Contents

1 Introduction

This document describes the test cases for HICUM/L2 v2.32. All required files, including model parameters and test cases are available for download on our homepage.

2 Model cards

The following model cards are used for testing. Since these model cards include different part of the HICUM/L2 model, it allows an easy tracking of deviations during testing.

2.1 1D Transistor

```
c10=9.074e-030 qp0=1.008e-013 ich=0 hfe=10.01
hfc=20.04 hjei=3.382 hjci=0.2 ibeis=1.328e-019 mbei=1.027
ireis=1.5e-014 mrei=2 ibeps=0 mbep=1 ireps=0 mrep=2 mcf=1
tbhrec=1e-010 ibcis=4.603e-017 mbci=1.15 ibcxs=0 mbcx=1 ibets=0
abet=40 tunode=1 favl=18.96 qavl=5.092e-014 alfav=-0.0024
alqav=-0.0006284 rbi0=0 rbx=0 fgeo=0.6557 fdqr0=0 fcrbi=0 fqi=1
re=0 rcx=0 itss=0 msf=1 iscs=0 msc=1 tsf=0 rsu=0 csu=0
cjei0=8.869e-015 vdei=0.714 zei=0.2489 ajei=1.65 cjep0=1e-020
vdep=0.9 zep=0.5 ajep=2.5 cjci0=3.58e-015 vdci=0.8201
zci=0.2857 vptci=1.79 cjcx0=1e-020 vdcx=0.7 zcx=0.4
vptcx=100 fbcpar=0 fbepar=1 cjs0=0 vds=0.6 zs=0.5 vpts=100
t0=2.089e-013 dt0h=8e-014 tbvl=8.25e-014 tef0=3.271e-013
gtfe=3.548 thcs=5.001e-012 ahc=0.05 fthc=0.7 rci0=9.523
vlim=0.6999 vces=0.01 vpt=2 tr=0 cbepar=0 cbcpar=0
alqf=0.16667 alit=0.33333 flnqs=0 kf=0 af=2 cfbe=-1 latb=0
latl=0 vgb=0.91 alt0=0.004 kt0=6.588e-005 zetaci=0.58
alvs=0.001 alces=-0.2286 zetarbi=0 zetarbx=0 zetarcx=0
zetare=0 zetacx=1 vge=1.17 vgc=1.17 vgs=1.17
f1vg=-0.00010238 f2vg=0.00043215 zetact=5 zetabet=4.892 alb=0
flsh=0 rth=0 cth=0 zetarth=0 alrth=0 flcomp=2.3
tnom=26.85 dt=0 acbar=1.5 flcono=0 icbar=0.01 vcbar=0.04
zetavgbe=0.7 hf0=40 ahjei=3 rhjei=2 delck=2 zetahjei=-0.5
```

2.2 Internal transistor, including R_{Bi}

```
c10=9.074e-030 qp0=1.008e-013 ich=0 hfe=10.01
hfc=20.04 hjei=3.382 hjci=0.2 ibeis=1.328e-019 mbei=1.027
ireis=1.5e-014 mrei=2 ibeps=0 mbep=1 ireps=0 mrep=2 mcf=1
tbhrec=1e-010 ibcis=4.603e-017 mbci=1.15 ibcxs=0 mbcx=1 ibets=0
abet=40 tunode=1 favl=18.96 qavl=5.092e-014 alfav=-0.0024
alqav=-0.0006284 rbi0=4.444 rbx=0 fgeo=0.7409 fdqr0=0 fcrbi=0
```

```
fqi=1 re=0 rcx=0 itss=0 msf=1 iscs=0 msc=1 tsf=0 rsu=0
csu=0 cjei0=8.869e-015 vdei=0.714 zei=0.2489 ajei=1.65
cjep0=1e-020 vdep=0.9 zep=0.5 ajep=2.5 cjci0=3.58e-015
vdci=0.8201 zci=0.2857 vptci=1.79 cjcx0=1e-020 vdcx=0.7
zcx=0.4 vptcx=100 fbcpar=0 fbepar=1 cjs0=0 vds=0.6 zs=0.5
vpts=100 t0=2.089e-013 dt0h=8e-014 tbvl=8.25e-014
tef0=3.271e-013 gtfe=3.548 thcs=5.001e-012 ahc=0.05 fthc=0.7
rci0=9.523 vlim=0.6999 vces=0.01 vpt=2 tr=0 cbepar=0
cbcpar=0 alqf=0.16667 alit=0.33333 flnqs=0 kf=0 af=2
cfbe=-1 latb=0 latl=0 vgb=0.91 alt0=0.004 kt0=6.588e-005
zetaci=0.58 alvs=0.001 alces=-0.2286 zetarbi=0.3002 zetarbx=0
zetarcx=0 zetare=0 zetacx=1 vge=1.17 vgc=1.17 vgs=1.17
f1vg=-0.00010238 f2vg=0.00043215 zetact=5 zetabet=4.892 alb=0
flsh=0 rth=0 cth=0 zetarth=0 alrth=0 flcomp=2.3
tnom=26.85 dt=0 acbar=1.5 flcono=0 icbar=0.01 vcbar=0.04
zetavgbe=0.7 hf0=40 ahjei=3 rhjei=2 delck=2 zetahjei=-0.5
```

