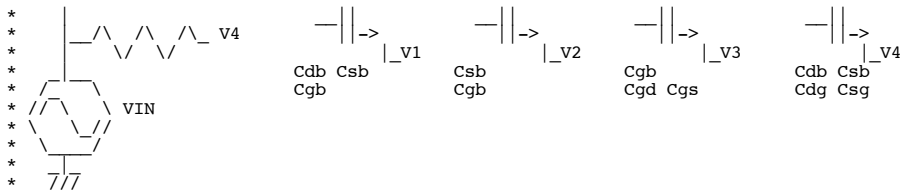
NMOS_DIODE

```

*
* Do four levels over temperature
*
*
*
*
*
*
*
*
*
*
*

```





```
.OPTIONS GMIN=1e-18 METHOD=gear ABSTOL=1e-15 temp=27
VIN      IN      0      DC      -10V
R1       IN      V1     10k
R2       IN      V2     100k
R3       IN      V3     1000k
R4       IN      V4     10000k
m1       V1      0      V1      0      N1      W=3u    L=1u    AD=7p  AS=7p  PD=10u  PS=10u
m2       V2      0      V2      0      N1      W=3u    L=1u    AD=7p  AS=7p  PD=10u  PS=10u
m3       V3      0      V3      0      N1      W=3u    L=1u    AD=7p  AS=7p  PD=10u  PS=10u
m4       V4      0      V4      0      N1      W=3u    L=1u    AD=7p  AS=7p  PD=10u  PS=10u
```

```
.control
*DC      SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc       TEMP -50 150 10
plot    mag(v1) mag(v2) mag(v3) mag(v4)      xlabel Temp ylabel VDIODE
```

.endc

```
.model          N1          NMOS
+ Level= 49      Tnom=27.0    version=3.24
+ mobmod=2      capmod=3     noimod=2
**-----
+ tox=160e-10   toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06      nch=0.5e+17
*-----
+ vth0=0.72     lvth0=0.025  nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2      dvt1=0.53          dvt2=-1.521E-01
*-----
+ w0=2.6e-04    wint=0.16e-06      ww=-9.525E-14    wwn=1.0
+ dvt0w=0       dvt1w=5.3e6        dvt2w=-1.E-01
+ k3=2.53       k3b=-5             dwg=0             dwb=0
*-----
+ k1=1.04       k2=-1.209E-01     kt2=-0.2916
+ cdscc=-2.4E-4 cdsccb=-1.506E-04 cdsccb=-2.219E-04
*-----
+ u0=678        ua=8.964e-10      ub=1.472e-18     uc=-4.441E-17
+ ute=-1.176    ual=5.705e-09     ubl=-1.147E-17   ucl=-1.302E-01
+ vsat=86000    at=20380          elm=2
*-----
+ rsh=70        rdsw=375          prt=-3.287E+02
+ wr=0.7586     prwb=0            prwg=-4.441E-17
*-----
+ lint=.12e-06  pclm=.19          pscbel=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39      pdiblc2=0.0086   drout=0.56
*-----
+ nfactor=1.8   cit=-5.0E-04      voff=-7.862E-02  dsub=0.7
+ eta0=4.441e-16 etab=-2.E-01      dsub=0.7
*-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----
+ cjswg=2.73e-10 mjswg=0.2          pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551         pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873       pbsw=0.8
+ cgso=9e-13    cgdo=9e-13        cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07       xpart=0
*-----
+ js=5.858e-08  jsw=1.25E-10      xti=2.000e+00    nj=1.08
*-----
+ a0=0.7         a1=1              a2=1              ags=0.05583
+ b0=6.305e-08  b1=6.579e-08     keta=-1.531E-02
*-----
+ af=1           kf=0              ef=1              em=4.1E+07
+ noia=1E+20     noib=50000        noic=-1.4E-12
*-----
+ wl=0           wln=1             ww1=0
+ ll=0           lln=1             lw=0              lwn=1
+ lw1=0          llc=2E-13        lwc=0             lwlc=0
+ wlc=0          wwc=0             wwlc=0
*-----
+ wk3=0          lk3=0             pk3=1.257
+ lk3b=0         wk3b=0            pk3b=0
+ pa0=0.0489    la0=-1.052        lags=0.01093
```



```
Vgs      G      0      dc      1.2v
VB       0      B      dc      5v
v1       D      1      dc      0v
m1       1      G      0      0      N1      W=3u    L=1u    AD=7p    AS=7p    PD=10u    PS=10u
```

```
.control
destroy all
altermod N1 a0=.3
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 5 5 5
altermod N1 a0=.7
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 5 5 5
altermod N1 a0=1.5
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 5 5 5
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel VDS ylabel Ids
let Reff1 = v(D)/(ic1 +1e-8)
let Reff2 = v(D)/(ic2 +1e-8)
let Reff3 = v(D)/(ic3 +1e-8)

plot Reff1 Reff2 Reff3 xlimit 0 1 ylimit .5k 1.5k xlabel VDS ylabel Rchan

.endc
```

```
.model
+ Level= 49          N1          Tnom=27.0          NMOS          version=3.24
+ mobmod=2          capmod=3          noimod=2
**-----Process-----
+ tox=160e-10       toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06       nch=0.5e+17
*-----V threshold-----
+ vth0=0.72        lvth0=0.025       nlx=0.12e-06     kt1=-0.9821
+ dvt0=2.2         dvt1=0.53         dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06     ww=-9.525E-14    wwn=1.0
+ dvt0w=0          dvt1w=5.3e6       dvt2w=-1.E-01
+ k3=2.53          k3b=-5            dwg=0            dwb=0
*-----Bulk-----
+ k1=1.04          k2=-1.209E-01     kt2=-0.2916
+ cdscc=-2.4E-4    cdscc=-1.506E-04  cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678           ua=8.964e-10      ub=1.472e-18     uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09     ub1=-1.147E-17  ucl=-1.302E-01
+ vsat=86000       at=20380          elm=2
*-----Resistance-----
+ rsh=70           rdsw=375          prt=-3.287E+02
+ wr=0.7586        prwb=0            prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06     pclm=.19          pscbe1=3.79e+08  psobe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39     pdiblc2=0.0086  drout=0.56
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04     voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01     dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05  beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10  mjswg=0.2         pbswg=8.800e-01
+ cj=0.0002424    mj=0.3551         pb=0.5614
+ cjsw=2.73e-10  mjsw=0.3873       pbsw=0.8
+ cgso=9e-13      cgdo=9e-13        cgbo=7e-10
+ dlc=5e-08       dwc=1.5e-07       xpart=0
*-----BulkDiode-----
+ js=5.858e-08    jsw=1.25E-10     xti=2.000e+00    nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7           a1=1              a2=1              ags=0.05583
+ b0=6.305e-08    b1=6.579e-08     keta=-1.531E-02
*-----Noise????-----
+ af=1             kf=0              ef=1              em=4.1E+07
+ noia=1E+20      noib=50000        noic=-1.4E-12
*-----dLdw????-----
+ wl=0            wln=1             wwl=0
+ ll=0            lln=1             llw=0             lwn=1
+ lw1=0           llc=2E-13         lwc=0             lwlc=0
+ wlc=0           wwc=0             wwlc=0
*-----Bsim???-----
+ wk3=0           lk3=0             pk3=1.257
+ lk3b=0          wk3b=0            pk3b=0
+ pa0=0.0489     la0=-1.052        lags=0.01093
+ wags=0          pags=0.1573       lketa=0
+ wdwg=0          ldwb=0            wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07    ldif=0            lu0=0             ldwg=0
+ uc1=-1.098E-11  acm=13            wu0=1
+ wua=3.641E-11  lua=9.782E-10     pua=-4.46E-10    lub=-7.249E-19
+ wub=1.056E-20  pub=8.812E-19    pu0=1
+ wuc=1.177E-11  luc=-2.164E-10   puc=1.231E-10
*-----Flagged!!-----
* ngsmod          lmlt=1.000e+00   wmlt=1.000e+00
* tlev=0.000e+00  tlevc=0.000e+00
*-----
```

