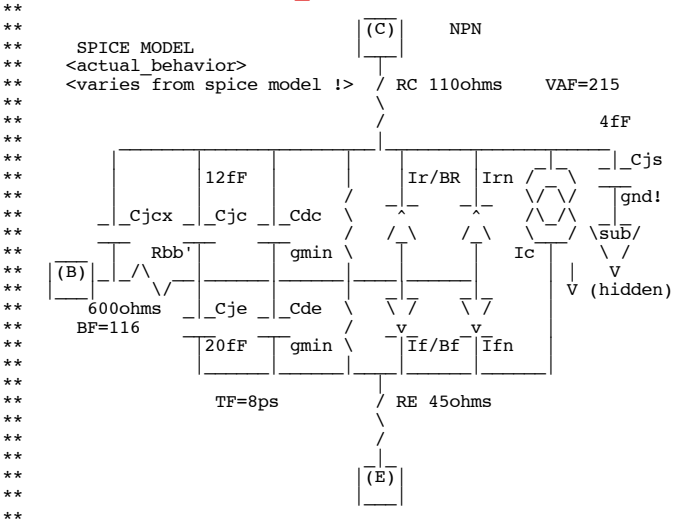
==========GUMMELPOON_PARAMETERSANITY_01==========

This document attempts to show how to test and display GummelPoon model curves for the model below. The order of source code in this document will follow this model. All included source code is in text format and can be run under ngspice.

==========SPICE_MODEL==========



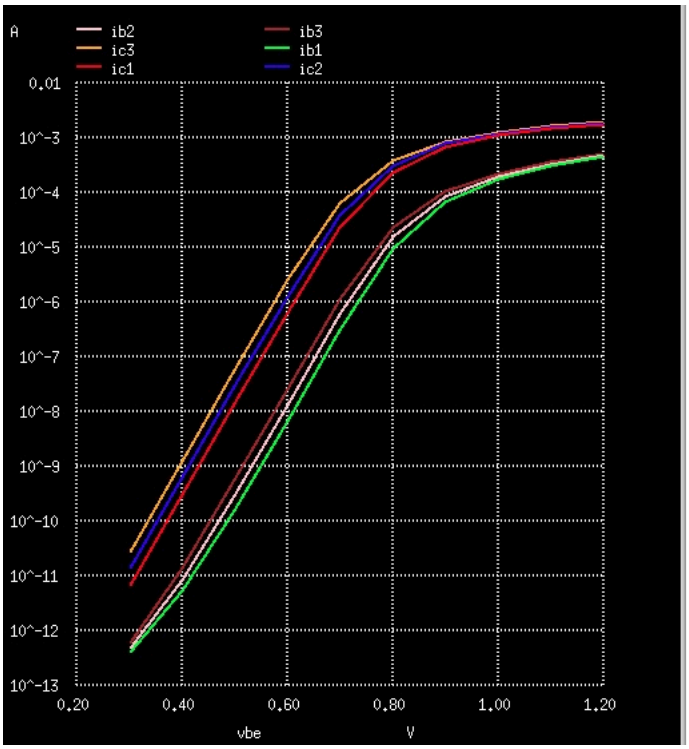

```
.MODEL  NPNV    NPN(
* ==========Gummel==========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==========LowCurrent=======================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==========Resistance======================================
+ RB=732        RBM=441.2                                IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==========Capacitance=====================================
+ 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
* ==========Speed===========================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==========Noise??=========================================
+ KF=1.000E-16  AF=1
* ==========Temperature=====================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ===========================================================
```

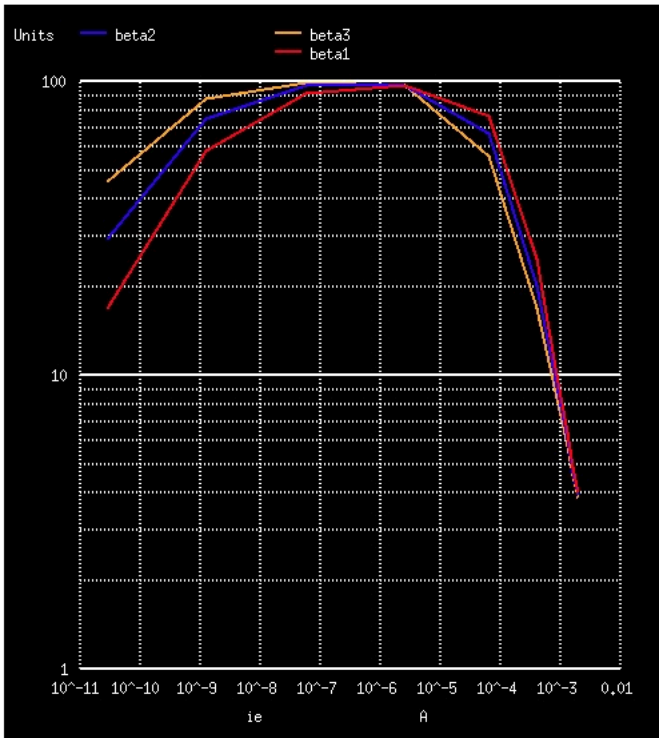
The GummelPoon parameters are grouped under the following headings

Gummel	**Most of the DC behavior over current is defined here**
LowCurrent	**The lifetime of minorities carriers define low current behavior**
Resistance	**High current behavior is mostly defined by internal resistances**
Capacitance	**Stray capacitance has an important impact at high frequencies.**
Speed	**Speed is mainly defined by transit time across the base**
Noise???	**Recommend using ngspice's transient noise features instead**
Temperature	**Critical to designing low TC internal bandgap references.**

==========IS=SatuationCurrent==========

```
* ==========Gummel==========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ===========================================================
```





NPN_IS IS=5E-17 10E-17 20E-17

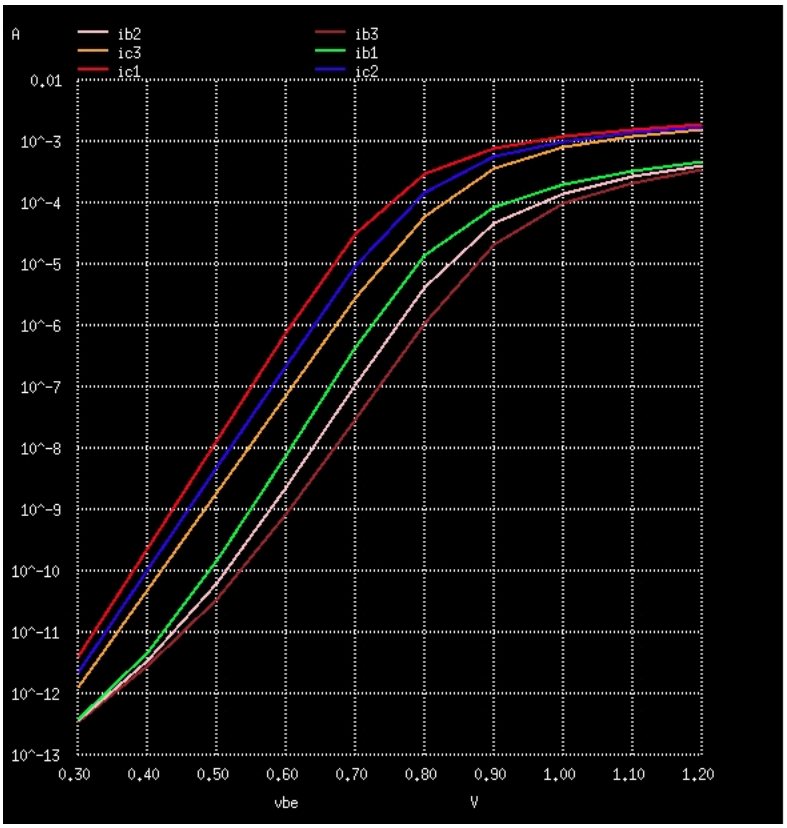
```
*
*
*                    _________
*                   |         | VC
*                   |C       _|_
*          B        |       /2v \
*          ____     |'  npnv  \___/
*              |    |`->
*     VB  _    |    |    0
*        /.7v\      |_________|
*        \___/       _|
*                   7//
*
*          _|_
*         7//  0       1u
```

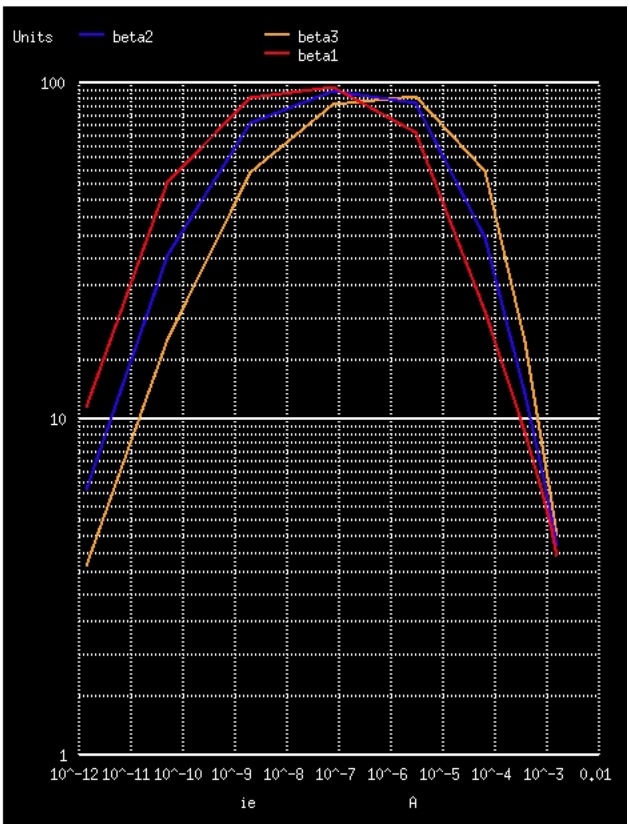
```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
* Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         C      0      DC     5V
VB         B      0      0V
Q1         C      B      0      NPNV

.control
destroy all
altermod   npnv   IS=5E-17
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vb     .3     1.2   .1
altermod   npnv   IS=10E-17
dc  vb     .3     1.2   .1
altermod   npnv   IS=20E-17
dc  vb     .3     1.2   .1
let ic1  = mag(-dc1.i(vc))
let ic2  = mag(-dc2.i(vc))
let ic3  = mag(-dc3.i(vc))
let ib1  = mag(-dc1.i(vb))
let ib2  = mag(-dc2.i(vb))
let ib3  = mag(-dc3.i(vb))
let beta1 = mag(dc1.i(vc)/dc1.i(vb))
let beta2 = mag(dc2.i(vc)/dc2.i(vb))
let beta3 = mag(dc3.i(vc)/dc3.i(vb))
let vbe   = mag(V(b))
let ie    = mag(vc#branch)
plot ic1 ic2 ic3 ib1 ib2 ib3 vs vbe   ylog   title Gummel
plot beta1  beta2  beta3  vs ie loglog title Beta_vs_IC
.endc

.MODEL  NPNV    NPN(
* ==============Gummel==========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=======================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=======================================
+ RB=732        RBM=441.2                            IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance======================================
+ 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
* ==============Speed=================================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??=============================================
+ KF=1.000E-16  AF=1
* ==============Temperature=========================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ===================================================================

.end

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

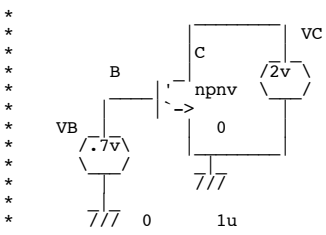
============NF=ForwardEmissionCoeff====================================

```
* ==============Gummel=============================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ================================================================
```





NPN_NF NF=.95 1.00 1.05

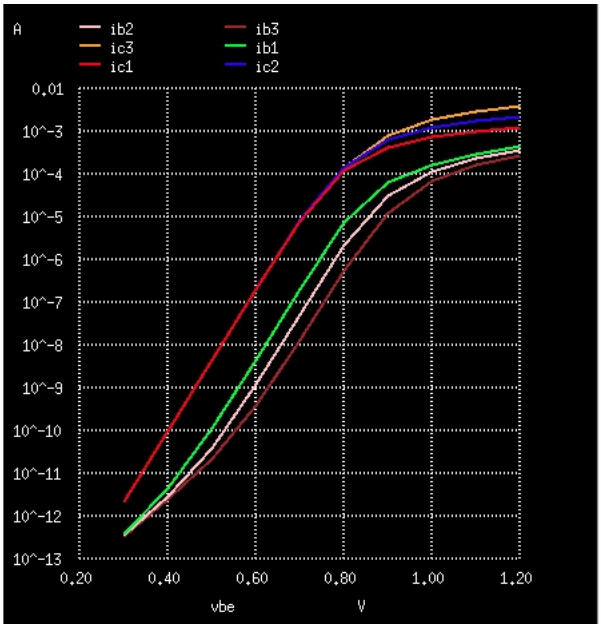


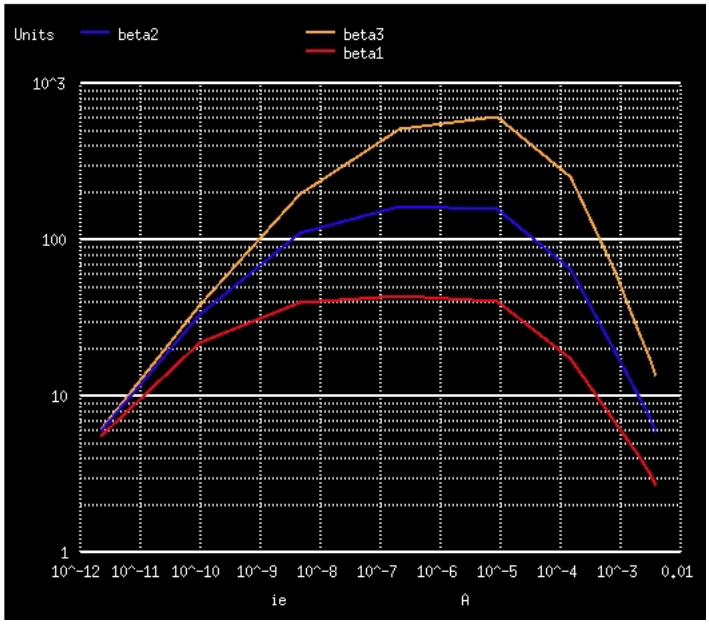

```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
* Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         C       0       DC      5V
VB         B       0       0V
Q1         C       B       0       NPNV

.control
destroy all
altermod   npnv    NF=.95
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vb     .3     1.2   .1
altermod   npnv    NF=1.00
dc  vb     .3     1.2   .1
altermod   npnv    NF=1.05
dc  vb     .3     1.2   .1
let ic1  = mag(-dc1.i(vc))
let ic2  = mag(-dc2.i(vc))
let ic3  = mag(-dc3.i(vc))
let ib1  = mag(-dc1.i(vb))
```