2.3 Complete transistor

```
c10=9.074e-030 qp0=1.008e-013 ich=0 hfe=10.01
hfc=20.04 hjei=3.382 hjci=0.2 ibeis=1.328e-019 mbei=1.027
ireis=1.5e-014 mrei=2 ibeps=1.26e-019 mbep=1.042 ireps=1.8e-014
mrep=1.8 mcf=1 tbhrec=1e-010 ibcis=4.603e-017 mbci=1.15
ibcxs=0 mbcx=1 ibets=0.02035 abet=24 tunode=1 favl=18.96
qavl=5.092e-014 alfav=-0.0024 alqav=-0.0006284 rbi0=4.444
rbx=2.568 fgeo=0.7409 fdqr0=0 fcrbi=0 fqi=1 re=1.511
rcx=2.483 itss=0 msf=1 iscs=0 msc=1 tsf=0 rsu=0 csu=0
cjei0=8.869e-015 vdei=0.714 zei=0.2489 ajei=1.65 cjep0=2.178e-015
vdep=0.8501 zep=0.2632 ajep=1.6 cjci0=3.58e-015 vdci=0.8201
zci=0.2857 vptci=1.79 cjcx0=6.299e-015 vdcx=0.8201
zcx=0.2863 vptcx=1.977 fbcpar=0.3 fbepar=1 cjs0=2.6e-014
vds=0.9997 zs=0.4295 vpts=100 t0=2.089e-013 dt0h=8e-014
tbvl=8.25e-014 tef0=3.271e-013 gtfe=3.548 thcs=5.001e-012
ahc=0.05 fthc=0.7 rci0=9.523 vlim=0.6999 vces=0.01 vpt=2
tr=0 cbepar=2.609e-014 cbcpar=1.6451e-014 alqf=0.16667
alit=0.33333 flnqs=0 kf=0 af=2 cfbe=-1 latb=0 latl=0 vgb=0.91
alt0=0.004 kt0=6.588e-005 zetaci=0.58 alvs=0.001
alces=-0.2286 zetarbi=0.3002 zetarbx=0.06011 zetarcx=-0.02768
zetare=-0.9605 zetacx=0 vge=1.17 vgc=1.17 vgs=1.17
f1vg=-0.00010238 f2vg=0.00043215 zetact=5 zetabet=4.892 alb=0
flsh=0 rth=0 cth=0 zetarth=0 alrth=0 flcomp=2.3
tnom=26.85 dt=0 acbar=1.5 flcono=0 icbar=0.01 vcbar=0.04
zetavgbe=0.7 hf0=40 ahjei=3 rhjei=2 delck=2 zetahjei=-0.5
```

2.4 Complete transistor including self-heating

```
c10=9.074e-030 qp0=1.008e-013 ich=0 hfe=10.01
hfc=20.04 hjei=3.382 hjci=0.2 ibeis=1.328e-019 mbei=1.027
ireis=1.5e-014 mrei=2 ibeps=1.26e-019 mbep=1.042 ireps=1.8e-014
mrep=1.8 mcf=1 tbhrec=1e-010 ibcis=4.603e-017 mbci=1.15
ibcxs=0 mbcx=1 ibets=0.02035 abet=24 tunode=1 favl=18.96
qavl=5.092e-014 alfav=-0.0024 alqav=-0.0006284 rbi0=4.444
rbx=2.568 fgeo=0.7409 fdqr0=0 fcrbi=0 fqi=1 re=1.511
rcx=2.483 itss=0 msf=1 iscs=0 msc=1 tsf=0 rsu=0 csu=0
cjei0=8.869e-015 vdei=0.714 zei=0.2489 ajei=1.65 cjep0=2.178e-015
vdep=0.8501 zep=0.2632 ajep=1.6 cjci0=3.58e-015 vdci=0.8201
zci=0.2857 vptci=1.79 cjcx0=6.299e-015 vdcx=0.8201
zcx=0.2863 vptcx=1.977 fbcpar=0.3 fbepar=1 cjs0=2.6e-014
vds=0.9997 zs=0.4295 vpts=100 t0=2.089e-013 dt0h=8e-014
tbvl=8.25e-014 tef0=3.271e-013 gtfe=3.548 thcs=5.001e-012
ahc=0.05 fthc=0.7 rci0=9.523 vlim=0.6999 vces=0.01 vpt=2
tr=0 cbepar=2.609e-014 cbcpar=1.6451e-014 alqf=0.16667
alit=0.33333 flnqs=0 kf=0 af=2 cfbe=-1 latb=0 latl=0 vgb=0.91
alt0=0.004 kt0=6.588e-005 zetaci=0.58 alvs=0.001
alces=-0.2286 zetarbi=0.3002 zetarbx=0.06011 zetarcx=-0.02768
zetare=-0.9605 zetacx=0 vge=1.17 vgc=1.17 vgs=1.17
f1vg=-0.00010238 f2vg=0.00043215 zetact=5 zetabet=4.892 alb=0
flsh=1 rth=1113.3957 cth=6.841e-012 zetarth=0
alrth=0.002 flcomp=2.3 tnom=26.85 dt=0 acbar=1.5 flcono=0
icbar=0.01 vcbar=0.04 zetavgbe=0.7 hf0=40 ahjei=3 rhjei=2
delck=2 zetahjei=-0.5
```