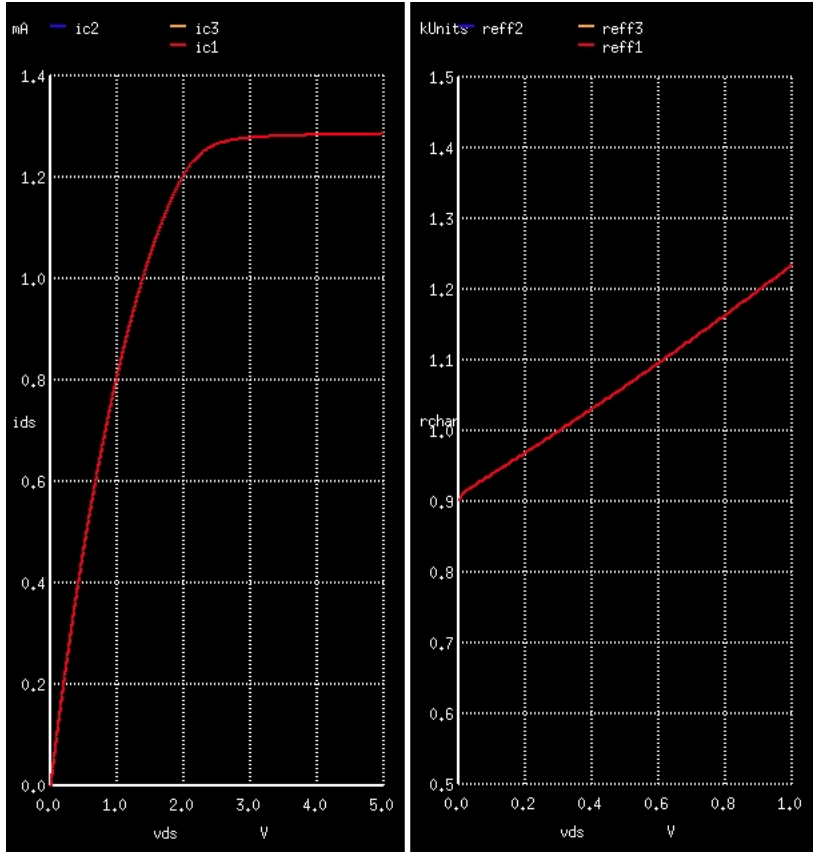
```
.end
```

```
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir
```

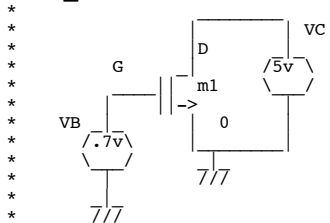
A1=CoefficientChannelLengthDependenceBulkChargeEffectt

BulkChargeEffect

```
*
+ a0=0.7          a1=1          a2=1          ags=0.05583
+ b0=6.305e-08   b1=6.579e-08   keta=-1.531E-02
*
```