```
let ib2  = mag(-dc2.i(vb))
let ib3   = mag(-dc3.i(vb))
let beta1 = mag(dc1.i(vc)/dc1.i(vb))
let beta2 = mag(dc2.i(vc)/dc2.i(vb))
let beta3 = mag(dc3.i(vc)/dc3.i(vb))
let vbe   = mag(V(b))
let ie    = mag(vc#branch)
plot ic1 ic2 ic3 ib1 ib2 ib3 vs vbe   ylog   title Gummel
plot beta1  beta2  beta3  vs ie loglog title Beta_vs_IC
.endc

.MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================================
+ RB=732        RBM=441.2                                IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance=====================================================
+ 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
* ==============Speed=============================================
+ TF=4.65E-12   XTF=1.25     VTF=1        ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??=========================================
+ KF=1.000E-16  AF=1
* ==============Temperature=====================================================
+ XTB=1.4       EG=1.11      XTI=8        TNOM=25       )
* ================================================================

.end

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

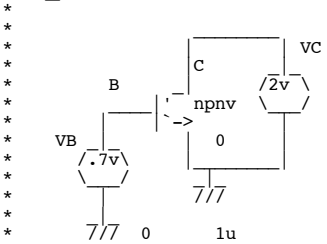
==========BF=ForwardBeta==========

```
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ================================================================
```



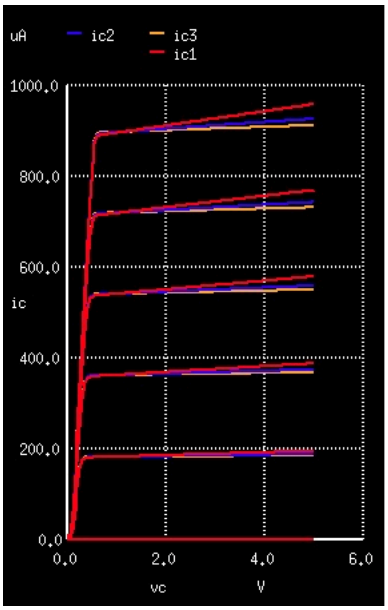


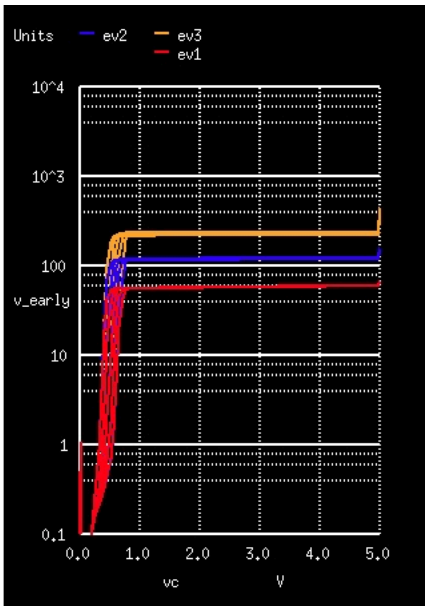
NPN_BF BF = 50 200 800



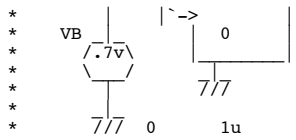

```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
* Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
```

```
VC          C       0       DC      5V
VB          B       0       0V
Q1          C       B       0       NPNV

.control
destroy all
altermod   npnv   BF = 50
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vb     .3     1.2   .1
altermod   npnv   BF = 200
dc  vb     .3     1.2   .1
altermod   npnv   BF = 800
dc  vb     .3     1.2   .1
let ic1 = mag(-dc1.i(vc))
let ic2 = mag(-dc2.i(vc))
let ic3 = mag(-dc3.i(vc))
let ib1 = mag(-dc1.i(vb))
let ib2 = mag(-dc2.i(vb))
let ib3 = mag(-dc3.i(vb))
let beta1 = mag(dc1.i(vc)/dc1.i(vb))
let beta2 = mag(dc2.i(vc)/dc2.i(vb))
let beta3 = mag(dc3.i(vc)/dc3.i(vb))
let vbe = mag(V(b))
let ie = mag(vc#branch)
plot ic1 ic2 ic3 ib1 ib2 ib3 vs vbe   ylog   title Gummel
plot beta1  beta2  beta3  vs ie loglog title Beta_vs_IC
.endc

..MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================
+ RB=732        RBM=441.2                        IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance====================================
+ 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
* ==============Speed==========================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??=======================================
+ KF=1.000E-16  AF=1
* ==============Temperature===================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ===========================================================

.end

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

==========VAF=ForwardEarlyVoltage==========
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ===========================================================
```

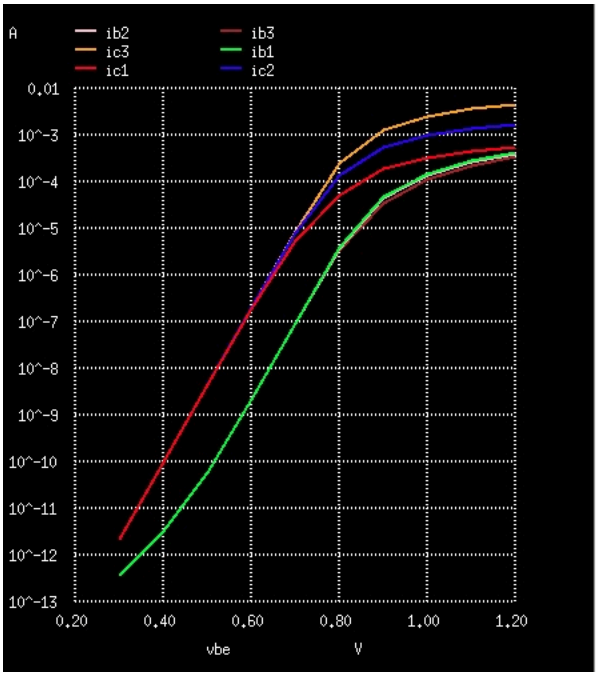


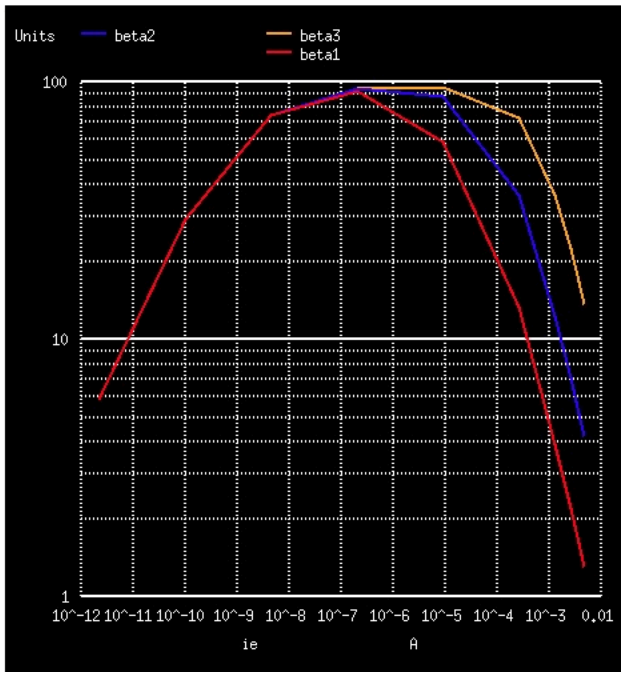



```
NPN_VAF   VAF = 70 150  300
**
*
*                  ________| VC
*                 |C       |_
*          B   _  |        /2v \
*          ____|'  npnv    \___/
```

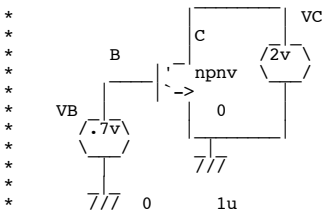



```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         C      0      DC     5V
IB         0      B      DC     1u
Q1         C      B      0      NPNV

.control
destroy    all
altermod   npnv   VAF=70
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc     0      5     .05    ib     0      10u   2u
altermod   npnv   VAF=150
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc     0      5     .05    ib     0      10u   2u
altermod   npnv   VAF=300
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc     0      5     .05    ib     0      10u   2u
let ic1 = mag(dc1.i(vc))
let ic2 = mag(dc2.i(vc))
let ic3 = mag(dc3.i(vc))

plot ic1 ic2 ic3         xlabel  VC  ylabel  IC

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  VC  ylabel  V_early



*plot mag(i(vc))
.endc

.MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================
+ RB=732        RBM=441.2                        IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance====================================
+ 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
* ==============Speed==========================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??========================================
+ KF=1.000E-16  AF=1
* ==============Temperature====================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ================================================================

.end

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

==========IKF=ForwardBetaRolloff==================================
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ============================================================
```





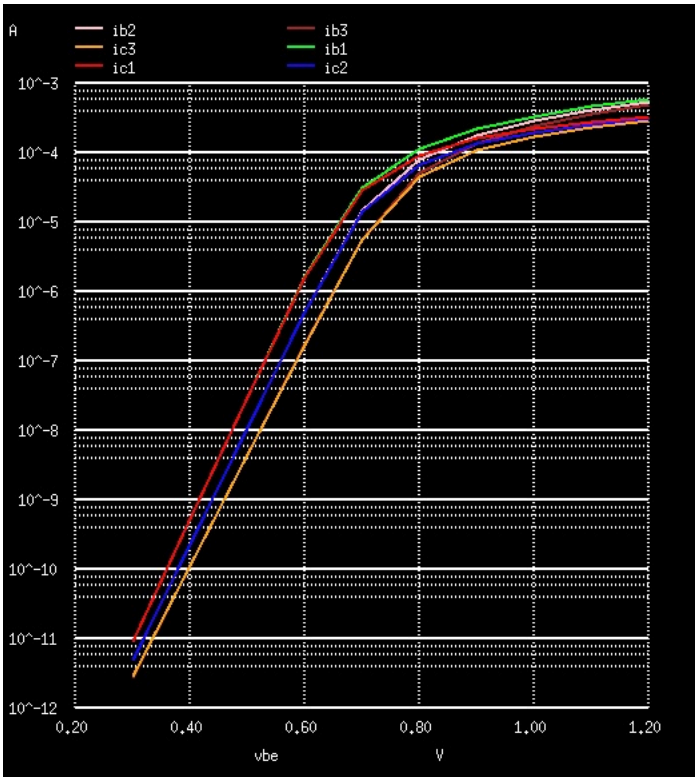
NPN_IKF IKF=0.00001 0.0001 0.001



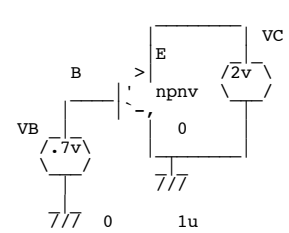

```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
* Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         C       0       DC      5V
VB         B       0       0V
Q1         C       B       0       NPNV

.control
destroy all
altermod   npnv    IKF=0.00001
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vb      .3     1.2   .1
altermod   npnv    IKF=0.0001
dc  vb      .3     1.2   .1
altermod   npnv    IKF=0.001
dc  vb      .3     1.2   .1
let ic1 = mag(-dc1.i(vc))
let ic2 = mag(-dc2.i(vc))
let ic3 = mag(-dc3.i(vc))
let ib1 = mag(-dc1.i(vb))
let ib2 = mag(-dc2.i(vb))
let ib3 = mag(-dc3.i(vb))
let beta1 = mag(dc1.i(vc)/dc1.i(vb))
let beta2 = mag(dc2.i(vc)/dc2.i(vb))
let beta3 = mag(dc3.i(vc)/dc3.i(vb))
let vbe = mag(V(b))
let ie = mag(vc#branch)
plot ic1 ic2 ic3 ib1 ib2 ib3 vs vbe   ylog   title Gummel
plot beta1  beta2  beta3  vs ie loglog title Beta_vs_IC
.endc

.MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================
+ RB=732        RBM=441.2                        IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance====================================
+ 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
* ==============Speed==========================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
```

```
* ==============Noise??=============================================
+ KF=1.000E-16  AF=1
* ==============Temperature==========================================
+ XTB=1.4        EG=1.11       XTI=8        TNOM=25        )
* ===================================================================

.end

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

==========NR=ReverseEmissionCoeff==========



NPN_NR NR=.95 1.00 1.05

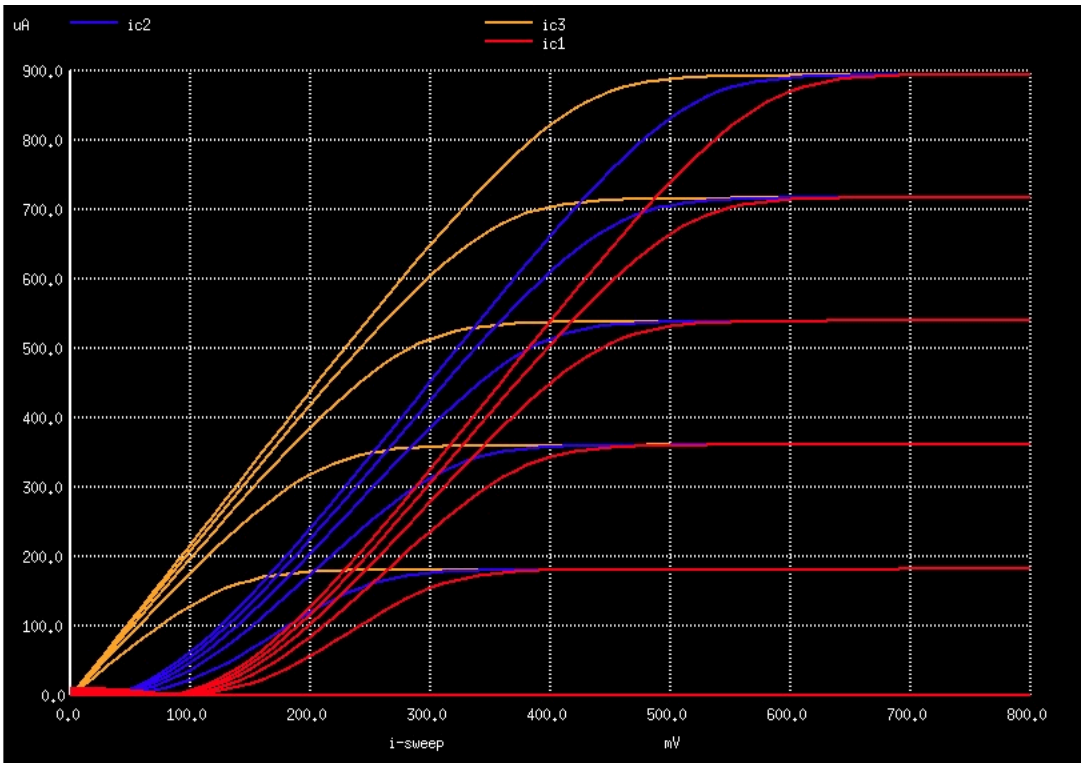