2.5 Complete transistor including substrate-transistor

```
c10=9.074e-030 qp0=1.008e-013 ich=0 hfe=10.01
hfc=20.04 hjei=3.382 hjci=0.2 ibeis=1.328e-019 mbei=1.027
ireis=1.5e-014 mrei=2 ibeps=1.26e-019 mbep=1.042 ireps=1.8e-014
mrep=1.8 mcf=1 tbhrec=1e-010 ibcis=4.603e-017 mbci=1.15
ibcxs=0 mbcx=1 ibets=0.02035 abet=24 tunode=1 favl=18.96
qavl=5.092e-014 alfav=-0.0024 alqav=-0.0006284 rbi0=4.444
rbx=2.568 fgeo=0.7409 fdqr0=0 fcrbi=0 fqi=1 re=1.511
rcx=2.483 itss=1.143e-019 msf=1.056 iscs=4.6011e-015
msc=1.018 tsf=0 rsu=0 csu=0 cjei0=8.869e-015 vdei=0.714
zei=0.2489 ajei=1.65 cjep0=2.178e-015 vdep=0.8501 zep=0.2632
ajep=1.6 cjci0=3.58e-015 vdci=0.8201 zci=0.2857 vptci=1.79
cjcx0=6.299e-015 vdcx=0.8201 zcx=0.2863 vptcx=1.977 fbcpar=0.3
fbepar=1 cjs0=2.6e-014 vds=0.9997 zs=0.4295 vpts=100
```

t0=2.089e-013 dt0h=8e-014 tbvl=8.25e-014 tef0=3.271e-013
gtfe=3.548 thcs=5.001e-012 ahc=0.05 fthc=0.7 rci0=9.523
vlim=0.6999 vces=0.01 vpt=2 tr=0 cbepar=2.609e-014
cbcpar=1.6451e-014 alqf=0.16667 alit=0.33333 flnqs=0 kf=0 af=2
cfbe=-1 latb=0 latl=0 vgb=0.91 alt0=0.004 kt0=6.588e-005
zetaci=0.58 alvs=0.001 alces=-0.2286 zetarbi=0.3002
zetarbx=0.06011 zetarcx=-0.02768 zetare=-0.9605 zetacx=0 vge=1.17
vgc=1.17 vgs=1.049 f1vg=-0.00010238 f2vg=0.00043215
zetact=5 zetabet=4.892 alb=0 flsh=1 rth=1113.3957
cth=6.841e-012 zetarth=0 alrth=0.002 flcomp=2.3 tnom=26.85 dt=0
acbar=1.5 flcono=0 icbar=0.01 vcbar=0.04 zetavgbe=0.7
hf0=40 ahjei=3 rhjei=2 delck=2 zetahjei=-0.5

2.6 Complete transistor including substrate-transistor and substrate network

c10=9.074e-030 qp0=1.008e-013 ich=0 hfe=10.01
hfc=20.04 hjei=3.382 hjci=0.2 ibeis=1.328e-019 mbei=1.027
ireis=1.5e-014 mrei=2 ibeps=1.26e-019 mbep=1.042 ireps=1.8e-014
mrep=1.8 mcf=1 tbhrec=1e-010 ibcis=4.603e-017 mbci=1.15
ibcxs=0 mbcx=1 ibets=0.02035 abet=24 tunode=1 favl=18.96
qavl=5.092e-014 alfav=-0.0024 alqav=-0.0006284 rbi0=4.444
rbx=2.568 fgeo=0.7409 fdqr0=0 fcrbi=0 fqi=1 re=1.511
rcx=2.483 itss=1.143e-019 msf=1.056 iscs=4.6011e-015
msc=1.018 tsf=0 rsu=500 csu=6.4e-014 cjei0=8.869e-015
vdei=0.714 zei=0.2489 ajei=1.65 cjep0=2.178e-015 vdep=0.8501
zep=0.2632 ajep=1.6 cjci0=3.58e-015 vdci=0.8201 zci=0.2857
vptci=1.79 cjcx0=6.299e-015 vdcx=0.8201 zcx=0.2863
vptcx=1.977 fbcpar=0.3 fbepar=1 cjs0=2.6e-014 vds=0.9997
zs=0.4295 vpts=100 t0=2.089e-013 dt0h=8e-014 tbvl=8.25e-014
tef0=3.271e-013 gtfe=3.548 thcs=5.001e-012 ahc=0.05 fthc=0.7
rci0=9.523 vlim=0.6999 vces=0.01 vpt=2 tr=0
cbepar=2.609e-014 cbcpar=1.6451e-014 alqf=0.16667 alit=0.33333
flnqs=0 kf=0 af=2 cfbe=-1 latb=0 latl=0 vgb=0.91
alt0=0.004 kt0=6.588e-005 zetaci=0.58 alvs=0.001
alces=-0.2286 zetarbi=0.3002 zetarbx=0.06011 zetarcx=-0.02768
zetare=-0.9605 zetacx=0 vge=1.17 vgc=1.17 vgs=1.049
f1vg=-0.00010238 f2vg=0.00043215 zetact=5 zetabet=4.892 alb=0
flsh=1 rth=1113.3957 cth=6.841e-012 zetarth=0
alrth=0.002 flcomp=2.3 tnom=26.85 dt=0 acbar=1.5 flcono=0
icbar=0.01 vcbar=0.04 zetavgbe=0.7 hf0=40 ahjei=3 rhjei=2
delck=2 zetahjei=-0.5