NMOS_A1 a1=.5 1 2



```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*****
Vds D 0 dc 5v
Vgs G 0 dc 1.2v
VB 0 B dc 5v
v1 D 1 dc 0v
m1 1 G 0 0 N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u
.control
destroy all
altermod N1 a1=.5
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds lm 5 0.01 vgs 5 5 5
altermod N1 a1=1
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds lm 5 0.01 vgs 5 5 5
altermod N1 a1=2
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds lm 5 0.01 vgs 5 5 5
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel VDS ylabel Ids
let Reff1 = v(D)/(ic1 +1e-8)
let Reff2 = v(D)/(ic2 +1e-8)
let Reff3 = v(D)/(ic3 +1e-8)

plot Reff1 Reff2 Reff3 xlimit 0 1 ylimit .5k 1.5k xlabel VDS ylabel Rchan
.endc

.model N1 NMOS version=3.24 noimod=2
+ Level= 49 Tnom=27.0
+ mobmod=2 capmod=3
**-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
```

```

*-----V_threshold-----
+ vth0=0.72      lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2      dvt1=0.53       dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04    wint=0.16e-06   ww=-9.525E-14    wwn=1.0
+ dvt0w=0       dvt1w=5.3e6     dvt2w=-1.E-01    dwg=0
+ k3=2.53       k3b=-5          dwb=0
*-----Bulk-----
+ k1=1.04       k2=-1.209E-01   kt2=-0.2916
+ cdscc=-2.4E-4 cdsccb=-1.506E-04 cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678        ua=8.964e-10    ub=1.472e-18     uc=-4.441E-17
+ ute=-1.176    ua1=5.705e-09   ub1=-1.147E-17   uc1=-1.302E-01
+ vsat=86000    at=20380        elm=2
*-----Resistance-----
+ rsh=70        rdsw=375        prt=-3.287E+02
+ wr=0.7586     prwb=0          prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06  pclm=.19        pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39    pdiblc2=0.0086    drou=0.56
*-----Subthreshold-----
+ nfactor=1.8   cit=-5.0E-04    voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01    dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2       pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551      pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873    pbsw=0.8
+ cgso=9e-13    cgdo=9e-13     cgbo=7e-10
+ dlc=5e-08     dwc=1.5e-07    xpart=0
*-----BulkDiode-----
+ js=5.858e-08  jsw=1.25E-10   xti=2.000e+00    nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7        a1=1           a2=1             ags=0.05583
+ b0=6.305e-08 b1=6.579e-08  keta=-1.531E-02
*-----Noise????-----
+ af=1          kf=0           ef=1             em=4.1E+07
+ noia=1E+20    noib=50000     noic=-1.4E-12
*-----dLdw????-----
+ wl=0          wln=1          wwl=0
+ ll=0          lln=1          lw=0             lwn=1
+ lw1=0         llc=2E-13     lwc=0            lwlc=0
+ wlc=0         wwc=0          wwlc=0
*-----Bsim???-----
+ wk3=0         lk3=0          pk3=1.257
+ lk3b=0        wk3b=0         pk3b=0
+ pa0=0.0489    la0=-1.052     lags=0.01093
+ wags=0         pags=0.1573    lketa=0
+ wdwg=0         ldwb=0         wdw=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07  ldif=0         lu0=0            ldwg=0
+ uc1=-1.098E-11 acm=13         wu0=1
+ wua=3.641E-11 lua=9.782E-10  pua=-4.46E-10   lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19  pu0=1
+ wuc=1.177E-11 luc=-2.164E-10 puc=1.231E-10
*-----Flagged!!-----
+ ngsmod        lmlt=1.000e+00 wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----

```

.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

=====**A2=CoefficientChannellengthDependenceBulkChargeEffectt**=====

```

*-----BulkChargeEffect-----
+ a0=0.7        a1=1           a2=1             ags=0.05583
+ b0=6.305e-08 b1=6.579e-08  keta=-1.531E-02
*-----

```



```

+ vsat=86000      at=20380      elm=2
*-----
+ rsh=70          rdsw=375          prt=-3.287E+02
+ wr=0.7586      prwb=0           prwg=-4.441E-17
*-----
+ lint=.12e-06   pclm=.19         pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655 pdiblc1=0.39     pdiblc2=0.0086    drou=0.56
*-----
+ nfactor=1.8    cit=-5.0E-04     voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01     dsub=0.7
*-----
+ alpha0=1.61e-05 alpha1=8.276E-05 beta0=36.68
*-----
+ cjswg=2.73e-10 mjswg=0.2        pbswg=8.800e-01
+ cj=0.0002424  mj=0.3551       pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873     pbsw=0.8
+ cgso=9e-13    cgdo=9e-13      cgbo=7e-10
+ dl=5e-08      dwc=1.5e-07     xpart=0
*-----
+ js=5.858e-08  jsw=1.25E-10    xti=2.000e+00    nj=1.08
*-----
+ a0=0.7         a1=1             a2=1              ags=0.05583
+ b0=6.305e-08  b1=6.579e-08    keta=-1.531E-02
*-----
+ af=1           kf=0             ef=1              em=4.1E+07
+ noia=1E+20     noib=50000       noic=-1.4E-12
*-----
+ w1=0           wln=1            ww1=0
+ l1=0           lln=1            lw=0              lwn=1
+ lw1=0          llc=2E-13        lwc=0             lwlc=0
+ wlc=0          wwc=0            wwlc=0
*-----
+ wk3=0          lk3=0            pk3=1.257
+ lk3b=0         wk3b=0           pk3b=0
+ pa0=0.0489    la0=-1.052       lags=0.01093
+ wags=0         pags=0.1573      lketa=0
+ wdwg=0         ldwb=0           wdwb=0
*-----
+ hdif=2.7E-07  ldif=0           lu0=0             ldwg=0
+ uc1=-1.098E-11 acm=13           wu0=1
+ wua=3.641E-11 lua=9.782E-10    pua=-4.46E-10    lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19    pu0=1
+ wuc=1.177E-11 luc=-2.164E-10  puc=1.231E-10
*-----
+ nqsmod         lmlt=1.000e+00  wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
*-----