```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
* Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         E      0      DC     5V
VB         B      0      0V
Q1         0      B      E      NPNV

.control
destroy    all
altermod   npnv   NR=.95
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vb     .3     1.2   .1
altermod   npnv   NR=1.00
dc  vb     .3     1.2   .1
altermod   npnv   NR=1.05
dc  vb     .3     1.2   .1
let ic1 = mag(-dc1.i(vc))
let ic2 = mag(-dc2.i(vc))
let ic3 = mag(-dc3.i(vc))
let ib1 = mag(-dc1.i(vb))
let ib2 = mag(-dc2.i(vb))
let ib3 = mag(-dc3.i(vb))
let beta1 = mag(dc1.i(vc)/dc1.i(vb))
let beta2 = mag(dc2.i(vc)/dc2.i(vb))
let beta3 = mag(dc3.i(vc)/dc3.i(vb))
let vbe = mag(V(b))
let ie = mag(vc#branch)
plot ic1 ic2 ic3 ib1 ib2 ib3 vs vbe   ylog   title Gummel
plot beta1  beta2  beta3  vs ie loglog title Beta_vs_IC
.endc
```

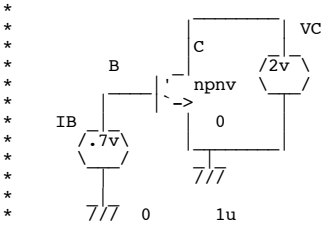
```
.MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005      BF=110       VAF=130.2     IKF=0.0001
+               NR=1.006      BR=0.4822    VAR=4.286     IKR=0.0002472
* ==============LowCurrent=====================================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================================
+ RB=732        RBM=441.2                                  IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance=====================================================
+ 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
* ==============Speed===========================================
+ TF=4.65E-12   XTF=1.25      VTF=1         ITF=0.009532
+ TR=6E-09      FC=0.88       PTF=205
* ==============Noise??=========================================
+ KF=1.000E-16  AF=1
* ==============Temperature=====================================================
+ XTB=1.4       EG=1.11       XTI=8         TNOM=25        )
* ================================================================

.end

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

==========BR=ReverseBeta==========

```
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005      BF=110       VAF=130.2     IKF=0.0001
+               NR=1.006      BR=0.4822    VAR=4.286     IKR=0.0002472
* ================================================================
```



NPN_BR BR = 10 20 40

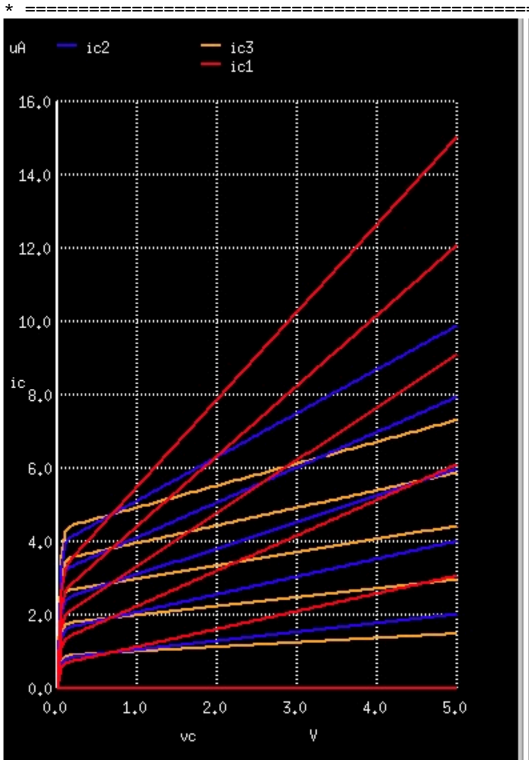


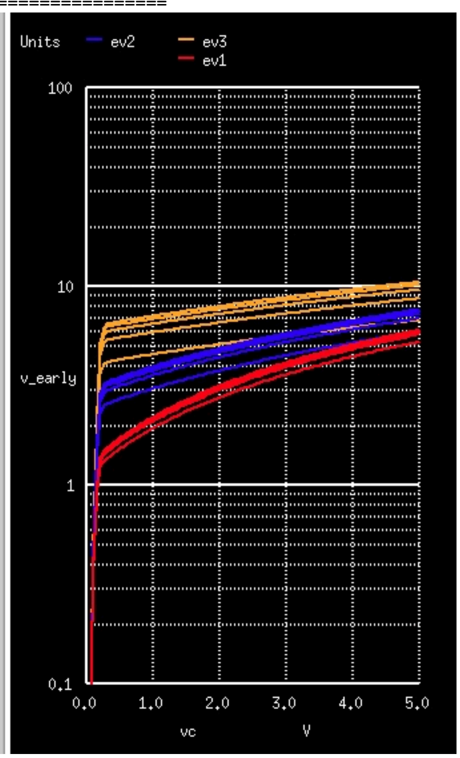

```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         C       0       DC      5V
IB         0       B       DC      1u
Q1         C       B       0       NPNV

.control
destroy all
```

```
altermod   npnv   BR=.05
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc      0       .8     .01     ib      0      10u    2u
altermod   npnv   BR=.5
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc      0       .8     .01     ib      0      10u    2u
altermod   npnv   BR=100
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc      0       .8     .01     ib      0      10u    2u
let ic1 = mag(dc1.i(vc))
let ic2 = mag(dc2.i(vc))
let ic3 = mag(dc3.i(vc))

plot ic1 ic2 ic3

*plot mag(i(vc))
.endc
.MODEL  NPNV    NPN(
* ==============Gummel==========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2     IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286     IKR=0.0002472
* ==============LowCurrent============================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance============================================
+ RB=732        RBM=441.2                              IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance=============================================
+ 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
* ==============Speed============================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??============================================
+ KF=1.000E-16  AF=1
* ==============Temperature=============================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ==================================================================

.end

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

============VAR=ReverseEarlyVoltage==================================

```
* ==============Gummel==========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2     IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286     IKR=0.0002472
* ==============================================================
```

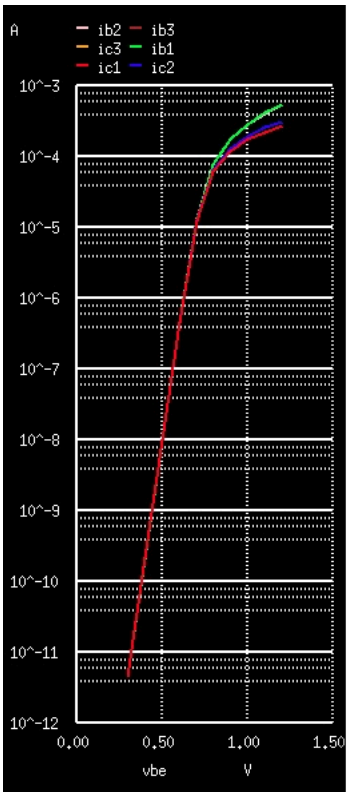


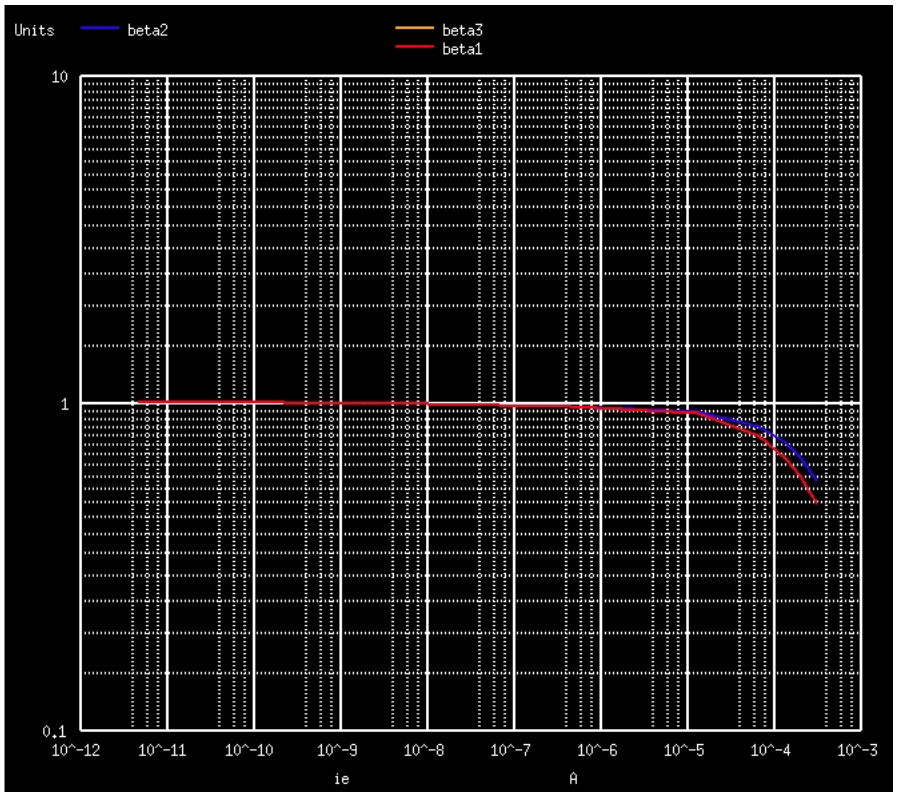


NPN_VAR   VAR = 2 4 8

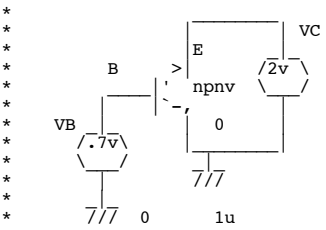
```
*
*                   _________
*                  |         |  VC
*                  |E       _|_
*          B      >|       /2v \
*            _____|'  npnv \___/
*           |     |`-,
*    VB    _|_        |  0
*         /.7v\       |_________|
*         \___/       _|_
```

```
*         |        ///
*         |
*       ///  0      1u

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC        E      0      DC     5V
IB        0      B      DC     1u
Q1        0      B      E      NPNV

.control
destroy    all
altermod   npnv   VAR=2
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc     0      5     .05    ib     0      10u   2u
altermod   npnv   VAR=4
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc     0      5     .05    ib     0      10u   2u
altermod   npnv   VAR=8
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc     0      5     .05    ib     0      10u   2u
let ic1 = mag(dc1.i(vc))
let ic2 = mag(dc2.i(vc))
let ic3 = mag(dc3.i(vc))

plot ic1 ic2 ic3         xlabel  VC  ylabel  IC

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 .1 100    xlabel  VC  ylabel  V_early

*plot mag(i(vc))
.endc

.MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================
+ RB=732        RBM=441.2                        IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance====================================
+ 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
* ==============Speed==========================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??========================================
+ KF=1.000E-16  AF=1
* ==============Temperature====================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ================================================================

.end

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



============IKR=ReverseBetaRolloff====================================
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ================================================================
```





NPN_IKR IKR=0.0001472 0.0002472 0.0004472

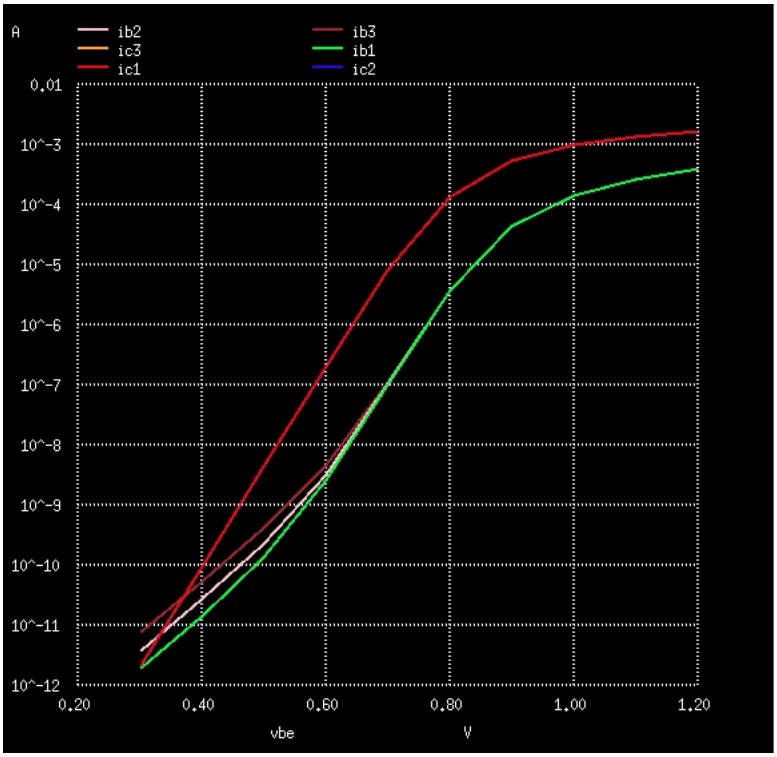


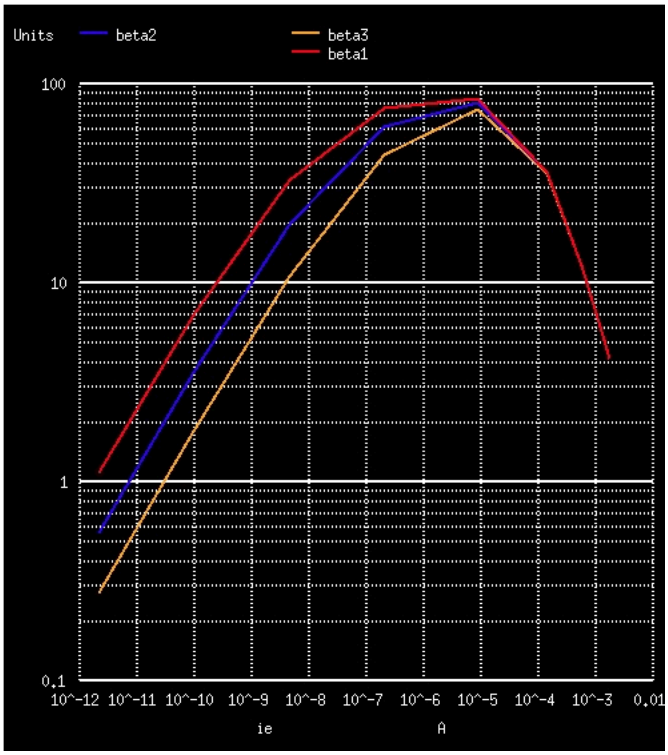

```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
* Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         E       0       DC      5V
VB         B       0       0V
Q1         0       B       E       NPNV

