NPN_GUM

* MEASURE IS,ISE,NF,NE,RE,IKF,BETA

```
*
*
*                         _____     VC
*              _____|           |____
*             |         C|            \2v /
*        B     |          |            \  /
*        |    |'-         |            /  \
*        |___| ,` npnv    |           /    \
*    VB   |    `.->       |
*    |    |         0     |
*    |   /.7v\            |_____
*    |   \   /               7/7
*    |    \ /
*    |     |
*         7/7
```
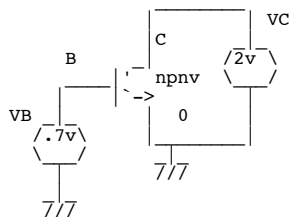
```
VC        C   0   DC   2V
VB        B   0   0V
Q1        C   B   0    NPNV
```
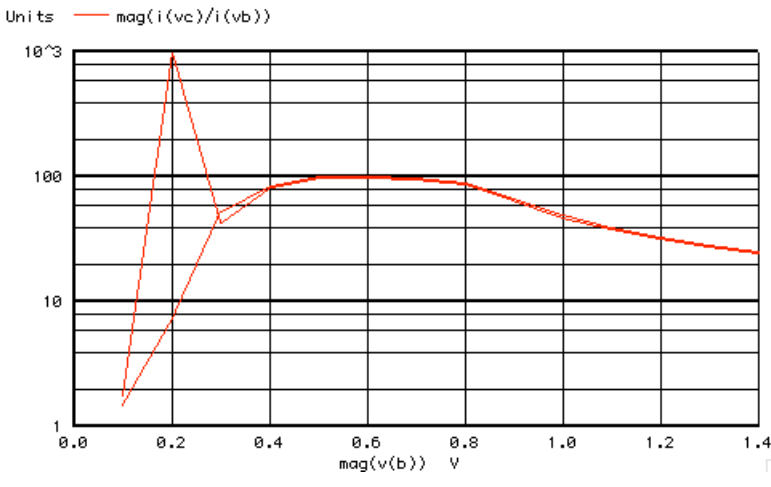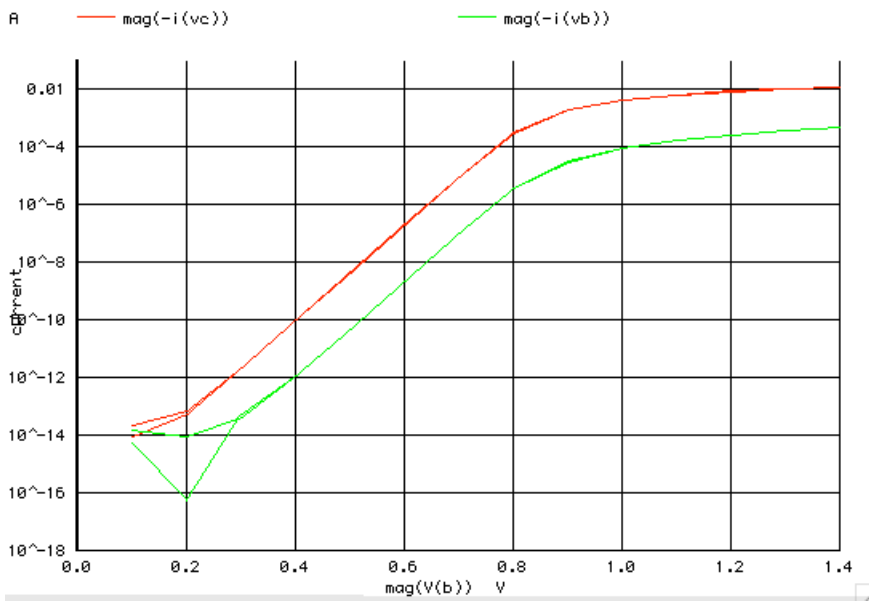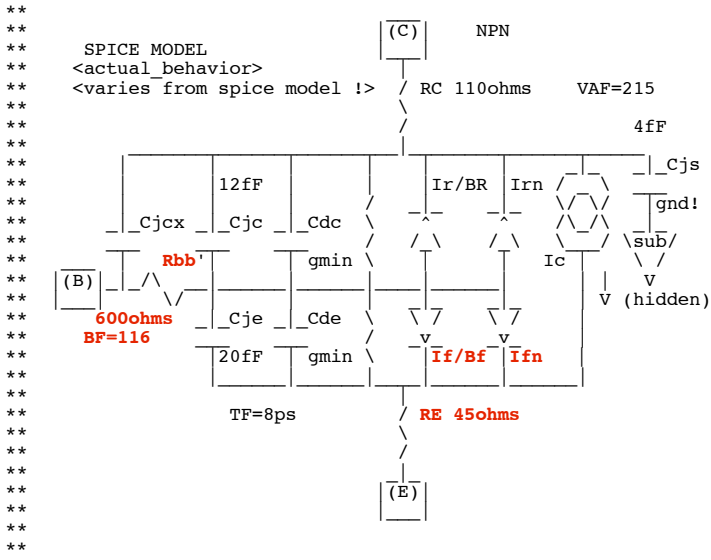
```
.OPTIONS   GMIN=1e-15 METHOD=gear ABSTOL=1e-15
.control
dc vb  .1V 1.4V .1V    vc 2V  5V 3V
plot mag(-i(vc)) mag(-i(vb))  vs mag(V(b))       ylog   title   Gummel
plot mag(-i(vc)) mag(-i(vb))                     ylog   title   Gummel
plot mag(i(vc)/i(vb))         vs mag(vc#branch) loglog title   Beta_vs_IC
plot mag(i(vc)/i(vb))         vs mag(v(b))       ylog   title   Beta_vs_Vb
.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          )

.END
```

```
**
**
**       SPICE MODEL                      |(C)|      NPN
**       <actual_behavior>                |   |
**       <varies from spice model !>     / RC 110ohms     VAF=215
**                                       \
**                                       /
**                                       \                             4fF
**                                       /
**                          _____|_____|_Cjs
**                         |            |                _|_      _|_    _|_
**                         |   12fF     |       Ir/BR   |Irn    /    \   |gnd!
**          _             |            /              _|_     \ / \ /
**          _|_Cjcx   _|_Cjc  _|_Cdc   \            _| |_    /\_/\   \sub/
**          _|        _|      _|       /           /  ^  \  /  ^  \   \_/  \ /
**     ____  Rbb'      |        |         gmin  \          / \   / \    | Ic   \ /
**    |(B)|__/\        |_____|_____        |        |      |          V
**    |   |  \/_____|        |                 |        \__7    \__7    V (hidden)
**     600ohms        _|_Cje   _|_Cde   \         |       _ v      _ v
**     BF=116         _|       _|       /         |      |If/Bf   |Ifn
**                     |20fF     |        gmin  \        ----     ----
**                     |_____|_____/
**                                                       /  RE 45ohms
**            TF=8ps              /                       \
**                               \                        /
**                               /                        \
**                               |(E)|
**                               |   |
**
**
**
**
```

A   ━━━ mag(-i(vc))   ━━━ mag(-i(vb))

Units ━━━ mag(i(vc)/i(vb))

Units ─── mag(i(vc)/i(vb))

10^3

100

10

1

10^-16   10^-14   10^-12   10^-10   10^-8   10^-6   10^-4   0.01

mag(vc#branch)   A