```

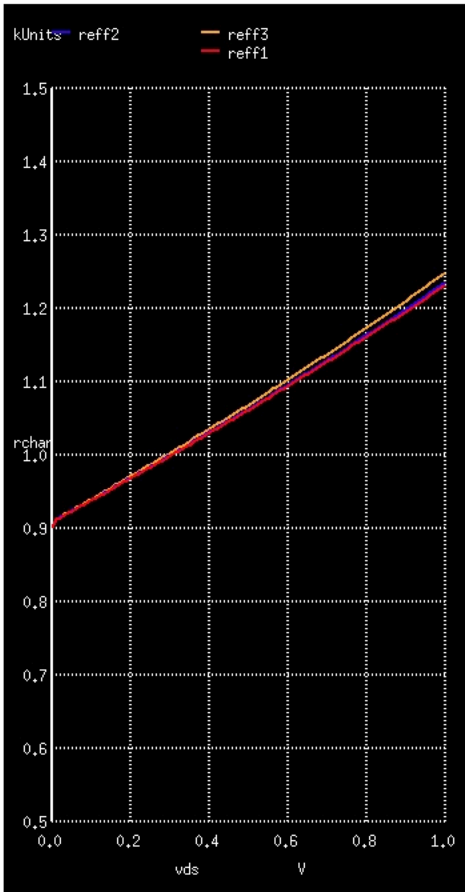
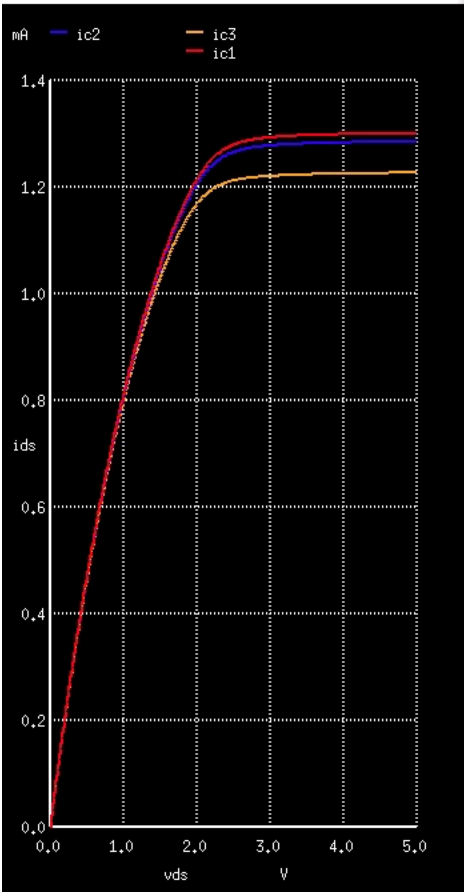
.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

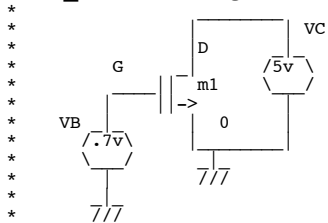
```

=====AGS=CoefficientVgsDependenceBulkChargeEffect=====
*-----
+ a0=0.7         a1=1             a2=1              ags=0.05583
+ b0=6.305e-08  b1=6.579e-08    keta=-1.531E-02
*-----

```

NMOS_AGS ags=0.005583 0.05583 0.25583



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds      D      0      dc      5v
Vgs      G      0      dc      1.2v
VB       0      B      dc      5v
v1       D      1      dc      0v
m1       1      G      0      0      N1      W=3u   L=1u   AD=7p  AS=7p  PD=10u  PS=10u
.control
destroy  all
altermod N1      ags=0.00583
*DC      SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc       Vds     1m      5      0.01  vgs     5      5      5
altermod N1      ags=0.05583
*DC      SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc       Vds     1m      5      0.01  vgs     5      5      5
altermod N1      ags=0.25583
*DC      SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc       Vds     1m      5      0.01  vgs     5      5      5
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot     ic1 ic2 ic3          xlabel VDS ylabel Ids
let Reff1 = v(D)/(ic1 +1e-8)
let Reff2 = v(D)/(ic2 +1e-8)
let Reff3 = v(D)/(ic3 +1e-8)

plot Reff1 Reff2 Reff3  xlimit 0 1 ylimit .5k 1.5k xlabel VDS ylabel Rchan
.endc

.model          N1          NMOS
+ Level= 49      Tnom=27.0   version=3.24
+ mobmod=2      capmod=3    noimod=2
**-----Process-----
+ tox=160e-10   toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06   nch=0.5e+17
*-----V threshold-----
+ vth0=0.72     lvth0=0.025   nlx=0.12e-06   kt1=-0.9821
+ dvt0=2.2      dvt1=0.53     dvt2=-1.521E-01
*-----NarrowChannel-----

```