2.7 1D Transistor including vertical NQS-effects

```
c10=9.074e-030 qp0=1.008e-013 ich=0 hfe=10.01
hfc=20.04 hjei=3.382 hjci=0.2 ibeis=1.328e-019 mbei=1.027
ireis=1.5e-014 mrei=2 ibeps=0 mbep=1 ireps=0 mrep=2 mcf=1
tbhrec=1e-010 ibcis=4.603e-017 mbci=1.15 ibcxs=0 mbcx=1 ibets=0
abet=40 tunode=1 favl=18.96 qavl=5.092e-014 alfav=-0.0024
alqav=-0.0006284 rbi0=0 rbx=0 fgeo=0.6557 fdqr0=0 fcrbi=0 fqi=1
re=0 rcx=0 itss=0 msf=1 iscs=0 msc=1 tsf=0 rsu=0 csu=0
cjei0=8.869e-015 vdei=0.714 zei=0.2489 ajei=1.65 cjep0=1e-020
vdep=0.9 zep=0.5 ajep=2.5 cjci0=3.58e-015 vdci=0.8201
zci=0.2857 vptci=1.79 cjcx0=1e-020 vdcx=0.7 zcx=0.4
vptcx=100 fbcpar=0 fbepar=1 cjs0=0 vds=0.6 zs=0.5 vpts=100
t0=2.089e-013 dt0h=8e-014 tbvl=8.25e-014 tef0=3.271e-013
gtfe=3.548 thcs=5.001e-012 ahc=0.05 fthc=0.7 rci0=9.523
vlim=0.6999 vces=0.01 vpt=2 tr=0 cbepar=0 cbcpar=0 alqf=0.167
alit=0.33 flnqs=1 kf=0 af=2 cfbe=-1 latb=0 latl=0 vgb=0.91
alt0=0.004 kt0=6.588e-005 zetaci=0.58 alvs=0.001
alces=-0.2286 zetarbi=0 zetarbx=0 zetarcx=0 zetare=0 zetacx=1
vge=1.17 vgc=1.17 vgs=1.17 f1vg=-0.00010238
f2vg=0.00043215 zetact=5 zetabet=4.892 alb=0 flsh=0 rth=0 cth=0
zetarth=0 alrth=0 flcomp=2.3 tnom=26.85 dt=0 acbar=1.5
flcono=0 icbar=0.01 vcbar=0.04 zetavgbe=0.7 hf0=40 ahjei=3
rhjei=2 delck=2 zetahjei=-0.5
```

2.8 Internal transistor including lateral NQS-effect

```
c10=9.074e-030 qp0=1.008e-013 ich=0 hfe=10.01
hfc=20.04 hjei=3.382 hjci=0.2 ibeis=1.328e-019 mbei=1.027
ireis=1.5e-014 mrei=2 ibeps=0 mbep=1 ireps=0 mrep=2 mcf=1
tbhrec=1e-010 ibcis=4.603e-017 mbci=1.15 ibcxs=0 mbcx=1 ibets=0
abet=40 tunode=1 favl=18.96 qavl=5.092e-014 alfav=-0.0024
alqav=-0.0006284 rbi0=4.444 rbx=0 fgeo=0.7409 fdqr0=0 fcrbi=0.6
fqi=1 re=0 rcx=0 itss=0 msf=1 iscs=0 msc=1 tsf=0 rsu=0
csu=0 cjei0=8.869e-015 vdei=0.714 zei=0.2489 ajei=1.65
cjep0=1e-020 vdep=0.9 zep=0.5 ajep=2.5 cjci0=3.58e-015
vdci=0.8201 zci=0.2857 vptci=1.79 cjcx0=1e-020 vdcx=0.7
zcx=0.4 vptcx=100 fbcpar=0 fbepar=1 cjs0=0 vds=0.6 zs=0.5
vpts=100 t0=2.089e-013 dt0h=8e-014 tbvl=8.25e-014
tef0=3.271e-013 gtfe=3.548 thcs=5.001e-012 ahc=0.05 fthc=0.7
rci0=9.523 vlim=0.6999 vces=0.01 vpt=2 tr=0 cbepar=0
cbcpar=0 alqf=0.16667 alit=0.33333 flnqs=0 kf=0 af=2
cfbe=-1 latb=0 latl=0 vgb=0.91 alt0=0.004 kt0=6.588e-005
```

```
zetaci=0.58 alvs=0.001 alces=-0.2286 zetarbi=0.3002 zetarbx=0
zetarcx=0 zetare=0 zetacx=1 vge=1.17 vgc=1.17 vgs=1.17
f1vg=-0.00010238 f2vg=0.00043215 zetact=5 zetabet=4.892 alb=0
flsh=0 rth=0 cth=0 zetarth=0 alrth=0 flcomp=2.3
tnom=26.85 dt=0 acbar=1.5 flcono=0 icbar=0.01 vcbar=0.04
zetavgbe=0.7 hf0=40 ahjei=3 rhjei=2 delck=2 zetahjei=-0.5
```

