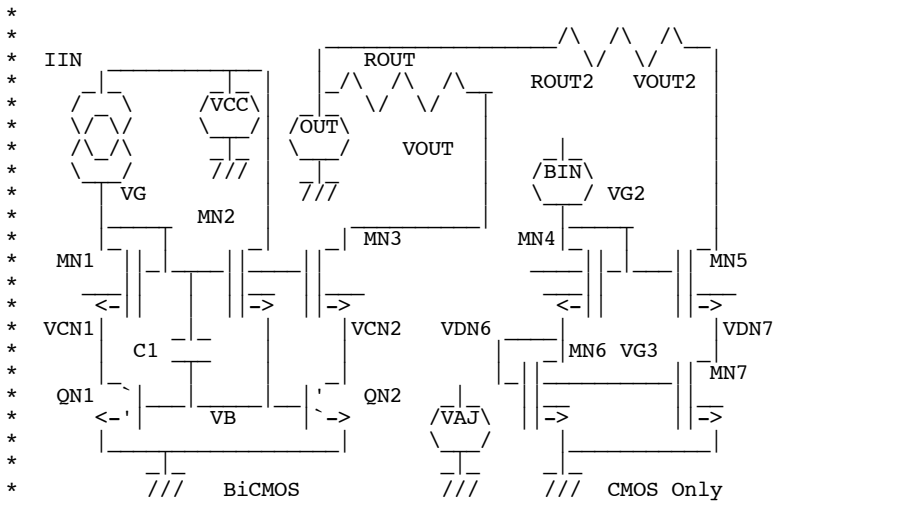


=====BiCMOS_MIRROR_CASCODE=====

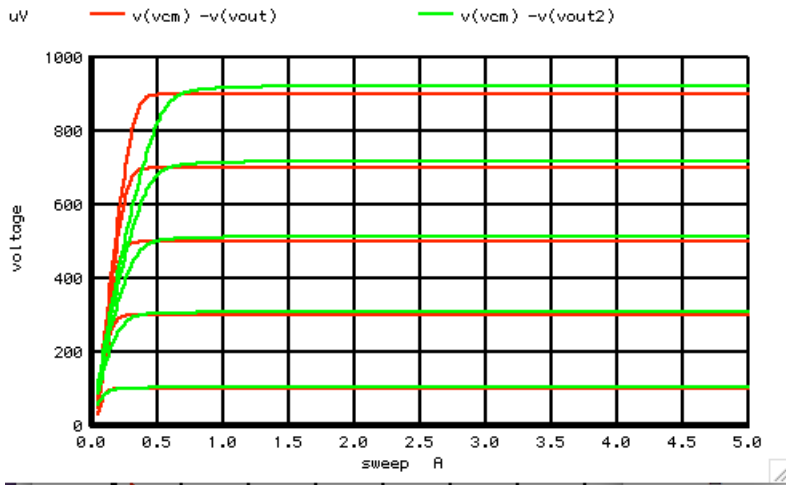
The early voltage of CMOS transistors is not very high for short channel lengths. As a result, CMOS transistors are usually in series which cascode stages. The quality of a current mirror stage could include the following.

- 1)How high is the output impedance?
- 2)How good is the current match?
- 3)What is the current dynamic range?
- 4)How low can the output swing?
- 5)How much supply voltage is required?
- 6)How much silicon area is required?

A simple CMOS cascode mirror shown below on the right is being simulated next to a BiCMOS Cascode current mirror on the left. This BiCMOS current mirror is being used as a standard for comparison. Both are being done using about the same area.



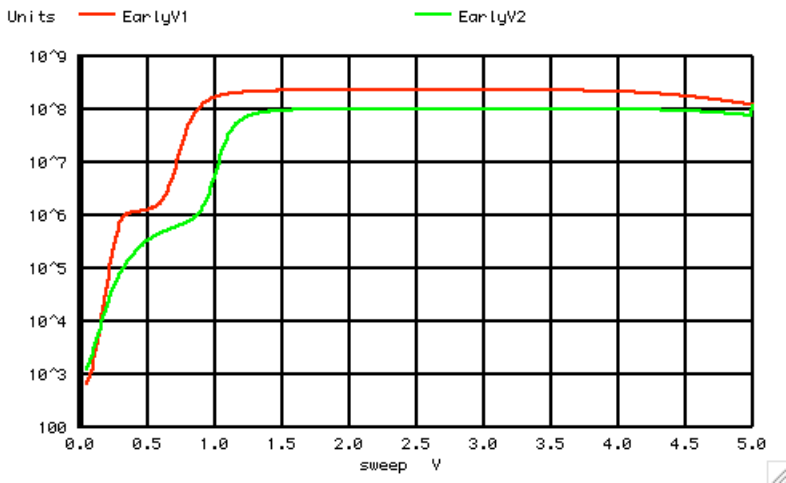
Both current mirrors have high output impedance. The BiCMOS current mirror is coming a lot closer to perfection since for their size bipolar transistors have much better match, much higher early voltage, much lower resistances, and much higher current dynamic range. Having this BiCMOS output as a background makes it easy to see whether any adjust in L or W improve the CMOS current mirror. What does it take for instance for the CMOS only stage to swing closer to ground? Well it takes area.



Spice has a derivative function which can make it possible to view the effective early voltage of each stage.

```
let EarlyV1 = 1/deriv(v(vcm) -v(vout))
let EarlyV2 = 1/deriv(v(vcm) -v(vout2))
```

The early voltages of both current mirrors are pretty high. When the output stage's voltage drops, the CMOS cascodes are going from current mode to resistor mode, and this shows up on the early voltage plots.