```

+ w0=2.6e-04      wint=0.16e-06      ww=-9.525E-14      wwn=1.0
+ dvt0w=0         dvt1w=5.3e6        dvt2w=-1.E-01      dwg=0
+ k3=2.53         k3b=-5             dwg=0               dwb=0
* -----
+ k1=1.04         k2=-1.209E-01      kt2=-0.2916
+ cdsc=-2.4E-4    cdsd=-1.506E-04    cdscb=-2.219E-04
* -----
+ u0=678          ua=8.964e-10       ub=1.472e-18       uc=-4.441E-17
+ ute=-1.176     ual=5.705e-09      ubl=-1.147E-17     ucl=-1.302E-01
+ vsat=86000     at=20380           elm=2
* -----
+ rsh=70          rdsw=375           prt=-3.287E+02
+ wr=0.7586      prwb=0             prwg=-4.441E-17
* -----
+ lint=.12e-06    pclm=.19           pscbe1=3.79e+08    pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39       pdiblc2=0.0086     drou=0.56
* -----
+ nfactor=1.8     cit=-5.0E-04       voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01       dsub=0.7
* -----
+ alpha0=1.61e-05 alpha1=8.276E-05    beta0=36.68
* -----
+ cjswg=2.73e-10 mjswg=0.2          pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551         pb=.5614
+ cjsw=2.73e-10 mjsw=0.3873       pbsw=0.8
+ cgso=9e-13     cgdo=9e-13        cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07       xpart=0
* -----
+ js=5.858e-08   jsw=1.25E-10      xti=2.000e+00      nj=1.08
* -----
+ a0=0.7          a1=1              a2=1                ags=0.05583
+ b0=6.305e-08   b1=6.579e-08     keta=-1.531E-02
* -----
+ af=1           kf=0              ef=1                em=4.1E+07
+ noia=1E+20     noib=50000        noic=-1.4E-12
* -----
+ w1=0           wln=1            wwl=0
+ ll=0           lln=1            lw=0                lwn=1
+ lw1=0          llc=2E-13        lwc=0              lwlc=0
+ wlc=0          wwc=0            wwlc=0
* -----
+ wk3=0          lk3=0            pk3=1.257
+ lk3b=0         wk3b=0           pk3b=0
+ pa0=0.0489     la0=-1.052       lags=0.01093
+ wags=0         pags=0.1573      lketa=0
+ wdwg=0         ldwb=0           wdwb=0
* -----
+ hdif=2.7E-07   ldif=0           lu0=0              ldwg=0
+ uc1=-1.098E-11 acm=13           wu0=1
+ wua=3.641E-11 lua=9.782E-10    pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19    pu0=1
+ wuc=1.177E-11 luc=-2.164E-10  puc=1.231E-10
* -----
+ nqsmod         lmlt=1.000e+00    wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
* -----

```

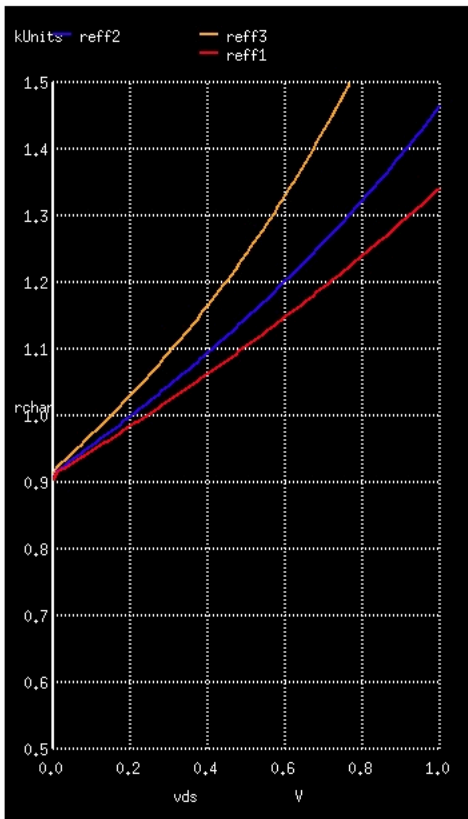
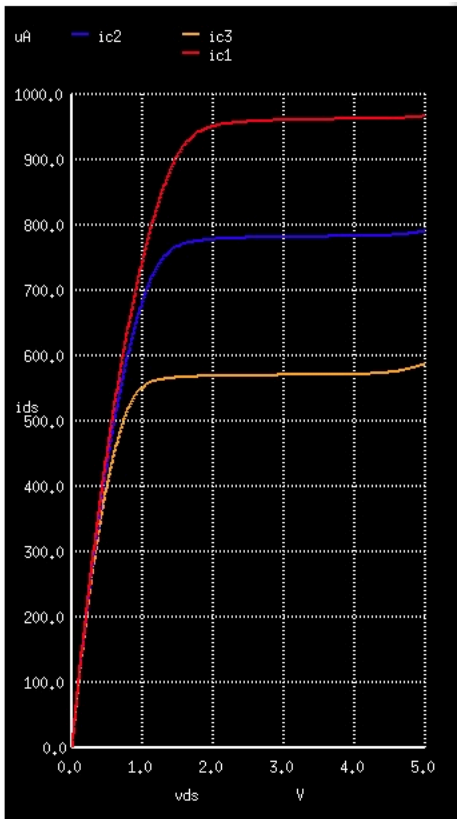
.end

* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

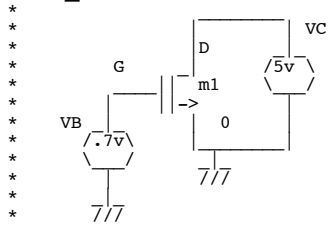
```

=====B0=BulkChargeEffectCoefficientChannelWidth=====
* -----
+ a0=0.7          a1=1              a2=1                ags=0.05583
+ b0=6.305e-08   b1=6.579e-08     keta=-1.531E-02
* -----

```



NMOS_B0 **b0=3.305e-06 6.305e-06 12.305e-06**



```

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
=====
Vds D 0 dc 5v
Vgs G 0 dc 1.2v
VB 0 B dc 5v
v1 D 1 dc 0v
m1 1 G 0 0 N1 W=3u L=1u AD=7p AS=7p PD=10u PS=10u