2.9 Complete transistor with correlated noise modeling

```
c10=9.074e-030 qp0=1.008e-013 ich=0 hfe=10.01
hfc=20.04 hjei=3.382 hjci=0.2 ibeis=1.328e-019 mbei=1.027
ireis=1.5e-014 mrei=2 ibeps=1.26e-019 mbep=1.042 ireps=1.8e-014
mrep=1.8 mcf=1 tbhrec=1e-010 ibcis=4.603e-017 mbci=1.15
ibcxs=0 mbcx=1 ibets=0.02035 abet=24 tunode=1 favl=18.96
qavl=5.092e-014 alfav=-0.0024 alqav=-0.0006284 rbi0=4.444
rbx=2.568 fgeo=0.7409 fdqr0=0 fcrbi=0 fqi=1 re=1.511
rcx=2.483 itss=1.143e-019 msf=1.056 iscs=4.6011e-015
msc=1.018 tsf=0 rsu=500 csu=6.4e-014 cjei0=8.869e-015
vdei=0.714 zei=0.2489 ajei=1.65 cjep0=2.178e-015 vdep=0.8501
zep=0.2632 ajep=1.6 cjci0=3.58e-015 vdci=0.8201 zci=0.2857
vptci=1.79 cjcx0=6.299e-015 vdcx=0.8201 zcx=0.2863
vptcx=1.977 fbcpar=0.3 fbepar=1 cjs0=2.6e-014 vds=0.9997
zs=0.4295 vpts=100 t0=2.089e-013 dt0h=8e-014 tbvl=8.25e-014
tef0=3.271e-013 gtfe=3.548 thcs=5.001e-012 ahc=0.05 fthc=0.7
rci0=9.523 vlim=0.6999 vces=0.01 vpt=2 tr=0
cbepar=2.609e-014 cbcpar=1.6451e-014 alqf=0.16667 alit=0.33333
flnqs=0 kf=0 af=2 cfbe=-1 latb=0 latl=0 vgb=0.91
alt0=0.004 kt0=6.588e-005 zetaci=0.58 alvs=0.001
alces=-0.2286 zetarbi=0.3002 zetarbx=0.06011 zetarcx=-0.02768
zetare=-0.9605 zetacx=0 vge=1.17 vgc=1.17 vgs=1.049
f1vg=-0.00010238 f2vg=0.00043215 zetact=5 zetabet=4.892 alb=0
flsh=1 rth=1113.3957 cth=6.841e-012 zetarth=0
alrth=0.002 flcomp=2.3 tnom=26.85 dt=0 acbar=1.5 flcono=1
icbar=0.01 vcbar=0.04 zetavgbe=0.7 hf0=40 ahjei=3 rhjei=2
delck=2 zetahjei=-0.5
```

3 Test setups

In case of AC tests, a test case `*_dc` and `*_ac` with the same bias conditions exists. The case `*_dc` gives the DC-operating points and `*_ac` the corresponding small signal quantities. This allows plotting of results if desired.

3.1 Forward gummel

```
Name: fgum_dc
Parameter sweep: V(base), Start: 0.300000, Stop, 1.050000, Step: 0.020000
Parameter list: V(coll), Values: 0.5;1;1.5
Constant bias: V(emit)=0, V(subs)=0
```

3.2 Transit and maximum osciallation frequency

```
Name: fgum_ac
Parameter sweep: V(base), Start: 0.750000, Stop, 1.050000, Step: 0.010000
Parameter list: V(coll), Values: 0.5;1;1.5
Constant bias: V(emit)=0, V(subs)=0
Frequency: Start: 1.000000e+010, Stop: 2.000000e+010, Points per dec: 10
```

3.3 Output curves at forced V_{BE}

```
Name: fout
Parameter sweep: V(coll), Start: 0.000000, Stop, 2.000000, Step: 0.050000
Parameter list: V(base), Values: 0.6;0.65;0.7;0.75;0.8;0.85;0.9
Constant bias: V(emit)=0, V(subs)=0
```

3.4 Base-emitter capacitance

```
Name: CBE
Parameter sweep: V(base), Start: -1.000000, Stop, 0.700000, Step: 0.050000
Constant bias: V(emit)=0, V(subs)=0, V(coll)=1.000000
Frequency: Start: 1.000000e+009, Stop: 1.000000e+010, Points per dec: 10
```

3.5 Base-collector and substrate-collector capacitance

```
Name: CBC_CCS
Parameter sweep: V(coll), Start: 1.000000, Stop, -0.700000, Step: -0.050000
Constant bias: V(emit)=0, V(subs)=0, V(base)=1.000000
Frequency: Start: 1.000000e+009, Stop: 1.000000e+010, Points per dec: 10
```

3.6 Base-emitter tunneling current

```
Name: vce_0
Parameter sweep: V(base), Start: -1.000000, Stop, 1.000000, Step: 0.050000
Constant bias: V(emit)=0, V(subs)=0, V(coll)=1.000000
```