.control
destroy    all
altermod   npnv    IKR=0.0001472
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vb      .3     1.2    .1
altermod   npnv    IKR=0.0002472
dc  vb      .3     1.2    .1
altermod   npnv    IKR=0.0002472
dc  vb      .3     1.2    .1
let ic1 = mag(-dc1.i(vc))
let ic2 = mag(-dc2.i(vc))
let ic3 = mag(-dc3.i(vc))
let ib1 = mag(-dc1.i(vb))
let ib2 = mag(-dc2.i(vb))
let ib3 = mag(-dc3.i(vb))
let beta1 = mag(dc1.i(vc)/dc1.i(vb))
let beta2 = mag(dc2.i(vc)/dc2.i(vb))
let beta3 = mag(dc3.i(vc)/dc3.i(vb))
let vbe = mag(V(b))
let ie = mag(vc#branch)
plot ic1 ic2 ic3 ib1 ib2 ib3 vs vbe   ylog   title Gummel
plot beta1  beta2  beta3  vs ie loglog title Beta_vs_IC
.endc

.MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================
+ RB=732        RBM=441.2                        IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance====================================
```

```
+ 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
* =============Speed=============================================
+ TF=4.65E-12   XTF=1.25     VTF=1        ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* =============Noise??===========================================
+ KF=1.000E-16  AF=1
* =============Temperature=======================================
+ XTB=1.4       EG=1.11      XTI=8        TNOM=25       )
* ================================================================


.end

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

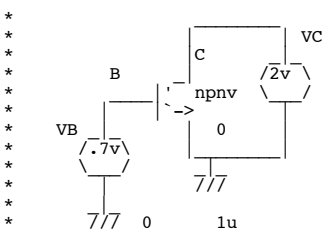
==========ISE=BELeakageSaturationCurrent==========

```
* =============LowCurrent=========================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ================================================================
```





NPN_ISE ISE=5E-15 10E-15 20E-15

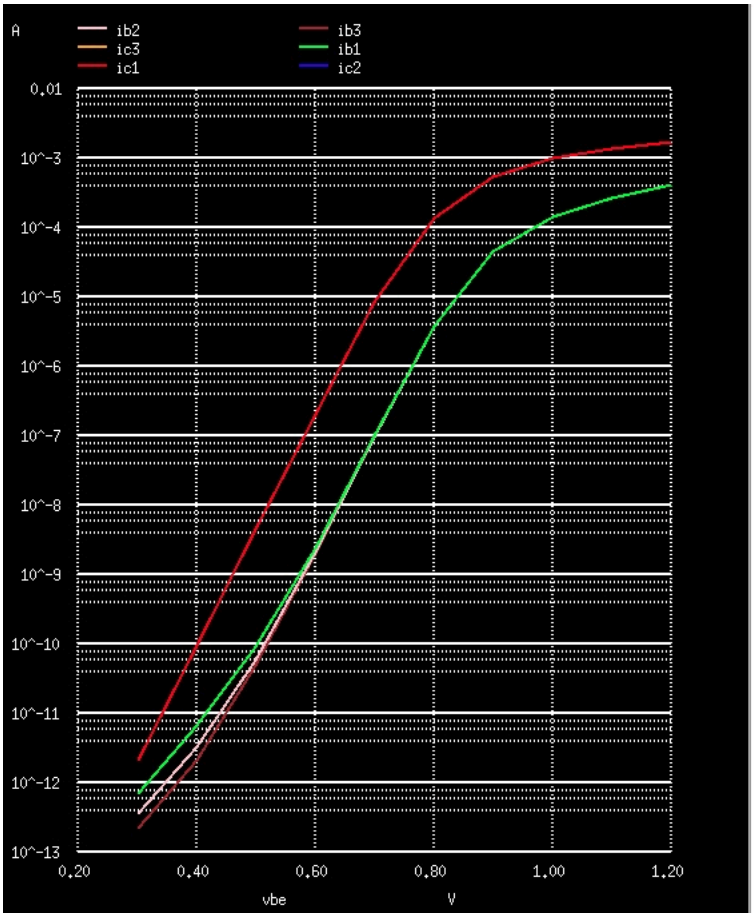


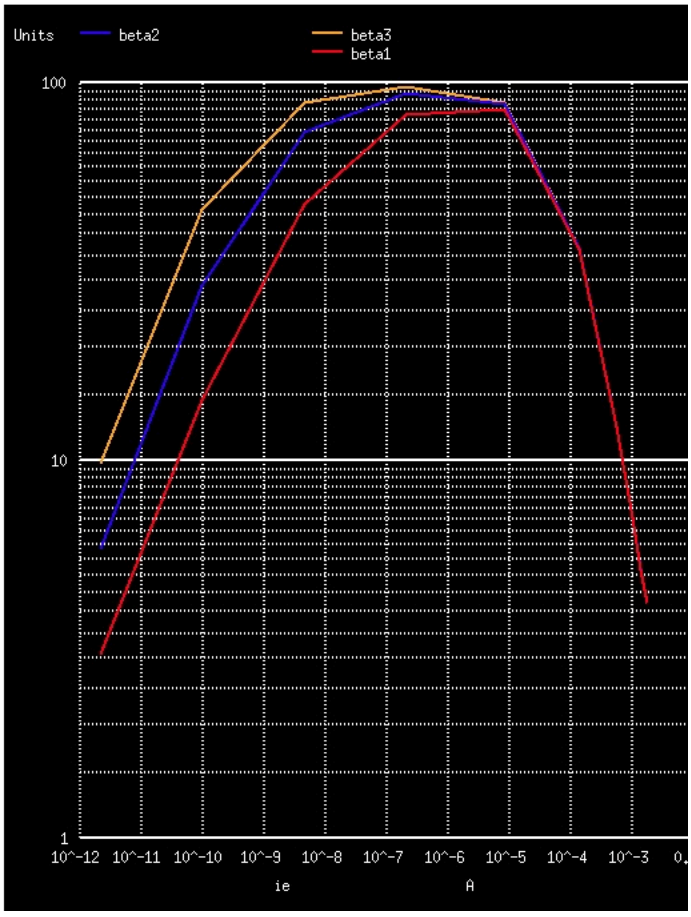

```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
* Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         C       0       DC      5V
VB         B       0       0V
Q1         C       B       0       NPNV

.control
destroy all
altermod   npnv   ISE=5E-15
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vb     .3     1.2   .1
altermod   npnv   ISE=10E-15
dc  vb     .3     1.2   .1
altermod   npnv   ISE=20E-15
```

```
dc  vb     .3     1.2   .1
let ic1 = mag(-dc1.i(vc))
let ic2 = mag(-dc2.i(vc))
let ic3 = mag(-dc3.i(vc))
let ib1 = mag(-dc1.i(vb))
let ib2 = mag(-dc2.i(vb))
let ib3 = mag(-dc3.i(vb))
let beta1 = mag(dc1.i(vc)/dc1.i(vb))
let beta2 = mag(dc2.i(vc)/dc2.i(vb))
let beta3 = mag(dc3.i(vc)/dc3.i(vb))
let vbe = mag(V(b))
let ie = mag(vc#branch)
plot ic1 ic2 ic3 ib1 ib2 ib3 vs vbe   ylog   title Gummel
plot beta1  beta2  beta3  vs ie loglog title Beta_vs_IC
.endc

.MODEL  NPNV    NPN(
* =============Gummel==========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* =============LowCurrent=====================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* =============Resistance=====================================
+ RB=732        RBM=441.2                                IRB=7.5E-04
+ RE=15.33      RC=109.1
* =============Capacitance====================================
+ 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
* =============Speed==========================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* =============Noise??========================================
+ KF=1.000E-16  AF=1
* =============Temperature====================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ============================================================

.end

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

================================NE=BELeakageEmissionCoeff==============================

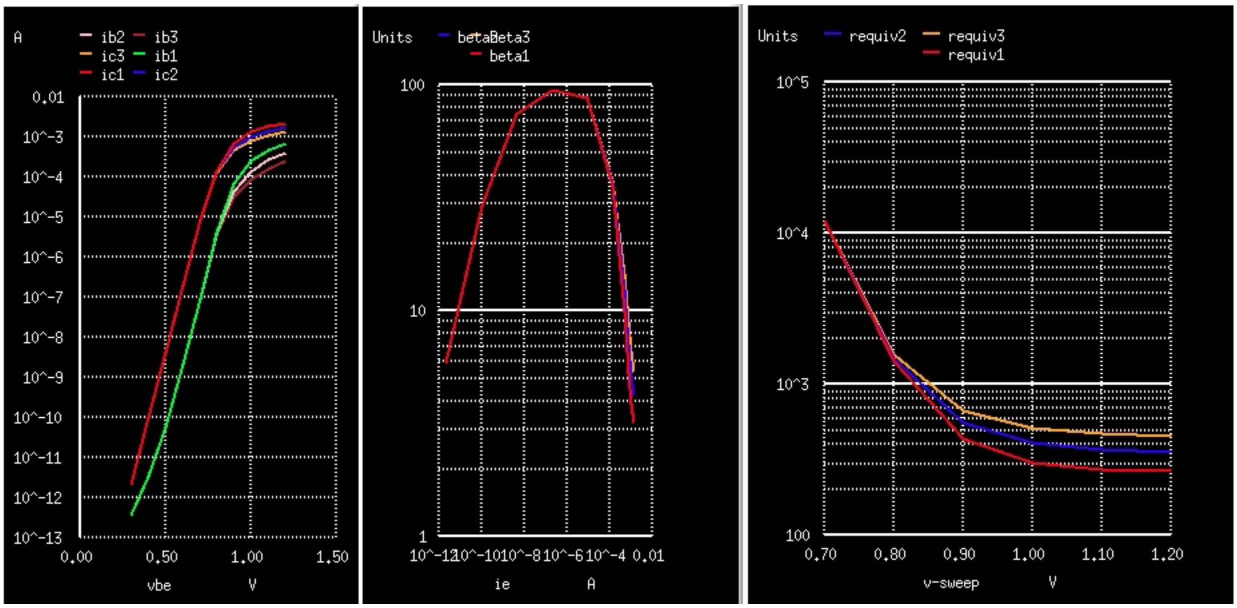
```
* =============LowCurrent=====================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ============================================================
```





NPN_NE

```
* MEASURE EFFECTS OF NE=1.8 2.00 2.2
*
*
*                  ________
*                 |        | VC
*                 |C      _|_
*          B      |_     /2v \
*           ______|'  npnv  \___/
*                 |`->
*     VB  _|_     |   0      |
*       /.7v\     |__________|
*       \___/      _|_
*          |       7//
*
*        7//  0      1u

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
* Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         C      0      DC     5V
VB         B      0      0V
Q1         C      B      0      NPNV

.control
destroy all
altermod   npnv   NE=1.8
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vb     .3     1.2   .1
altermod   npnv   NE=2.00
dc  vb     .3     1.2   .1
altermod   npnv   NE=2.2
dc  vb     .3     1.2   .1
let ic1 = mag(-dc1.i(vc))
let ic2 = mag(-dc2.i(vc))
let ic3 = mag(-dc3.i(vc))
let ib1 = mag(-dc1.i(vb))
let ib2 = mag(-dc2.i(vb))
let ib3 = mag(-dc3.i(vb))
let beta1 = mag(dc1.i(vc)/dc1.i(vb))
let beta2 = mag(dc2.i(vc)/dc2.i(vb))
let beta3 = mag(dc3.i(vc)/dc3.i(vb))
let vbe = mag(V(b))
let ie = mag(vc#branch)
plot ic1 ic2 ic3 ib1 ib2 ib3 vs vbe   ylog   title Gummel
plot beta1  beta2  beta3  vs ie loglog title Beta_vs_IC
.endc

.MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================
+ RB=732        RBM=441.2                        IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance====================================
+ 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
* ==============Speed==========================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??=======================================
+ KF=1.000E-16  AF=1
* ==============Temperature====================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ================================================================

.end

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


==========RB=BaseResistance==========
* ==============Resistance=====================================
+ RB=732        RBM=441.2                        IRB=7.5E-04
+ RE=15.33      RC=109.1
* ================================================================
```

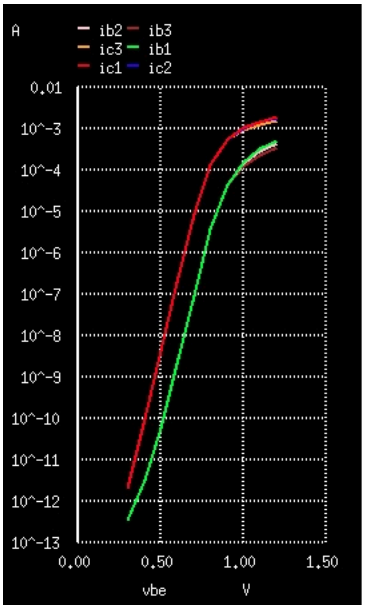


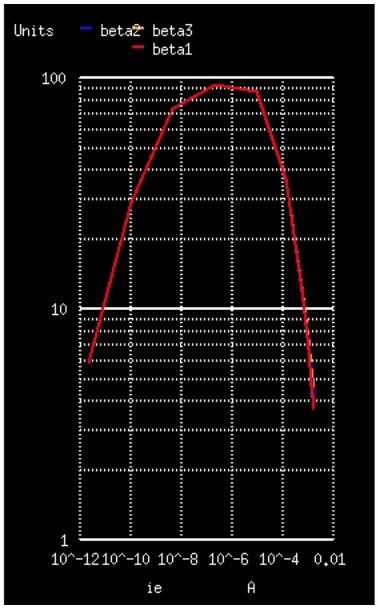
NPN_RB   RB=200 700 1400

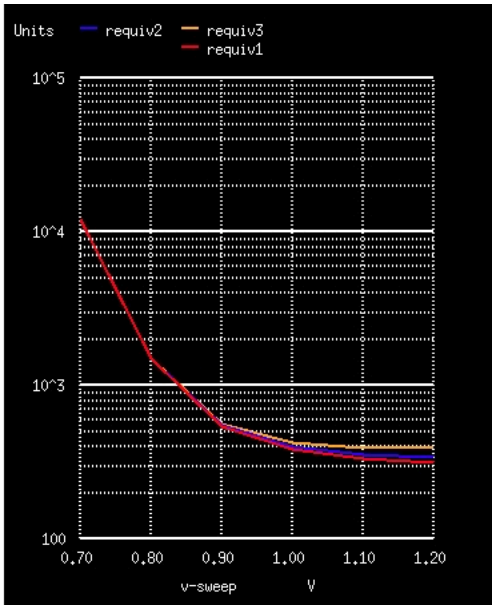
```
*
*                    _________
*                   |         |  VC
*                   |C        |
*         B        _|       /2v \
*            _____|'  npnv  \___/
*           |     |`->        |
*    VB    _|_      |   0     |
*         /.7v\     |_________|
*         \___/      _|_
*           |        7/7
*          _|_
*          7/7   0       1u