.control
destroy all
altermod N1 b0=3.305e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 5 5 5
altermod N1 b0=6.305e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 5 5 5
altermod N1 b0=12.305e-06
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc Vds 1m 5 0.01 vgs 5 5 5
let ic1 = mag(dc1.i(v1))
let ic2 = mag(dc2.i(v1))
let ic3 = mag(dc3.i(v1))
plot ic1 ic2 ic3 xlabel VDS ylabel Ids
let Reff1 = v(D)/(ic1 +1e-8)
let Reff2 = v(D)/(ic2 +1e-8)
let Reff3 = v(D)/(ic3 +1e-8)

plot Reff1 Reff2 Reff3 xlimit 0 1 ylimit .5k 1.5k xlabel VDS ylabel Rchan

.endc

.model N1 NMOS
+ Level= 49 Tnom=27.0 version=3.24
+ mobmod=2 capmod=3 noimod=2
*-----Process-----
+ tox=160e-10 toxm=160e-10
+ ngate=8.000e+19 xj=0.25e-06 nch=0.5e+17
*-----V_threshold-----
+ vth0=0.72 lvth0=0.025 nlx=0.12e-06 kt1=-0.9821
+ dvt0=2.2 dvt1=0.53 dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04 wint=0.16e-06 ww=-9.525E-14 wwn=1.0
+ dvt0w=0 dvt1w=5.3e6 dvt2w=-1.E-01
+ k3=2.53 k3b=-5 dwg=0 dwb=0
*-----Bulk-----

```

```

+ k1=1.04          k2=-1.209E-01      kt2=-0.2916
+ cdsc=-2.4E-4    cdscd=-1.506E-04      cdscb=-2.219E-04
* -----Mobility-----
+ u0=678          ua=8.964e-10      ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176     ual=5.705e-09          ub1=-1.147E-17   uc1=-1.302E-01
+ vsat=86000     at=20380                elm=2
* -----Resistance-----
+ rsh=70          rdsw=375                prt=-3.287E+02
+ wr=0.7586      prwb=0                  prwg=-4.441E-17
* -----VAF-----
+ lint=.12e-06   pclm=.19                pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655  pdiblc1=0.39           pdiblc2=0.0086    drou=0.56
* -----Subthreshold-----
+ nfactor=1.8    cit=-5.0E-04           voff=-7.862E-02
+ eta0=4.441e-16 etab=-2.E-01           dsub=0.7
* -----HotElectrons-----
+ alpha0=1.61e-05 alpha1=8.276E-05       beta0=36.68
* -----Capacitance-----
+ cjswg=2.73e-10 mjswg=0.2              pbswg=8.800e-01
+ cj=0.0002424   mj=0.3551             pb=0.5614
+ cjsw=2.73e-10 mjsw=0.3873           pbsw=0.8
+ cgso=9e-13     cgdo=9e-13            cgbo=7e-10
+ dlc=5e-08      dwc=1.5e-07           xpart=0
* -----BulkDiode-----
+ js=5.858e-08   jsw=1.25E-10          xti=2.000e+00     nj=1.08
* -----BulkChargeEffect-----
+ a0=0.7          a1=1                    a2=1              ags=0.05583
+ b0=6.305e-08   b1=6.579e-08          keta=-1.531E-02
* -----Noise????-----
+ af=1            kf=0                    ef=1              em=4.1E+07
+ noia=1E+20     noib=50000             noic=-1.4E-12
* -----dLdW????-----
+ wl=0           wln=1                   wwl=0
+ ll=0           lln=1                   lw=0              lwn=1
+ lw1=0          llc=2E-13              lwc=0             lwlc=0
+ wlc=0          wwc=0                   wwlc=0
* -----Bsim???-----
+ wk3=0          lk3=0                   pk3=1.257
+ lk3b=0         wk3b=0                  pk3b=0
+ pa0=0.0489    la0=-1.052              lags=0.01093
+ wags=0         pags=0.1573            lketa=0
+ wdwg=0         ldwb=0                  wdwb=0
* -----HspiceBSIM4???-----
+ hdif=2.7E-07   ldif=0                  lu0=0             ldwg=0
+ uc1=-1.098E-11 acm=13                  wu0=1
+ wua=3.641E-11 lua=9.782E-10     pua=-4.46E-10    lub=-7.249E-19
+ wub=1.056E-20 pub=8.812E-19         pu0=1
+ wuc=1.177E-11 luc=-2.164E-10       puc=1.231E-10
* -----Flagged!!-----
+ nqsmod         lmlt=1.000e+00        wmlt=1.000e+00
+ tlev=0.000e+00 tlevc=0.000e+00
* -----

```