3.7 Reverse gummel

```
Name: vbe_0
Parameter sweep: V(coll), Start: -1.000000, Stop, 1.000000, Step: 0.050000
Constant bias: V(emit)=0, V(subs)=0, V(base)=1.000000
```

3.8 Small signal parameters

```
Name: ypara
Parameter sweep: V(base), Start: 0.800000, Stop, 0.950000, Step: 0.050000
Constant bias: V(emit)=0, V(subs)=0, V(coll)=1.000000
Frequency: Start: 1.000000e+008, Stop: 1.000000e+011, Points per dec: 5
```

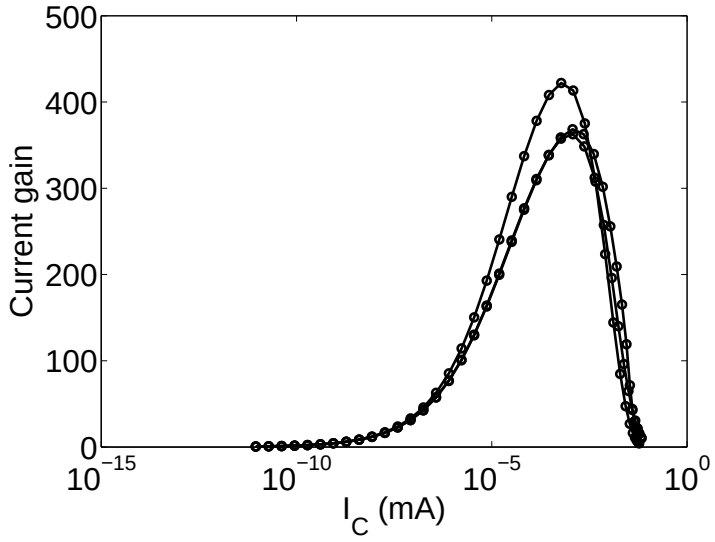
3.9 Noise

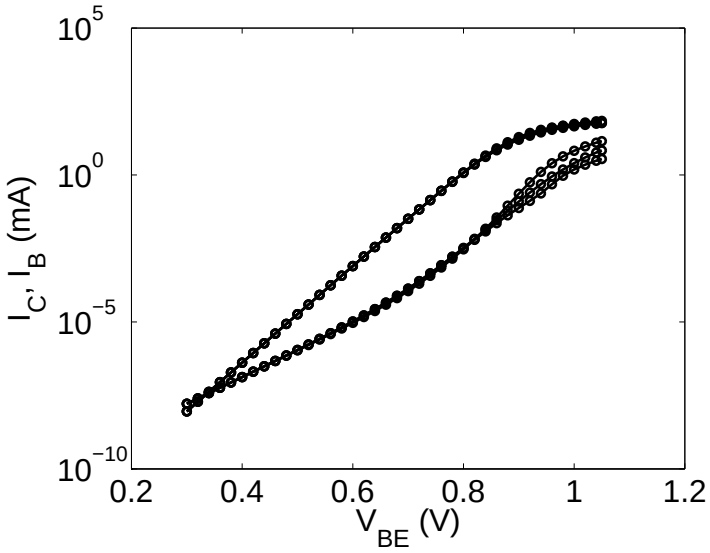
```
Name: noise
Parameter sweep: V(base), Start: 0.700000, Stop, 1.100000, Step: 0.100000
Constant bias: V(emit)=0, V(subs)=0, V(coll)=1.000000
Frequency: Start: 1.000000e+003, Stop: 1.000000e+011, Points per dec: 2
```

4 Model results

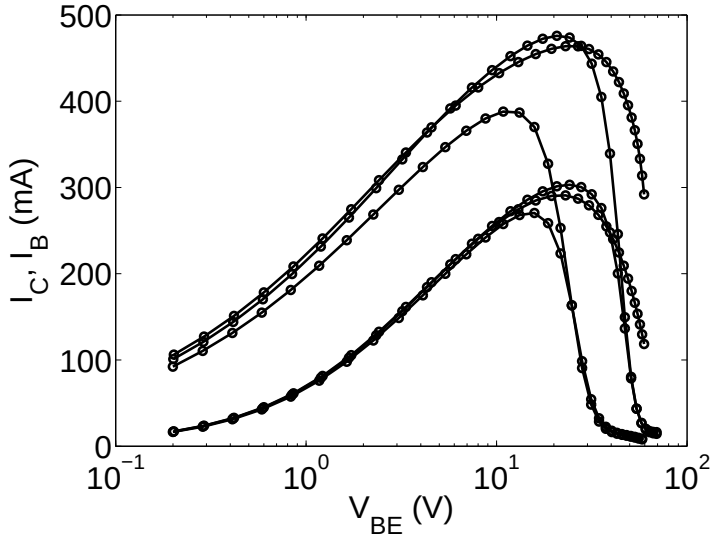
Results here are shown for the complete transistors including thermal and substrate related effects.