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
* Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC        C      0      DC     5V
VB        B      0      0V
Q1        C      B      0      NPNV
.control
destroy all
altermod   npnv   RB=200
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vb     .3     1.2   .1
altermod   npnv   RB=732
dc  vb     .3     1.2   .1
altermod   npnv   RB=1400
dc  vb     .3     1.2   .1
let ic1 = mag(-dc1.i(vc))
let ic2 = mag(-dc2.i(vc))
let ic3 = mag(-dc3.i(vc))
let ib1 = mag(-dc1.i(vb))
let ib2 = mag(-dc2.i(vb))
let ib3 = mag(-dc3.i(vb))
let beta1 = mag(dc1.i(vc)/dc1.i(vb))
let beta2 = mag(dc2.i(vc)/dc2.i(vb))
let beta3 = mag(dc3.i(vc)/dc3.i(vb))
let vbe = mag(V(b))
let ie = mag(vc#branch)
plot ic1 ic2 ic3 ib1 ib2 ib3 vs vbe   ylog   title Gummel
plot beta1  beta2  beta3  vs ie loglog title Beta_vs_IC
let requiv1 =(b-.6)/ic1
let requiv2 =(b-.6)/ic2
let requiv3 =(b-.6)/ic3
plot requiv1 requiv2 requiv3 ylog xlimit .7 1.2 ylimit 100 100k
.endc
```

```
.MODEL  NPNV    NPN(
* ==============Gummel==========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2     IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286     IKR=0.0002472
* ==============LowCurrent============================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance============================================
+ RB=732        RBM=441.2                              IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance============================================
+ 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
* ==============Speed============================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??============================================
```

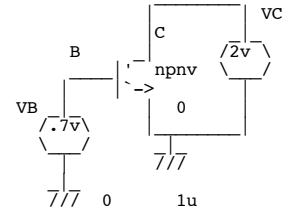
```
+ KF=1.000E-16  AF=1
* ==============Temperature=============================================
+ XTB=1.4        EG=1.11       XTI=8        TNOM=25        )
* ======================================================================

.end

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

============RBM=RbHiCurrent====================================
* ==============Resistance=================================================
+ RB=732         RBM=441.2                                IRB=7.5E-04
+ RE=15.33       RC=109.1
* ==========================================================================
```







NPN_RBM RBM=100 300 800

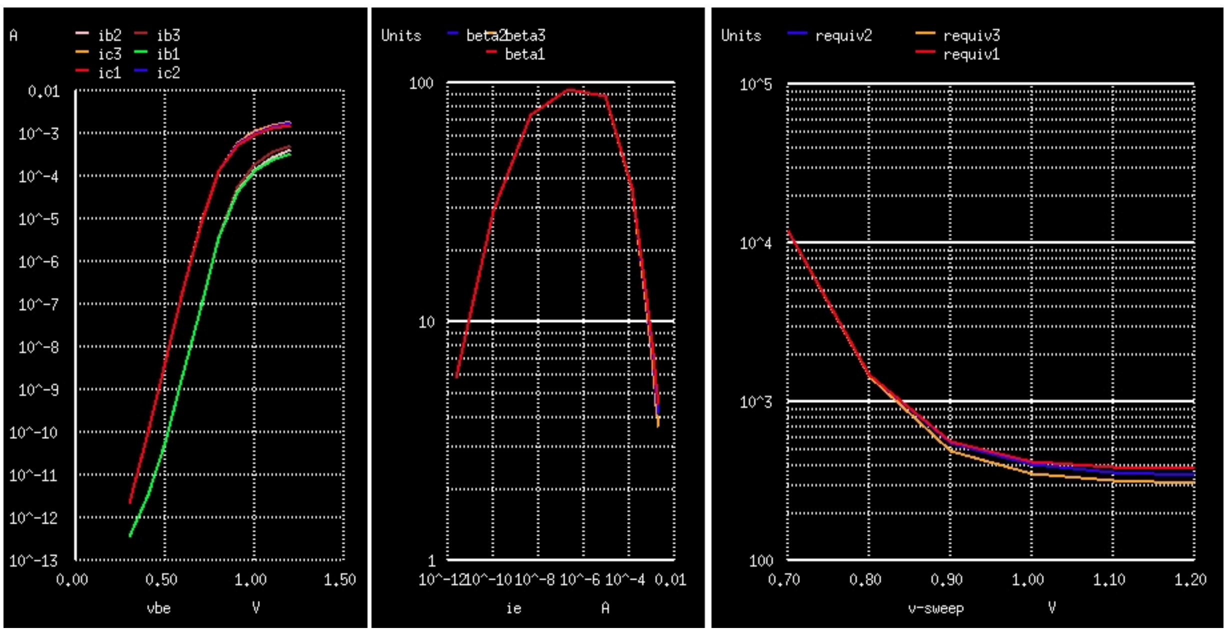



```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
* Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         C       0       DC      5V
VB         B       0       0V
Q1         C       B       0       NPNV

.control
destroy all
altermod   npnv   RBM=100
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vb     .3     1.2   .1
altermod   npnv   RBM=300
dc  vb     .3     1.2   .1
altermod   npnv   RBM=800
dc  vb     .3     1.2   .1
let ic1 = mag(-dc1.i(vc))
let ic2 = mag(-dc2.i(vc))
let ic3 = mag(-dc3.i(vc))
let ib1 = mag(-dc1.i(vb))
let ib2 = mag(-dc2.i(vb))
let ib3 = mag(-dc3.i(vb))
let beta1 = mag(dc1.i(vc)/dc1.i(vb))
let beta2 = mag(dc2.i(vc)/dc2.i(vb))
let beta3 = mag(dc3.i(vc)/dc3.i(vb))
let vbe = mag(V(b))
let ie = mag(vc#branch)
plot ic1 ic2 ic3 ib1 ib2 ib3 vs vbe   ylog   title Gummel
plot beta1  beta2  beta3  vs ie loglog title Beta_vs_IC
let requiv1 =(b-.6)/ic1
let requiv2 =(b-.6)/ic2
let requiv3 =(b-.6)/ic3
plot requiv1 requiv2 requiv3 ylog xlimit .7 1.2 ylimit 100 100k

.endc
```

```
..MODEL  NPNV    NPN(
* ==============Gummel==========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent==============================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance==============================================
+ RB=732        RBM=441.2                             IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance==============================================
+ 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
* ==============Speed============================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??===========================================
+ KF=1.000E-16  AF=1
* ==============Temperature==============================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25        )
* ===================================================================

.end

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

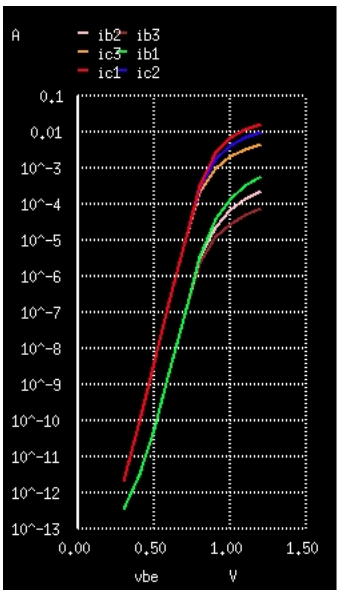
============IRB=I@medium_Rb==========================

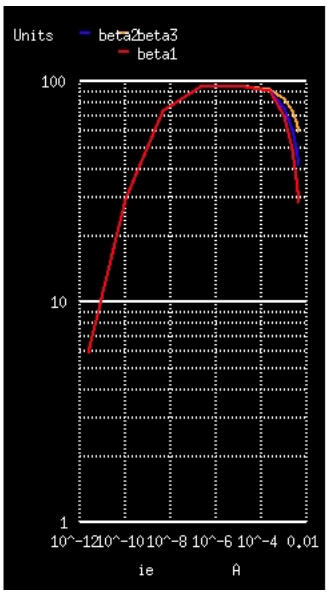
```
* ==============Resistance==============================================
+ RB=732        RBM=441.2                             IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==================================================================
```

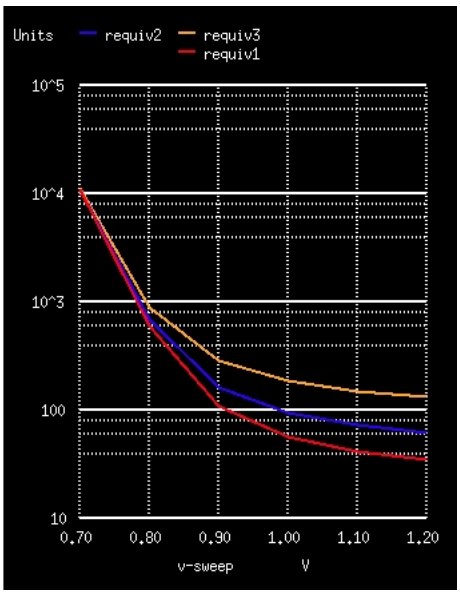



```
NPN_IRB
* MEASURE EFFECTS OF IRB=4.5E-01 4.5E-04 4.5E-08
*
*
*                 _________
*                |         |  VC
*                |C        |
*          B    _|        /2v\
*          _____|'  npnv  \___/
*         |     |`->        |
*    VB  _|_         0      |
*       /.7v\    |_________|
*       \___/      _|_
*         |        7/7
*        _|_
*        7/7  0      1u

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
* Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         C      0      DC     5V
VB         B      0      0V
Q1         C      B      0      NPNV

.control
destroy all
altermod   npnv   IRB=4.5E-01
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vb     .3     1.2    .1
altermod   npnv   IRB=4.5E-04
```

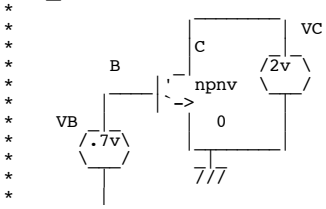
```
dc  vb     .3     1.2   .1
altermod   npnv   IRB=4.5E-08
dc  vb     .3     1.2   .1
let ic1 = mag(-dc1.i(vc))
let ic2 = mag(-dc2.i(vc))
let ic3 = mag(-dc3.i(vc))
let ib1 = mag(-dc1.i(vb))
let ib2 = mag(-dc2.i(vb))
let ib3 = mag(-dc3.i(vb))
let beta1 = mag(dc1.i(vc)/dc1.i(vb))
let beta2 = mag(dc2.i(vc)/dc2.i(vb))
let beta3 = mag(dc3.i(vc)/dc3.i(vb))
let vbe = mag(V(b))
let ie = mag(vc#branch)
plot ic1 ic2 ic3 ib1 ib2 ib3 vs vbe   ylog   title Gummel
plot beta1  beta2  beta3  vs ie loglog title Beta_vs_IC
let requiv1 =(b-.6)/ic1
let requiv2 =(b-.6)/ic2
let requiv3 =(b-.6)/ic3
plot requiv1 requiv2 requiv3 ylog xlimit .7 1.2 ylimit 100 100k

.endc

.MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005      BF=110       VAF=130.2     IKF=0.0001
+               NR=1.006      BR=0.4822    VAR=4.286     IKR=0.0002472
* ==============LowCurrent=====================================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================================
+ RB=732        RBM=441.2                                  IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance=====================================================
+ 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
* ==============Speed=============================================
+ TF=4.65E-12   XTF=1.25      VTF=1        ITF=0.009532
+ TR=6E-09      FC=0.88       PTF=205
* ==============Noise??=========================================
+ KF=1.000E-16  AF=1
* ==============Temperature=====================================================
+ XTB=1.4       EG=1.11       XTI=8        TNOM=25       )
* ================================================================

.end

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

==========RE=EmitterResistance==========
* ==============Resistance=====================================================
+ RB=732        RBM=441.2                                  IRB=7.5E-04
+ RE=15.33      RC=109.1
* ================================================================
```



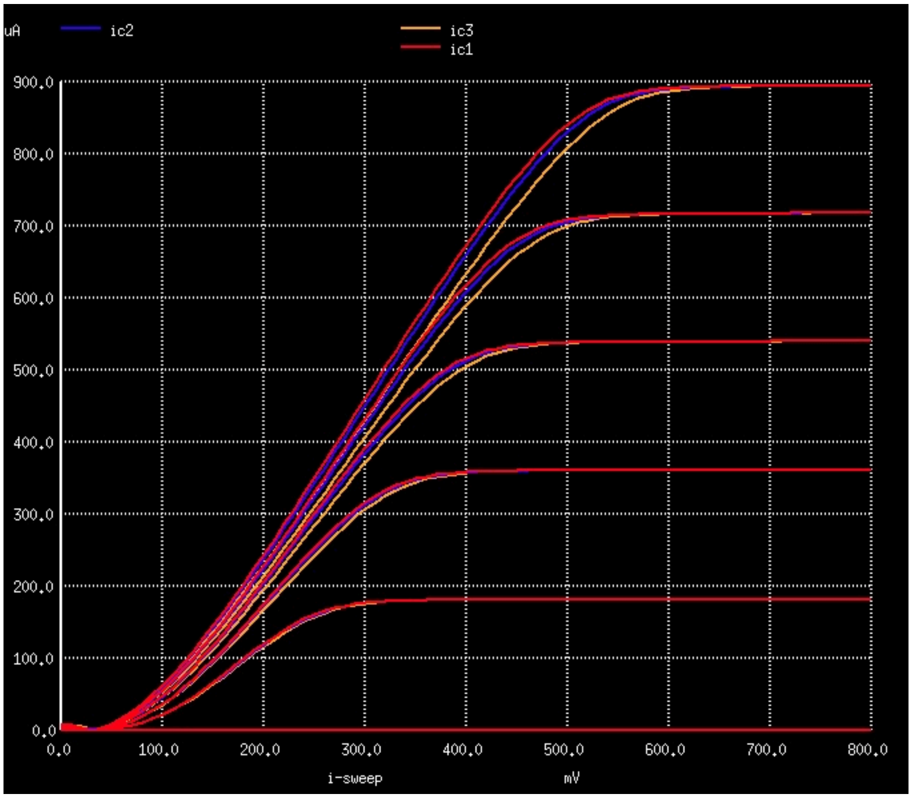




NPN_RE RE=15 30 70



```
*       ///  0      1u

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
* Param-example
.param scaleby=1
*
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC        C      0      DC     5V
VB        B      0      0V
Q1        C      B      0      NPNV

.control
destroy all
altermod   npnv   RE=15
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vb     .3     1.2   .1
altermod   npnv   RE=30
dc  vb     .3     1.2   .1
altermod   npnv   RE=70
dc  vb     .3     1.2   .1
let ic1 = mag(-dc1.i(vc))
let ic2 = mag(-dc2.i(vc))
let ic3 = mag(-dc3.i(vc))
let ib1 = mag(-dc1.i(vb))
let ib2 = mag(-dc2.i(vb))
let ib3 = mag(-dc3.i(vb))
let beta1 = mag(dc1.i(vc)/dc1.i(vb))
let beta2 = mag(dc2.i(vc)/dc2.i(vb))
let beta3 = mag(dc3.i(vc)/dc3.i(vb))
let vbe = mag(V(b))
let ie = mag(vc#branch)
plot ic1 ic2 ic3 ib1 ib2 ib3 vs vbe   ylog   title Gummel
plot beta1  beta2  beta3  vs ie loglog title Beta_vs_IC
let requiv1 =(b-.6)/ic1
let requiv2 =(b-.6)/ic2
let requiv3 =(b-.6)/ic3
plot requiv1 requiv2 requiv3 ylog xlimit .7 1.2 ylimit 10 100k
.endc

.MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================================
+ RB=732        RBM=441.2                                IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance=====================================================
+ 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
* ==============Speed=========================================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??=======================================
+ KF=1.000E-16  AF=1
* ==============Temperature=====================================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ================================================================

.end

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

============RE=EmitterResistance=====================================
* ==============Resistance=====================================================
+ RB=732        RBM=441.2                                IRB=7.5E-04
+ RE=15.33      RC=109.1
* ================================================================
```