```

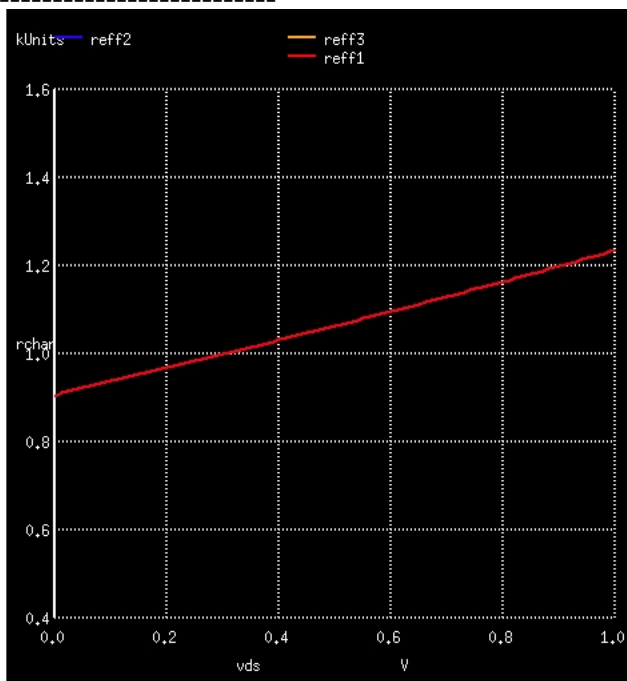
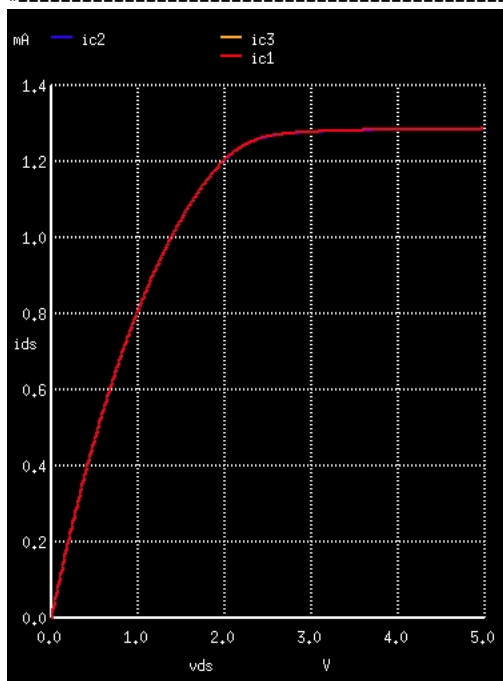
.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

```

=====B1=BulkChargeEffectWidthOffset=====
* -----BulkChargeEffect-----
+ a0=0.7          a1=1                    a2=1              ags=0.05583
+ b0=6.305e-08   b1=6.579e-08          keta=-1.531E-02
* -----

```



NMOS_B1 b1=6.579e-07 6.579e-08 6.579e-09

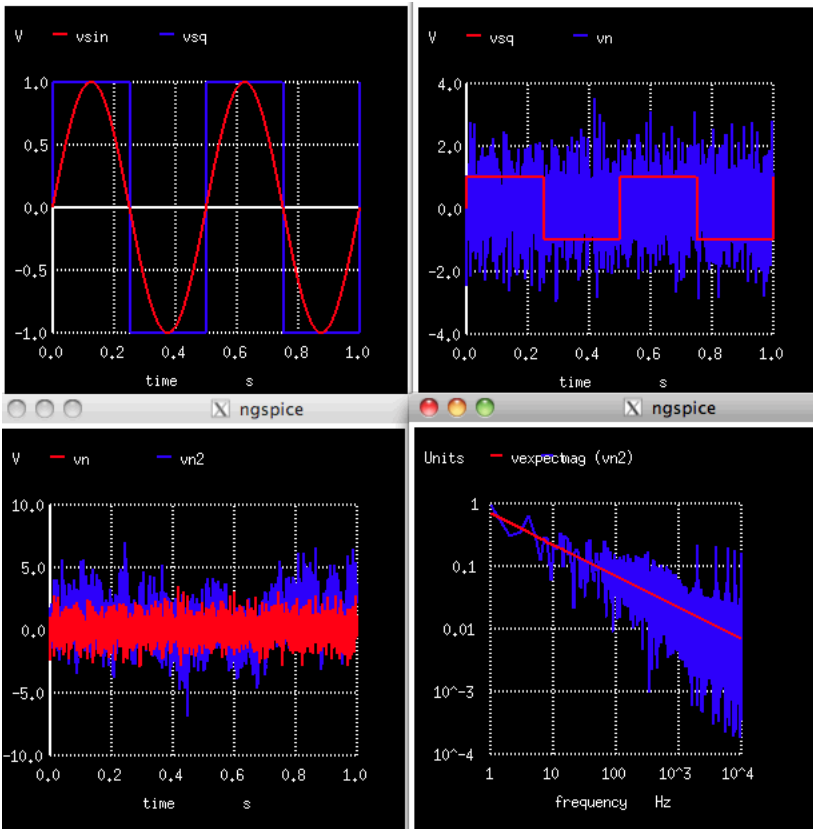

```

+ Level= 49          Tnom=27.0          version=3.24
+ mobmod=2          capmod=3          noimod=2
**-----Process-----
+ tox=160e-10      toxm=160e-10
+ ngate=8.000e+19  xj=0.25e-06      nch=0.5e+17
*-----V threshold-----
+ vth0=0.72        lvth0=0.025      nlx=0.12e-06      kt1=-0.9821
+ dvt0=2.2         dvt1=0.53        dvt2=-1.521E-01
*-----NarrowChannel-----
+ w0=2.6e-04       wint=0.16e-06    ww=-9.525E-14     wwn=1.0
+ dvt0w=0          dvt1w=5.3e6      dvt2w=-1.E-01     dwg=0
+ k3=2.53          k3b=-5           dwb=0
*-----Bulk-----
+ k1=1.04          k2=-1.209E-01    kt2=-0.2916
+ cdscc=-2.4E-4    cdscc=-1.506E-04 cdsccb=-2.219E-04
*-----Mobility-----
+ u0=678           ua=8.964e-10     ub=1.472e-18      uc=-4.441E-17
+ ute=-1.176       ual=5.705e-09    ub1=-1.147E-17    ucl=-1.302E-01
+ vsat=86000       at=20380         elm=2
*-----Resistance-----
+ rsh=70           rdsw=375         prt=-3.287E+02
+ wr=0.7586        prwb=0           prwg=-4.441E-17
*-----VAF-----
+ lint=.12e-06     pclm=.19          pscbe1=3.79e+08   pscbe2=9.4e-05
+ delta=0.01655    pdiblc1=0.39     pdiblc2=0.0086    drou=0.56
*-----Subthreshold-----
+ nfactor=1.8      cit=-5.0E-04     voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01     dsub=0.7
*-----HotElectrons-----
+ alpha0=1.61e-05  alpha1=8.276E-05 beta0=36.68
*-----Capacitance-----
+ cjswg=2.73e-10   mjswg=0.2         pbswg=8.800e-01
+ cj=0.0002424     mj=0.3551         pb=0.5614
+ cjsw=2.73e-10   mjsw=0.3873       pbsw=0.8
+ cgso=9e-13       cgdo=9e-13        cgbo=7e-10
+ dlc=5e-08        dwc=1.5e-07       xpart=0
*-----BulkDiode-----
+ js=5.858e-08     jsw=1.25E-10     xti=2.000e+00     nj=1.08
*-----BulkChargeEffect-----
+ a0=0.7           a1=1             a2=1               ags=0.05583
+ b0=6.305e-08     bi=6.579e-08     keta=-1.531E-02
*-----Noise????-----
+ af=1             kf=0             ef=1               em=4.1E+07
+ noia=1E+20       noib=50000       noic=-1.4E-12
*-----dLdW????-----
+ wl=0            wln=1            wwl=0
+ ll=0            lln=1            lw=0               lwn=1
+ lw1=0           llc=2E-13        lwc=0              lwlc=0
+ wlc=0           wwc=0            wwlc=0
*-----Bsim??-----
+ wk3=0           lk3=0            pk3=1.257
+ lk3b=0          wk3b=0           pk3b=0
+ pa0=0.0489      la0=-1.052       lags=0.01093
+ wags=0           pags=0.1573      lketa=0
+ wdwg=0           ldwb=0           wdwb=0
*-----HspiceBSIM4??-----
+ hdif=2.7E-07     ldif=0           lu0=0              ldwg=0
+ ucl=-1.098E-11   acm=13           wu0=1
+ wua=3.641E-11    lua=9.782E-10    pua=-4.46E-10     lub=-7.249E-19
+ wub=1.056E-20    pub=8.812E-19    pu0=1
+ wuc=1.177E-11    luc=-2.164E-10   puc=1.231E-10
*-----Flagged!!-----
+ ngsmo=0.000e+00  lmlt=1.000e+00   wmlt=1.000e+00
+ tlev=0.000e+00  tlevc=0.000e+00
*-----
.end
* source /Users/don_sauer/Downloads/stabie/SI_Lib/Tests.cir