This CMOS cascode stage is making no effort to lower the **required supply voltage**. Two threshold voltages are required compared to the BiCMOS's need of a diode and a threshold.


```

IIN      VCC2  VG    DC    100u
VCM      VCM   0     DC    5V
IB       VB    0     DC    1u
BIN      VCC  VG2   I     = v(vcc)-v(vcc2)
ROUT     VCM  VOUT   1
C1       VG   VB     1p
IA       VB2  0     600u
MN1      VG   VG    VCN1  0     NMOSC  W=100u  L=1u
MN2      VCC2 VG    VB    0     NMOSC  W=30u   L=1u
MN3      VOUT  VG    VCN2  0     NMOSC  W=100u  L=1u
MN4      VG2  VG2   VDN6  0     NMOSC  W=100u  L=1u
MN5      VOUT2 VG2   VDN7  0     NMOSC  W=100u  L=1u
MN6      VDN6  VDN6  0     0     NMOSC  W=100u  L=1u
MN7      VDN7  VDN6  0     0     NMOSC  W=100u  L=1u
VAJ      VG3  0     DC    2
ROUT2    VCM  VOUT2  1
*MN1     VG   VG    VCN1  0     NMOSC  W=300u  L=1u  AD=7p  AS=7p  PD=10u  PS=10u
QN1      VCN1  VB    0     NPNV  10.00
QN2      VCN2  VB    0     NPNV  10.00
.model1  NPN1  NPN(   BF=2100  VAF=216 )
.control
*DC      SOURC1 VSTART VSTOP  VSTEP  SOURC2 START2 STOP2 STEP2
dc       vcm    .05V  5V    .01V  iin   100uA  1000uA  200uA
plot    v(vcm) -v(vout) v(vcm) -v(vout2)
*DC      SOURC1 VSTART VSTOP  VSTEP  SOURC2 START2 STOP2 STEP2
dc       vcm    .05V  5V    .01V
let     EarlyV1 = 1/deriv(v(vcm) -v(vout))
let     EarlyV2 = 1/deriv(v(vcm) -v(vout2))
plot    EarlyV1 EarlyV2 ylog
plot    v(vg)  v(vg2)
.endc

```

```

.MODEL  NPNV  NPN(
+ IS=15.51E-18  NF=1.005  BF=110  VAF=130.2  IKF=0.0057
+ NR=1.006  BR=0.4822  VAR=4.286  IKR=0.0002472
+ ISE=9.15E-17  NE=2
+ ISC=1E-21  NC=2
+ RB=732  RBM=441.2  IRB=7.5E-04
+ RE=15.33  RC=109.1
+ CJE=1.727E-14  VJE=0.6408  MJE=0.2563
+ CJC=1.826E-14  VJC=0.6399  MJC=0.3531
+ CJS=2.939E-14  VJS=0.3488  MJS=0.1813  XCJC=0.4201
+ TF=1.65E-11  XTF=1.25  VTF=1  ITF=0.003532
+ TR=6E-09  FC=0.88  PTF=205
+ KF=1.000E-16  AF=1
+ XTB=2  EG=1.11  XTI=5  TNOM=25 )
.model  NMOSC  NMOS(
+ Level= 8  Tnom=27.0
*-----Process-----
+ tox=160e-10  xj=0.25e-06  nch=0.5e+17
*-----V_threshold-----
+ vth0=0.72  nlx=0.12e-06
*-----Bulk-----
+ k1=1.04  k2=-1.209E-01
+ 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  vsat=86000
*-----Subthreshold-----
+ nfactor=1.8
+ cit=-5.0E-04  voff=-7.862E-02
+ eta0=4.441e-16  etab=-2.E-01  dsub=0.7
*-----Hot electrons-----
+ alpha0=1.61e-05  beta0=36.68
*-----VAF-----
+ lint=.12e-06  pclm=.19  pscbe1=3.79e+08  pscbe2=9.4e-05
+ delta=0.01655  pvag=0.4484
*-----Bulk_diode-----
+ js=5.858e-08
*-----Resistance-----
+ rsh=70  rdsw=375
+ wr=0.7586  prwb=0  prwg=-4.441E-17
*-----Capacitance-----
+ cj=0.0002424  cjsw=2.73e-10  mj=0.3551  mjsw=0.3873
+ cgso=9e-13  cgdo=9e-13  cgbo=7e-10
+ pb=0.5614  pbsw=0.8  xpart=0
+ dlc=5e-08  dwc=1.5e-07
*-----BulkChargeEffect-----
+ a0=0.7  a1=0  a2=1  ags=0.05583
+ b0=6.305e-08  b1=6.579e-08  keta=-1.531E-02
*-----ShortChannel-----
+ dvt0=2.2  dvt1=0.53  dvt2=-1.521E-01  drout=0.76
+ pdiblcb=.4  pdiblc1=0.00886  pdiblc2=0.00029
*-----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
* -----Noise-----
* af=1           kf=1e-28        ef=0.95
* -----Temperature-----
* pvsat=0        ute=-1.258E+00   kt1=-3.85E-01
* kt11=0         kt2=-3.098E-02   ua1=5.705e-09
* ub1=-1.147E-17 uc1=-1.302E-01   at=20380
* prt=-3.287E+02 lk1=0            lk2=0
* lvsat=0        la0=0           lags=0          lute=0
* luc=0
.end
)

```

```

4.11.10_4.54PM
dsauersanjose@aol.com
Don Sauer
http://www.idea2ic.com/

```