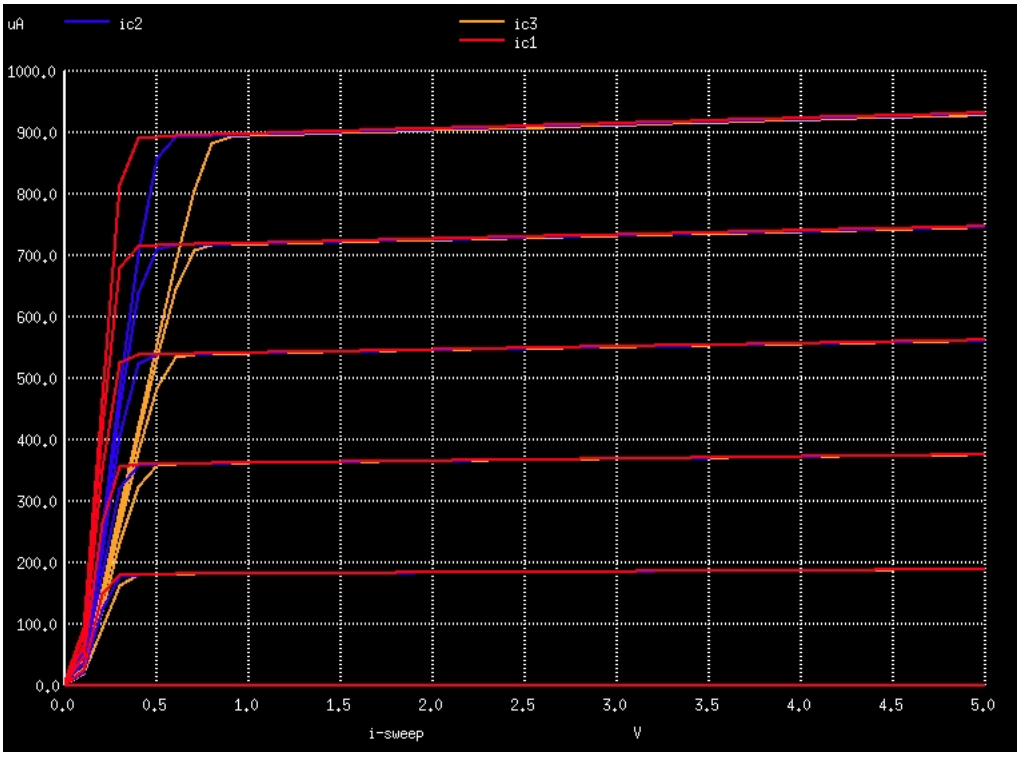
NPN_RE RE = 10 20 40

```
**
*
*                 _________
*                |         | VC
*                |C        |
*         B     _|       /2v \
*         _____|'  npnv  \___/
*        |     |`->        |
*    IB _|_        |  0    |
*     /.7v\        |_______|
*     \___/          _|_
*       |            ///
*      _|_
*      ///   0       1u

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         C      0      DC      5V
IB         0      B      DC      1u
Q1         C      B      0       NPNV

.control
destroy all
altermod   npnv   RE=10
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc     0      .8     .01    ib     0      10u   2u
altermod   npnv   RE=20
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc     0      .8     .01    ib     0      10u   2u
altermod   npnv   RE=40
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc     0      .8     .01    ib     0      10u   2u
let ic1 = mag(dc1.i(vc))
let ic2 = mag(dc2.i(vc))
let ic3 = mag(dc3.i(vc))

plot ic1 ic2 ic3

*plot mag(i(vc))
.endc

.MODEL  NPNV    NPN(
* ==============Gummel==========================================
+ IS=15.51E-18  NF=1.005      BF=110      VAF=130.2     IKF=0.0001
+               NR=1.006      BR=0.4822   VAR=4.286     IKR=0.0002472
* ==============LowCurrent=============================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=============================================
+ RB=732        RBM=441.2                               IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance=============================================
+ 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
* ==============Speed==============================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??============================================
```

```
+ KF=1.000E-16  AF=1
* ==============Temperature=============================================
+ XTB=1.4        EG=1.11       XTI=8        TNOM=25        )
* ======================================================================

.end

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

============RC=CollectorResistance==================================

```
* ==============Resistance=============================================
+ RB=732         RBM=441.2                                IRB=7.5E-04
+ RE=15.33       RC=109.1
* ======================================================================
```



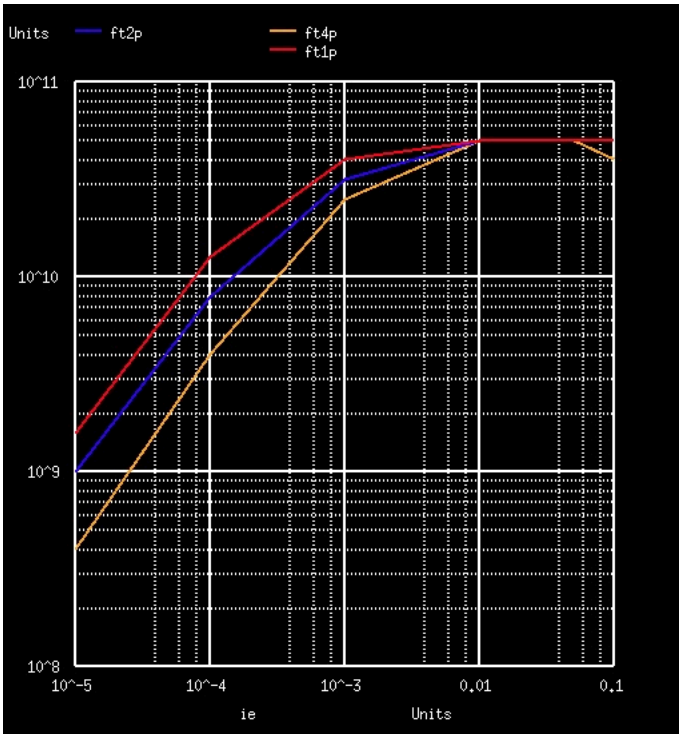
NPN_RC RC = 100 300 600

```
**
*                    ________
*                   |        | VC
*                   |C       |
*          B        |       /2v \
*          ____     |'  npnv  \__/
*              |    |`->
*     VB  _|_  |    |   0    |
*       /.7v\     |________|
*       \___/       |
*         |        ///
*         |
*        ///  0      1u

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15
*======== ====== ====== ====== ====== ====== ====== ====== ======
VC         C       0       DC      5V
IB         0       B       DC      1u
Q1         C       B       0       NPNV

.control
destroy all
altermod   npnv   RC=100
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc     0      5     .1    ib     0      10u   2u
altermod   npnv   RC=300
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc     0      5     .1    ib     0      10u   2u
altermod   npnv   RC=600
*DC SOURC1 VSTART VSTOP VSTEP SOURC2 START2 STOP2 STEP2
dc  vc     0      5     .1    ib     0      10u   2u
let ic1 = mag(dc1.i(vc))
let ic2 = mag(dc2.i(vc))
let ic3 = mag(dc3.i(vc))

plot ic1 ic2 ic3

*plot mag(i(vc))
.endc

.MODEL  NPNV    NPN(
* ==============Gummel=================================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+              NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
```

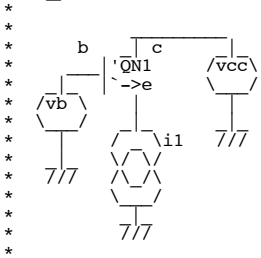
```
* ==============LowCurrent=============================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance============================================
+ RB=732        RBM=441.2                              IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance===========================================
+ 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
* ==============Speed=================================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??===============================================
+ KF=1.000E-16  AF=1
* ==============Temperature===========================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ====================================================================

.end

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

==========CJE=BECapacitance==========

```
* ==============Capacitance===========================================
+ CJE=37e-15    VJE=0.6408   MJE=0.2563
+ CJC=45E-15    VJC=0.6399   MJC=0.3531
+ CJS=2.94E-15  VJS=0.3488   MJS=0.1813  XCJC=0.4201
* ====================================================================
```



NPN_CJE CJE = 20f 40f 80f



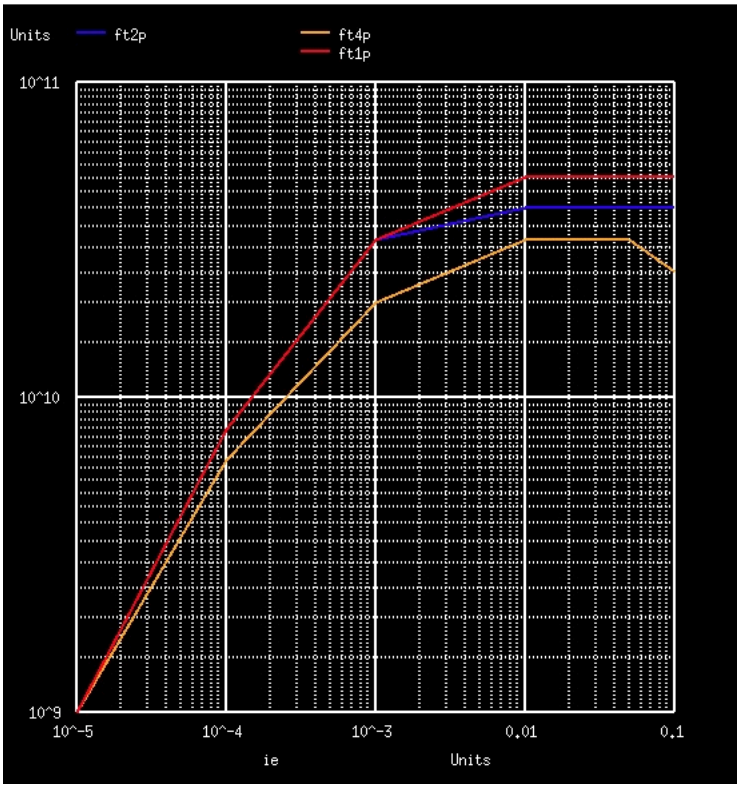
```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15 TEMP=27 srcsteps = 1 gminsteps = 1
VCC C  0    DC 5V
QN1 C  B E  NPNV
VB  B  0 0
I1  E  0    DC 100u AC .01u

.control
destroy all

foreach mytf 20f  37f   80f
foreach myic 10u 100u 1e-3 10e-3 50e-3 100e-3
 alter  i1 = $myic
 altermod   npnv   cje = $mytf
```

```
 ac dec 10 10k 100g
end
end

echo $plots
plot abs(ac1.vb#branch) abs(ac1.vcc#branch)
plot abs(ac2.vb#branch) abs(ac2.vcc#branch)

compose ie    start = 0 stop = 5 step =1
compose ft1p  start = 0 stop = 5 step =1
compose ft2p  start = 0 stop = 5 step =1
compose ft4p  start = 0 stop = 5 step =1
let index = 0
while (  index < length(abs(ac1.vb#branch)) )
if ( abs(ac1.vcc#branch[index]) >  abs(ac1.vb#branch[index]) )
let ft1p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac2.vcc#branch[index]) >  abs(ac2.vb#branch[index]) )
let ft1p[1] = mag(frequency[index] )
let ie[1] = 100e-6
end
if ( abs(ac3.vcc#branch[index]) >  abs(ac3.vb#branch[index]) )
let ft1p[2] = mag(frequency[index] )
let ie[2] = 1e-3
end
if ( abs(ac4.vcc#branch[index]) >  abs(ac4.vb#branch[index]) )
let ft1p[3] = mag(frequency[index] )
let ie[3] = 10e-3
end
if ( abs(ac5.vcc#branch[index]) >  abs(ac5.vb#branch[index]) )
let ft1p[4] = mag(frequency[index] )
let ie[4] = 50e-3
end
if ( abs(ac6.vcc#branch[index]) >  abs(ac6.vb#branch[index]) )
let ft1p[5] = mag(frequency[index] )
let ie[5] = 100e-3
end


if ( abs(ac7.vcc#branch[index]) >  abs(ac7.vb#branch[index]) )
let ft2p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac8.vcc#branch[index]) >  abs(ac8.vb#branch[index]) )
let ft2p[1] = mag(frequency[index] )
end
if ( abs(ac9.vcc#branch[index]) >  abs(ac9.vb#branch[index]) )
let ft2p[2] = mag(frequency[index] )
end
if ( abs(ac10.vcc#branch[index]) >  abs(ac10.vb#branch[index]) )
let ft2p[3] = mag(frequency[index] )
end
if ( abs(ac11.vcc#branch[index]) >  abs(ac11.vb#branch[index]) )
let ft2p[4] = mag(frequency[index] )
end
if ( abs(ac12.vcc#branch[index]) >  abs(ac12.vb#branch[index]) )
let ft2p[5] = mag(frequency[index] )
end

if ( abs(ac13.vcc#branch[index]) >  abs(ac13.vb#branch[index]) )
let ft4p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac14.vcc#branch[index]) >  abs(ac14.vb#branch[index]) )
let ft4p[1] = mag(frequency[index] )
end
if ( abs(ac15.vcc#branch[index]) >  abs(ac15.vb#branch[index]) )
let ft4p[2] = mag(frequency[index] )
end
if ( abs(ac16.vcc#branch[index]) >  abs(ac16.vb#branch[index]) )
let ft4p[3] = mag(frequency[index] )
end
if ( abs(ac17.vcc#branch[index]) >  abs(ac17.vb#branch[index]) )
let ft4p[4] = mag(frequency[index] )
end
if ( abs(ac18.vcc#branch[index]) >  abs(ac18.vb#branch[index]) )
let ft4p[5] = mag(frequency[index] )
end

let index = index +1
end
*print ft1p[0] ft1p[1] ft1p[2] ft1p[3] ft1p[4] ft1p[5]
plot ft1p ft2p ft4p vs ie loglog
.endc

.MODEL  NPNV    NPN(
* ==============Gummel==========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================
+ RB=732        RBM=441.2                        IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance====================================
+ 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
* ==============Speed==========================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
```