4.1 Forward gummel

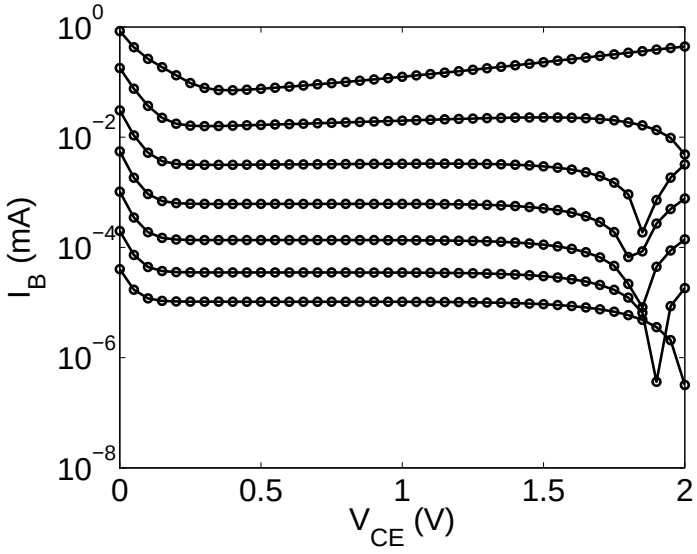


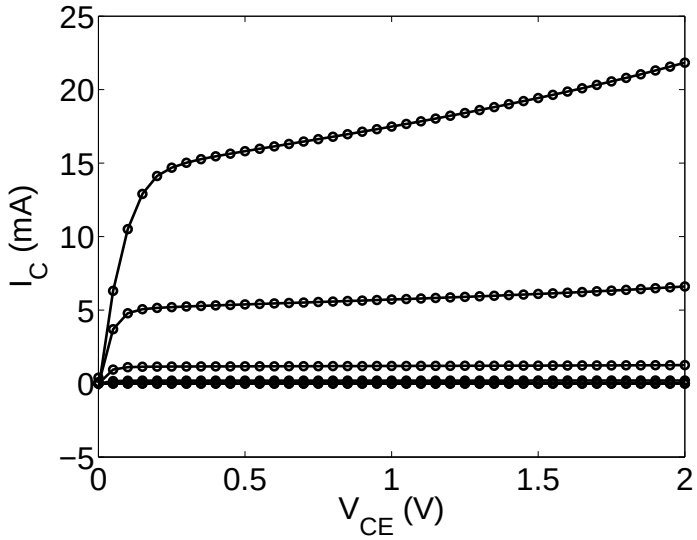

10^5
10^0
10^{-5}
10^{-10}
I_C, I_B (mA)
0.2
0.4
0.6
0.8
1
1.2
V_{BE} (V)