```

Ngpsice provides a way to do 1/f noise as a transient simulation.
If a spice noise simulation must be used,
it should be sanity checked using this additional feature.

=====1_F_Tests_NGSPICE=====



- 1) Create a **Vsin** sine wave and **Vsq** square wave and **Vn** noise wave at 1V peak magnitude
- 2) Create **Vn** **TRNOISE** noise wave having magnitude 1 and period 1/2 msec
- 2) Create **Vn2** **TRNOISE** noise wave having two 1/f values of unity
- 3) The RMS values for **vsin**, **Vsq**, **Vn** and **Vn2** are 0.707, 1, , 0.87, and 1.938
- 4) The noise **Vn2** should have a **bandwidth** of 1KHz for a 1/2msec sample rate
- 5) The total sample time is 1 sec for a 1Hz **resolution**
- 6) Set the **spectrum bandwidth** and **resolution** at 4KHz and 1Hz
- 7) The spectrum for **Vn2** is plotted with next to a **1/sqrt(frequency)** reference

1_F_Tests

```

VT  Vtime 0 PWL(0 0 1 1 )
Bsin Vsin 0 V = sin(6.283185307179586232*2*v(Vtime) )
Bsq  Vsq 0 V = 2*u(V(Vsin)) -1
Vn   Vn  0 TRNOISE( 1 .5m 0 0)    $ 1Vrms, 0.05m period, 1/fslope=0, 1/fmag=0
Vn2  Vn2 0 TRNOISE( 1 .5m 1 1)    $ 1Vrms, 0.05m period, 1/fslope=1, 1/fmag=1

```

```

.control
*destroy all

```

```

tran .05m 1
plot Vsin Vsq
plot Vsq Vn
plot Vn Vn2

```

```

let RmsValsin = sqrt(mean(vsin*vsin))
let RmsValsq = sqrt(mean(vsq*vsq))
let RmsValn = sqrt(mean(vn*vn))
let RmsValn2 = sqrt(mean(vn2*vn2))
echo "RMS level sin  $&RmsValsin"
echo "RMS level sq  $&RmsValsq"
echo "RMS level nois $&RmsValn"
echo "RMS level oneF $&RmsValn2"

```

```

let FFT_BandWidth_Hz = 10k
let FFT_resolution_Hz = 1
echo "FFT_BandWidth_Hz= $&FFT_BandWidth_Hz"
echo "FFT_resolution_Hz= $&FFT_resolution_Hz"
set specwindow="rectangular"
spec $&FFT_resolution_Hz $&FFT_BandWidth_Hz $&FFT_resolution_Hz v(vn2)
let Vexpect = .7/( sqrt(frequency))
plot Vexpect mag (vn2) loglog
let freq1 = frequency[100]
echo "Freq at index 100 = $&freq1"

```

```

*display
.endc
.end

```

```

* source /Users/don_sauer/Downloads/SI_Lib/Tests.cir

```

```

=====END OF SPICE=====

```

```

No. of Data Rows : 26005

```



```
rms level sin      0.707039
rms level sq       0.999981
rms level nois     0.848564
rms level onef     1.93869
fft_bandwidth_hz= 10000
fft_resolution_hz= 1
freq at index 100 = 101
ngspice 25 ->
```

TO BE CONTINUED....

it is best if actual silicon data is included in all spice verifications...

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