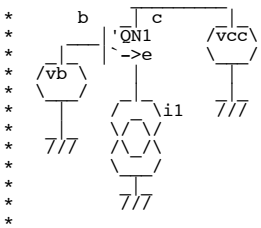
```
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??=============================================
+ KF=1.000E-16  AF=1
* ==============Temperature=========================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ===================================================================

.end

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

============CJC=CBCapacitance==============================

```
* ==============Capacitance=========================================
+ CJE=37e-15    VJE=0.6408   MJE=0.2563
+ CJC=45E-15    VJC=0.6399   MJC=0.3531
+ CJS=2.94E-15  VJS=0.3488   MJS=0.1813  XCJC=0.4201
* ===================================================================
```



NPN_CJC CJC = 40f 80f 160f

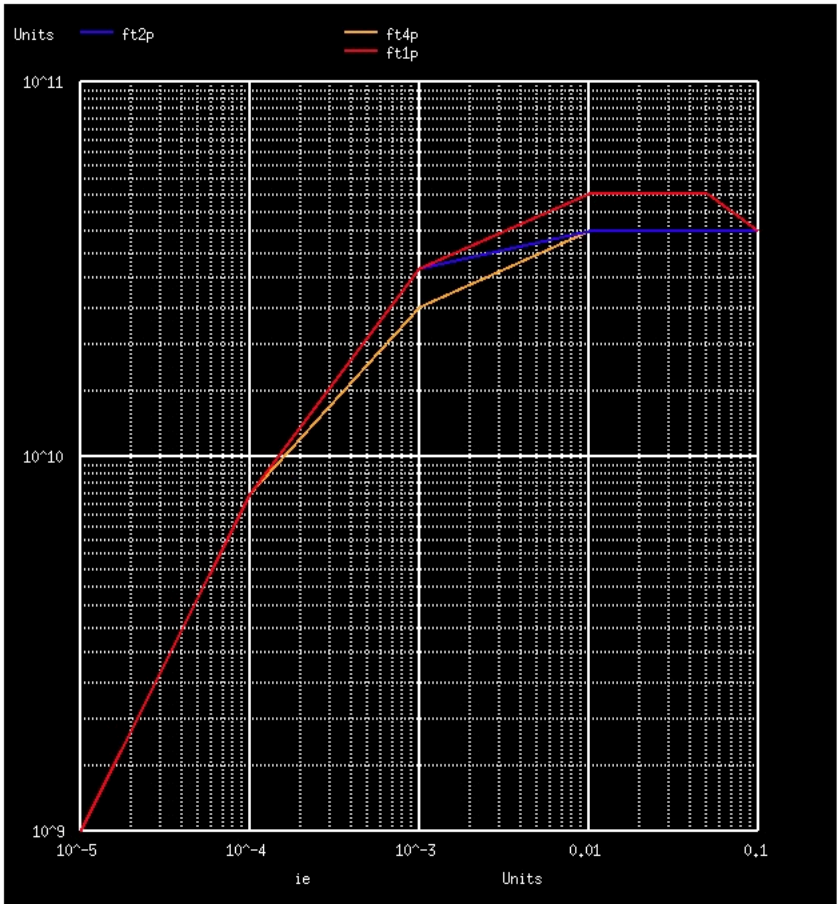


```
*
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15 TEMP=27 srcsteps = 1 gminsteps = 1
VCC C  0    DC 5V
QN1 C  B E  NPNV
VB  B  0 0
I1  E  0    DC 100u AC .01u

.control
destroy all

foreach mytf 40f  80f   160f
foreach myic 10u 100u 1e-3 10e-3 50e-3 100e-3
 alter  i1 = $myic
 altermod   npnv   cjc = $mytf
 ac dec 10 10k 100g
end
end

echo $plots
plot abs(ac1.vb#branch) abs(ac1.vcc#branch)
plot abs(ac2.vb#branch) abs(ac2.vcc#branch)

compose ie    start = 0 stop = 5 step =1
compose ft1p  start = 0 stop = 5 step =1
compose ft2p  start = 0 stop = 5 step =1
compose ft4p  start = 0 stop = 5 step =1
```

```
let index = 0
while (  index < length(abs(ac1.vb#branch)) )
if ( abs(ac1.vcc#branch[index]) >  abs(ac1.vb#branch[index]) )
let ft1p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac2.vcc#branch[index]) >  abs(ac2.vb#branch[index]) )
let ft1p[1] = mag(frequency[index] )
let ie[1] = 100e-6
end
if ( abs(ac3.vcc#branch[index]) >  abs(ac3.vb#branch[index]) )
let ft1p[2] = mag(frequency[index] )
let ie[2] = 1e-3
end
if ( abs(ac4.vcc#branch[index]) >  abs(ac4.vb#branch[index]) )
let ft1p[3] = mag(frequency[index] )
let ie[3] = 10e-3
end
if ( abs(ac5.vcc#branch[index]) >  abs(ac5.vb#branch[index]) )
let ft1p[4] = mag(frequency[index] )
let ie[4] = 50e-3
end
if ( abs(ac6.vcc#branch[index]) >  abs(ac6.vb#branch[index]) )
let ft1p[5] = mag(frequency[index] )
let ie[5] = 100e-3
end


if ( abs(ac7.vcc#branch[index]) >  abs(ac7.vb#branch[index]) )
let ft2p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac8.vcc#branch[index]) >  abs(ac8.vb#branch[index]) )
let ft2p[1] = mag(frequency[index] )
end
if ( abs(ac9.vcc#branch[index]) >  abs(ac9.vb#branch[index]) )
let ft2p[2] = mag(frequency[index] )
end
if ( abs(ac10.vcc#branch[index]) >  abs(ac10.vb#branch[index]) )
let ft2p[3] = mag(frequency[index] )
end
if ( abs(ac11.vcc#branch[index]) >  abs(ac11.vb#branch[index]) )
let ft2p[4] = mag(frequency[index] )
end
if ( abs(ac12.vcc#branch[index]) >  abs(ac12.vb#branch[index]) )
let ft2p[5] = mag(frequency[index] )
end

if ( abs(ac13.vcc#branch[index]) >  abs(ac13.vb#branch[index]) )
let ft4p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac14.vcc#branch[index]) >  abs(ac14.vb#branch[index]) )
let ft4p[1] = mag(frequency[index] )
end
if ( abs(ac15.vcc#branch[index]) >  abs(ac15.vb#branch[index]) )
let ft4p[2] = mag(frequency[index] )
end
if ( abs(ac16.vcc#branch[index]) >  abs(ac16.vb#branch[index]) )
let ft4p[3] = mag(frequency[index] )
end
if ( abs(ac17.vcc#branch[index]) >  abs(ac17.vb#branch[index]) )
let ft4p[4] = mag(frequency[index] )
end
if ( abs(ac18.vcc#branch[index]) >  abs(ac18.vb#branch[index]) )
let ft4p[5] = mag(frequency[index] )
end

let index = index +1
end
*print ft1p[0] ft1p[1] ft1p[2] ft1p[3] ft1p[4] ft1p[5]
plot ft1p ft2p ft4p vs ie loglog
.endc

.MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================================
+ RB=732        RBM=441.2                            IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance====================================================
+ 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
* ==============Speed==========================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??=======================================
+ KF=1.000E-16  AF=1
* ==============Temperature====================================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ================================================================

.end

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

==========CJS=CSCapacitance==========

```
* ==============Capacitance=============================================
+ CJE=37e-15     VJE=0.6408    MJE=0.2563
+ CJC=45E-15     VJC=0.6399    MJC=0.3531
+ CJS=2.94E-15   VJS=0.3488    MJS=0.1813   XCJC=0.4201
* ======================================================================
```



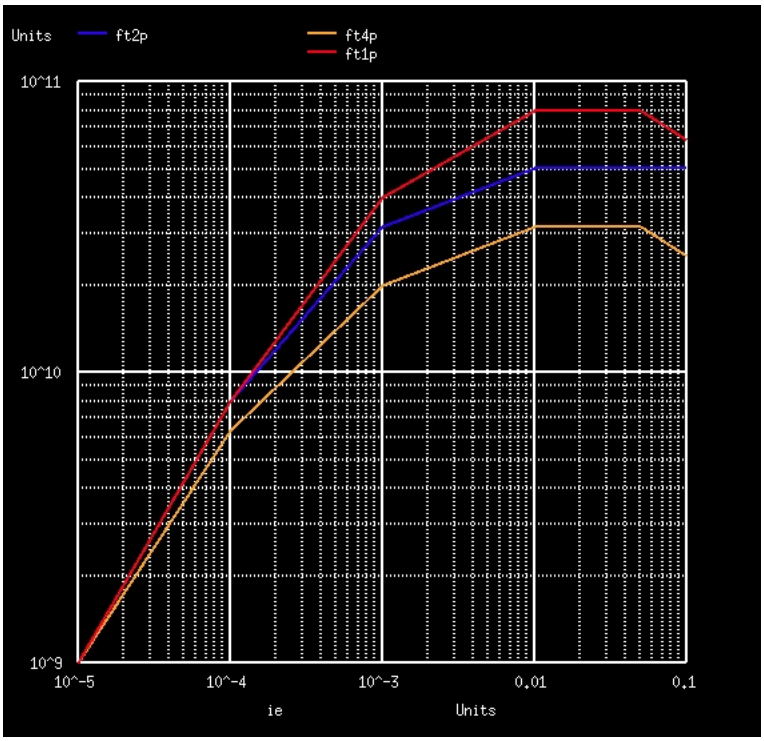
NPN_CJS CJS = 40f 80f 160f

```
*
*
*       b    _________
*          _| c      _|_
*      ____|'QN1     /vcc\
*    _|_   |`->e     \___/
*   /vb \     |        |
*   \___/     |        |
*     |     /   \i1    ///
*    _|_    \   /
*    ///    /\_/\
*           \___/
*             |
*            ///
*
```

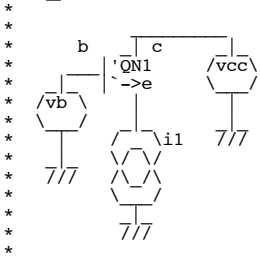
```
.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15 TEMP=27 srcsteps = 1 gminsteps = 1
VCC C  0    DC 5V
QN1 C  B E  NPNV
VB  B  0 0
I1  E  0    DC 100u AC .01u

.control
destroy all

foreach mytf 40f  80f   160f
foreach myic 10u 100u 1e-3 10e-3 50e-3 100e-3
 alter  i1 = $myic
 altermod   npnv   cjs = $mytf
 ac dec 10 10k 100g
end
end

echo $plots
plot abs(ac1.vb#branch) abs(ac1.vcc#branch)
plot abs(ac2.vb#branch) abs(ac2.vcc#branch)

compose ie    start = 0 stop = 5 step =1
compose ft1p  start = 0 stop = 5 step =1
compose ft2p  start = 0 stop = 5 step =1
compose ft4p  start = 0 stop = 5 step =1
let index = 0
while (  index < length(abs(ac1.vb#branch)) )
if ( abs(ac1.vcc#branch[index]) >  abs(ac1.vb#branch[index]) )
```

```
let ft1p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac2.vcc#branch[index]) >  abs(ac2.vb#branch[index]) )
let ft1p[1] = mag(frequency[index] )
let ie[1] = 100e-6
end
if ( abs(ac3.vcc#branch[index]) >  abs(ac3.vb#branch[index]) )
let ft1p[2] = mag(frequency[index] )
let ie[2] = 1e-3
end
if ( abs(ac4.vcc#branch[index]) >  abs(ac4.vb#branch[index]) )
let ft1p[3] = mag(frequency[index] )
let ie[3] = 10e-3
end
if ( abs(ac5.vcc#branch[index]) >  abs(ac5.vb#branch[index]) )
let ft1p[4] = mag(frequency[index] )
let ie[4] = 50e-3
end
if ( abs(ac6.vcc#branch[index]) >  abs(ac6.vb#branch[index]) )
let ft1p[5] = mag(frequency[index] )
let ie[5] = 100e-3
end


if ( abs(ac7.vcc#branch[index]) >  abs(ac7.vb#branch[index]) )
let ft2p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac8.vcc#branch[index]) >  abs(ac8.vb#branch[index]) )
let ft2p[1] = mag(frequency[index] )
end
if ( abs(ac9.vcc#branch[index]) >  abs(ac9.vb#branch[index]) )
let ft2p[2] = mag(frequency[index] )
end
if ( abs(ac10.vcc#branch[index]) >  abs(ac10.vb#branch[index]) )
let ft2p[3] = mag(frequency[index] )
end
if ( abs(ac11.vcc#branch[index]) >  abs(ac11.vb#branch[index]) )
let ft2p[4] = mag(frequency[index] )
end
if ( abs(ac12.vcc#branch[index]) >  abs(ac12.vb#branch[index]) )
let ft2p[5] = mag(frequency[index] )
end

if ( abs(ac13.vcc#branch[index]) >  abs(ac13.vb#branch[index]) )
let ft4p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac14.vcc#branch[index]) >  abs(ac14.vb#branch[index]) )
let ft4p[1] = mag(frequency[index] )
end
if ( abs(ac15.vcc#branch[index]) >  abs(ac15.vb#branch[index]) )
let ft4p[2] = mag(frequency[index] )
end
if ( abs(ac16.vcc#branch[index]) >  abs(ac16.vb#branch[index]) )
let ft4p[3] = mag(frequency[index] )
end
if ( abs(ac17.vcc#branch[index]) >  abs(ac17.vb#branch[index]) )
let ft4p[4] = mag(frequency[index] )
end
if ( abs(ac18.vcc#branch[index]) >  abs(ac18.vb#branch[index]) )
let ft4p[5] = mag(frequency[index] )
end

let index = index +1
end
*print ft1p[0] ft1p[1] ft1p[2] ft1p[3] ft1p[4] ft1p[5]
plot ft1p ft2p ft4p vs ie loglog
.endc
.MODEL  NPNV    NPN(
* ==============Gummel==========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=======================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance======================================
+ RB=732        RBM=441.2                           IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance=====================================
+ 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
* ==============Speed===========================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??========================================
+ KF=1.000E-16  AF=1
* ==============Temperature=====================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ================================================================

.end

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


==========TF=ForwardTransitTime==========================================
* ==============Speed===========================================
```

```
+ TF=2E-12       XTF=1         VTF=1.5       ITF=0.8
+ TR=6E-09       FC=0.5        PTF=30
* ================================================================
```

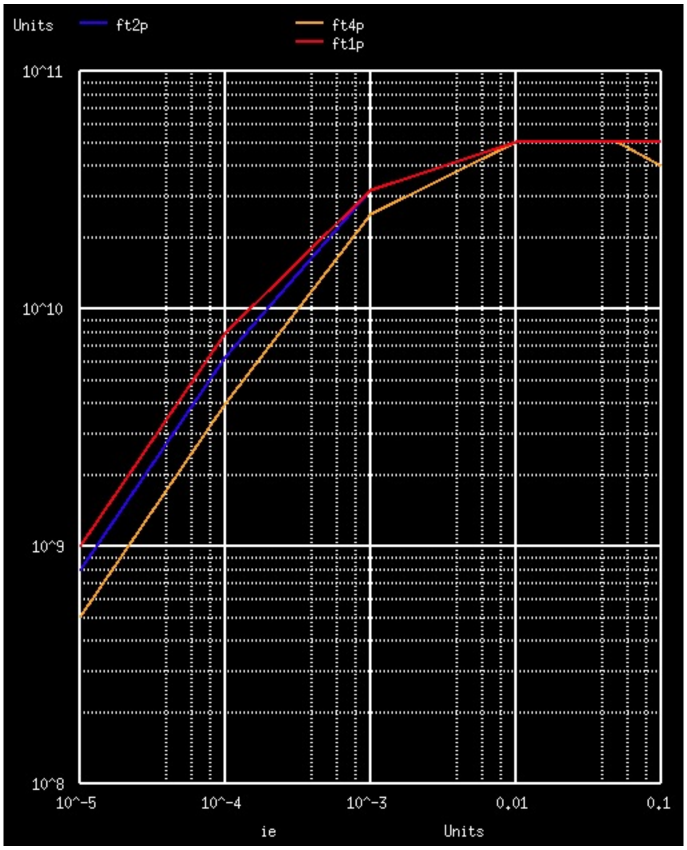


NPN_TF TF = 1p 2p 4p




```
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15 TEMP=27 srcsteps = 1 gminsteps = 1
VCC C  0    DC 5V
QN1 C  B E  NPNV
VB  B  0 0
I1  E  0    DC 100u AC .01u

.control
destroy all

foreach mytf 1p  2p   4p
foreach myic 10u 100u 1e-3 10e-3 50e-3 100e-3
 alter  i1 = $myic
 altermod   npnv   tf = $mytf
 ac dec 10 10k 100g
end
end

echo $plots
plot abs(ac1.vb#branch) abs(ac1.vcc#branch)
plot abs(ac2.vb#branch) abs(ac2.vcc#branch)

compose ie    start = 0 stop = 5 step =1
compose ft1p  start = 0 stop = 5 step =1
compose ft2p  start = 0 stop = 5 step =1
compose ft4p  start = 0 stop = 5 step =1
let index = 0
while (  index < length(abs(ac1.vb#branch)) )
if ( abs(ac1.vcc#branch[index]) >  abs(ac1.vb#branch[index]) )
let ft1p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac2.vcc#branch[index]) >  abs(ac2.vb#branch[index]) )
let ft1p[1] = mag(frequency[index] )
let ie[1] = 100e-6
end
if ( abs(ac3.vcc#branch[index]) >  abs(ac3.vb#branch[index]) )
let ft1p[2] = mag(frequency[index] )
let ie[2] = 1e-3
end
if ( abs(ac4.vcc#branch[index]) >  abs(ac4.vb#branch[index]) )
let ft1p[3] = mag(frequency[index] )
let ie[3] = 10e-3
```

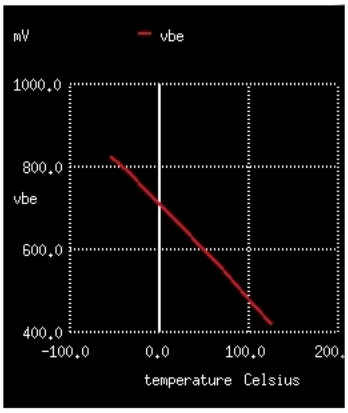
```
end
if ( abs(ac5.vcc#branch[index]) >  abs(ac5.vb#branch[index]) )
let ft1p[4] = mag(frequency[index] )
let ie[4] = 50e-3
end
if ( abs(ac6.vcc#branch[index]) >  abs(ac6.vb#branch[index]) )
let ft1p[5] = mag(frequency[index] )
let ie[5] = 100e-3
end


if ( abs(ac7.vcc#branch[index]) >  abs(ac7.vb#branch[index]) )
let ft2p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac8.vcc#branch[index]) >  abs(ac8.vb#branch[index]) )
let ft2p[1] = mag(frequency[index] )
end
if ( abs(ac9.vcc#branch[index]) >  abs(ac9.vb#branch[index]) )
let ft2p[2] = mag(frequency[index] )
end
if ( abs(ac10.vcc#branch[index]) >  abs(ac10.vb#branch[index]) )
let ft2p[3] = mag(frequency[index] )
end
if ( abs(ac11.vcc#branch[index]) >  abs(ac11.vb#branch[index]) )
let ft2p[4] = mag(frequency[index] )
end
if ( abs(ac12.vcc#branch[index]) >  abs(ac12.vb#branch[index]) )
let ft2p[5] = mag(frequency[index] )
end

if ( abs(ac13.vcc#branch[index]) >  abs(ac13.vb#branch[index]) )
let ft4p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac14.vcc#branch[index]) >  abs(ac14.vb#branch[index]) )
let ft4p[1] = mag(frequency[index] )
end
if ( abs(ac15.vcc#branch[index]) >  abs(ac15.vb#branch[index]) )
let ft4p[2] = mag(frequency[index] )
end
if ( abs(ac16.vcc#branch[index]) >  abs(ac16.vb#branch[index]) )
let ft4p[3] = mag(frequency[index] )
end
if ( abs(ac17.vcc#branch[index]) >  abs(ac17.vb#branch[index]) )
let ft4p[4] = mag(frequency[index] )
end
if ( abs(ac18.vcc#branch[index]) >  abs(ac18.vb#branch[index]) )
let ft4p[5] = mag(frequency[index] )
end

let index = index +1
end
*print ft1p[0] ft1p[1] ft1p[2] ft1p[3] ft1p[4] ft1p[5]
plot ft1p ft2p ft4p vs ie loglog
.endc

.MODEL  NPNV    NPN(
* ==============Gummel==========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================================
+ RB=732        RBM=441.2                        IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance=====================================================
+ 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
* ==============Speed===========================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??========================================
+ KF=1.000E-16  AF=1
* ==============Temperature=====================================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ================================================================

.end

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



==========FC=ForwardBiasDepletionCapCoeff==========
* ==============Speed==========================================
+ TF=2E-12      XTF=1        VTF=1.5       ITF=0.8
+ TR=6E-09      FC=0.5       PTF=30
* ================================================================
```

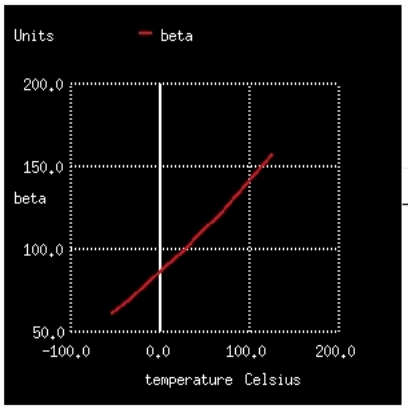


NPN_FC   FC = .5 .7   .9

```
*
*            _________
*      b    _|_c      _|_
*       ___|'QN1     /vcc\
*    _|_   |`->e     \___/
*   /vb \    |         |
*   \___/   _|_       _|_
*     |    / _ \i1    ///
*    _|_   \/ \/
*    ///   /\_/\
*          \___/
*           _|_
*           ///
*

.OPTIONS GMIN=1e-15 METHOD=gear ABSTOL=1e-15 TEMP=27 srcsteps = 1 gminsteps = 1
VCC C  0    DC 5V
QN1 C  B E  NPNV
VB  B  0 0
I1  E  0    DC 100u AC .01u

.control
destroy all

foreach mytf .5 .7  .9
foreach myic 10u 100u 1e-3 10e-3 50e-3 100e-3
 alter  i1 = $myic
 altermod   npnv    fc=$mytf
 ac dec 10 10k 100g
end
end

echo $plots
plot abs(ac1.vb#branch) abs(ac1.vcc#branch)
plot abs(ac2.vb#branch) abs(ac2.vcc#branch)

compose ie    start = 0 stop = 5 step =1
compose ft1p  start = 0 stop = 5 step =1
compose ft2p  start = 0 stop = 5 step =1
compose ft4p  start = 0 stop = 5 step =1
let index = 0
while (  index < length(abs(ac1.vb#branch)) )
if ( abs(ac1.vcc#branch[index]) >  abs(ac1.vb#branch[index]) )
let ft1p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac2.vcc#branch[index]) >  abs(ac2.vb#branch[index]) )
let ft1p[1] = mag(frequency[index] )
let ie[1] = 100e-6
end
if ( abs(ac3.vcc#branch[index]) >  abs(ac3.vb#branch[index]) )
let ft1p[2] = mag(frequency[index] )
let ie[2] = 1e-3
end
if ( abs(ac4.vcc#branch[index]) >  abs(ac4.vb#branch[index]) )
```

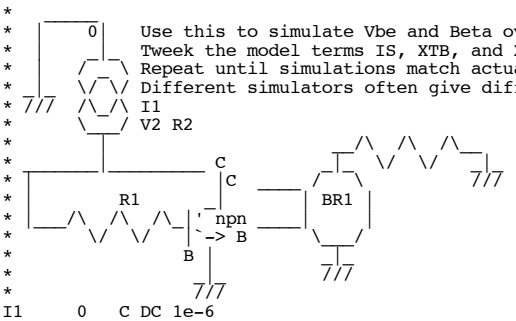
```
let ft1p[3] = mag(frequency[index] )
let ie[3] = 10e-3
end
if ( abs(ac5.vcc#branch[index]) >  abs(ac5.vb#branch[index]) )
let ft1p[4] = mag(frequency[index] )
let ie[4] = 50e-3
end
if ( abs(ac6.vcc#branch[index]) >  abs(ac6.vb#branch[index]) )
let ft1p[5] = mag(frequency[index] )
let ie[5] = 100e-3
end


if ( abs(ac7.vcc#branch[index]) >  abs(ac7.vb#branch[index]) )
let ft2p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac8.vcc#branch[index]) >  abs(ac8.vb#branch[index]) )
let ft2p[1] = mag(frequency[index] )
end
if ( abs(ac9.vcc#branch[index]) >  abs(ac9.vb#branch[index]) )
let ft2p[2] = mag(frequency[index] )
end
if ( abs(ac10.vcc#branch[index]) >  abs(ac10.vb#branch[index]) )
let ft2p[3] = mag(frequency[index] )
end
if ( abs(ac11.vcc#branch[index]) >  abs(ac11.vb#branch[index]) )
let ft2p[4] = mag(frequency[index] )
end
if ( abs(ac12.vcc#branch[index]) >  abs(ac12.vb#branch[index]) )
let ft2p[5] = mag(frequency[index] )
end

if ( abs(ac13.vcc#branch[index]) >  abs(ac13.vb#branch[index]) )
let ft4p[0] = mag(frequency[index] )
let ie[0] = 10e-6
end
if ( abs(ac14.vcc#branch[index]) >  abs(ac14.vb#branch[index]) )
let ft4p[1] = mag(frequency[index] )
end
if ( abs(ac15.vcc#branch[index]) >  abs(ac15.vb#branch[index]) )
let ft4p[2] = mag(frequency[index] )
end
if ( abs(ac16.vcc#branch[index]) >  abs(ac16.vb#branch[index]) )
let ft4p[3] = mag(frequency[index] )
end
if ( abs(ac17.vcc#branch[index]) >  abs(ac17.vb#branch[index]) )
let ft4p[4] = mag(frequency[index] )
end
if ( abs(ac18.vcc#branch[index]) >  abs(ac18.vb#branch[index]) )
let ft4p[5] = mag(frequency[index] )
end

let index = index +1
end
*print ft1p[0] ft1p[1] ft1p[2] ft1p[3] ft1p[4] ft1p[5]
plot ft1p ft2p ft4p vs ie loglog
.endc

.MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================
+ RB=732        RBM=441.2                            IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance====================================
+ 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
* ==============Speed==========================================
+ TF=4.65E-12   XTF=1.25     VTF=1       ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??=======================================
+ KF=1.000E-16  AF=1
* ==============Temperature====================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ================================================================

.end

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


==========TemperatureTests==========
* ==============Temperature====================================
+ XTB=1.4       EG=1.11      XTI=8       TNOM=25       )
* ================================================================
```





temp-sweep	vbe	beta
-5.50000e+01	8.269816e-01	6.149752e+01
-3.50000e+01	7.859245e-01	7.023587e+01
-1.50000e+01	7.435478e-01	7.946586e+01
5.000000e+00	7.000694e-01	8.918947e+01
2.500000e+01	6.555567e-01	9.941049e+01
4.500000e+01	6.100683e-01	1.101334e+02
6.500000e+01	5.636621e-01	1.213633e+02
8.500000e+01	5.163903e-01	1.331062e+02
1.050000e+02	4.682986e-01	1.453689e+02
1.250000e+02	4.194283e-01	1.581608e+02

Test Match NPN TC to Silicon




```
I1      0    C DC 1e-6
R1      C    B 1
R2      VR1 0 1k
Q1      C    B 0 NPNV 1
BR1     VR1 0  v = V(C) -V(B)

.control
dc TEMP -55 125 20

let Vbe = v(c)
plot Vbe
let beta = 1e-6/v(VR1)
plot beta
 print  Vbe beta
.endc


.MODEL  NPNV    NPN(
* ==============Gummel=========================================
+ IS=15.51E-18  NF=1.005     BF=110      VAF=130.2    IKF=0.0001
+               NR=1.006     BR=0.4822   VAR=4.286    IKR=0.0002472
* ==============LowCurrent=====================================
+ ISE=9.15E-16  NE=2
+ ISC=1E-21     NC=2
* ==============Resistance=====================================
+ RB=732        RBM=441.2                        IRB=7.5E-04
+ RE=15.33      RC=109.1
* ==============Capacitance=====================================
+ 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
* ==============Speed=========================================
+ TF=4.65E-12   XTF=1.25     VTF=1        ITF=0.009532
+ TR=6E-09      FC=0.88      PTF=205
* ==============Noise??=======================================
+ KF=1.000E-16  AF=1
* ==============Temperature===================================
+ XTB=1.4       EG=1.11      XTI=8        TNOM=25        )
* ================================================================

.end



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

*********Actual Silicon DATA**********************
** Temp NPN_1uA Beta
** -55 8.23E-01 67%
** -35 7.87E-01
** -15 7.43E-01 75%
**   5 6.96E-01
**  25 6.53E-01 100%
**  45 6.09E-01
**  65 5.64E-01 125%
**  85 5.19E-01
** 105 4.74E-01
** 125 4.17E-01 160%
** tweek XTI & IS XTB
```

11-16-13-18-04-22
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