4.2 Transit and maximum osciallation frequency

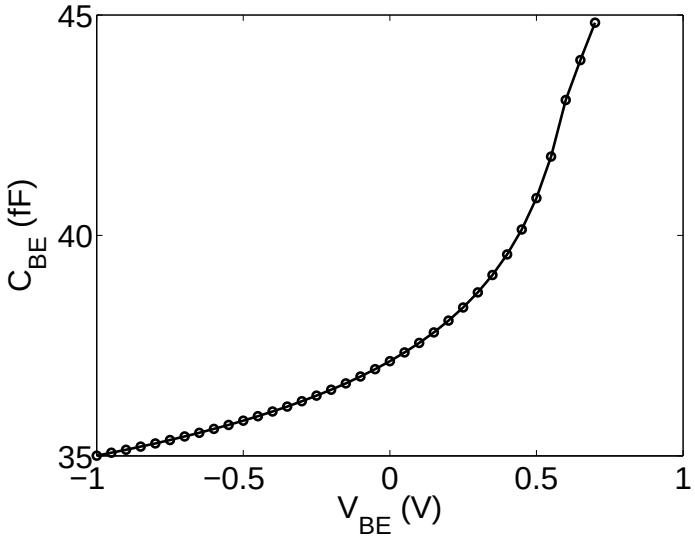


4.3 Output curves at forced V_{BE}

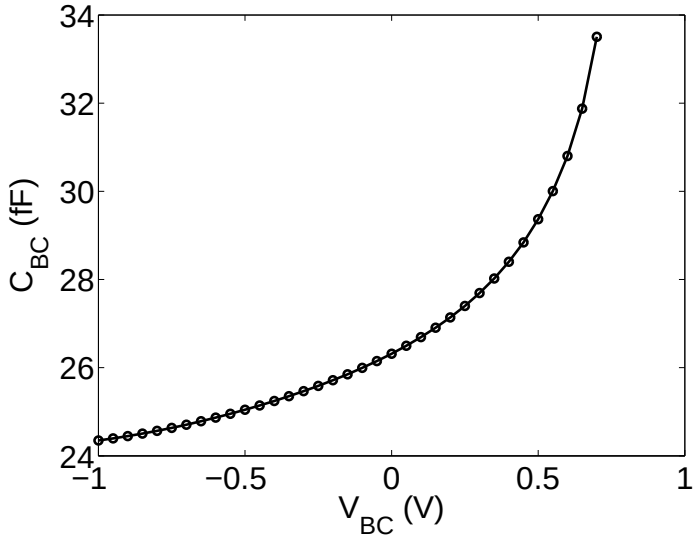


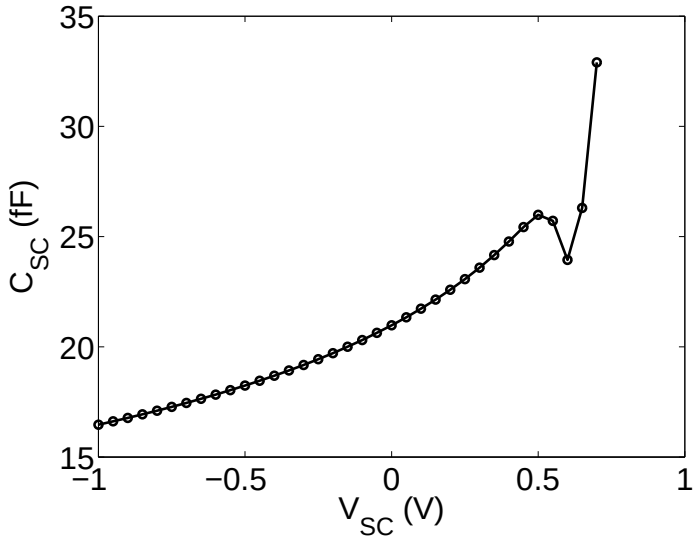


4.4 Base-emitter capacitance

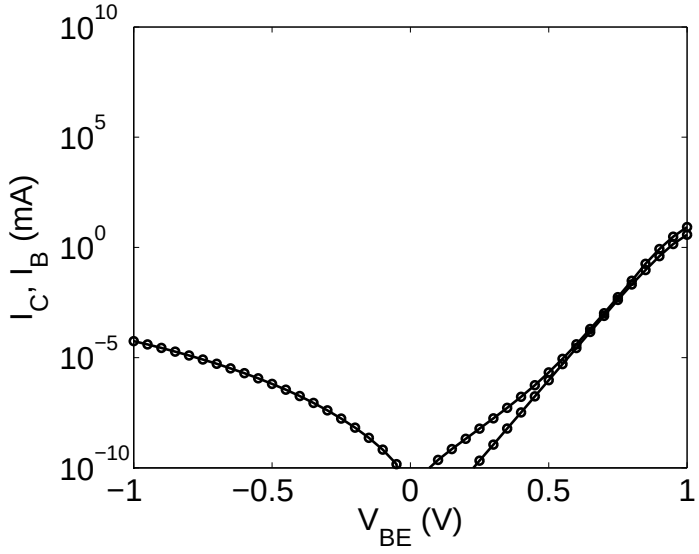


4.5 Base-collector and substrate-collector capacitance

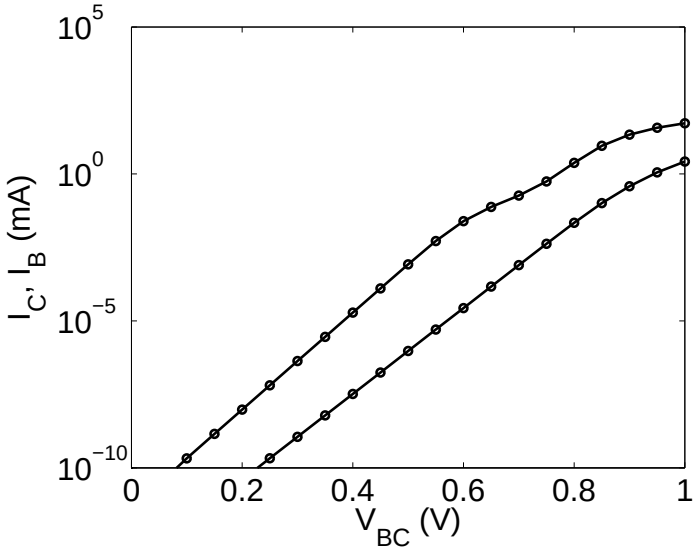




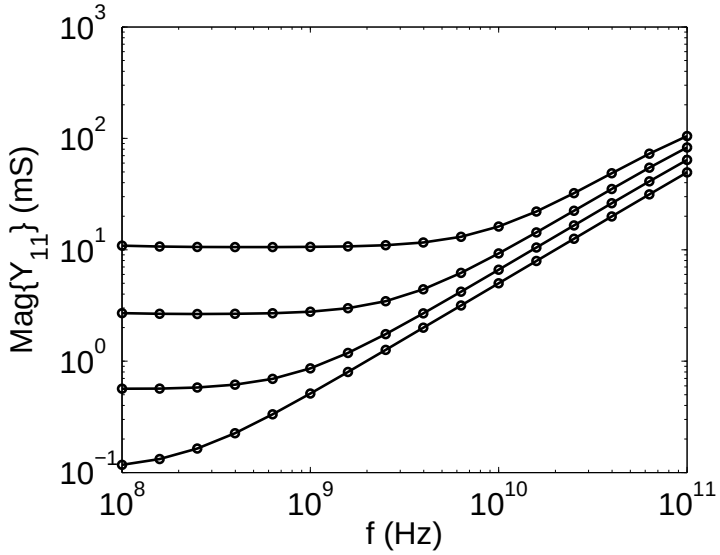
4.6 Base-emitter tunneling current

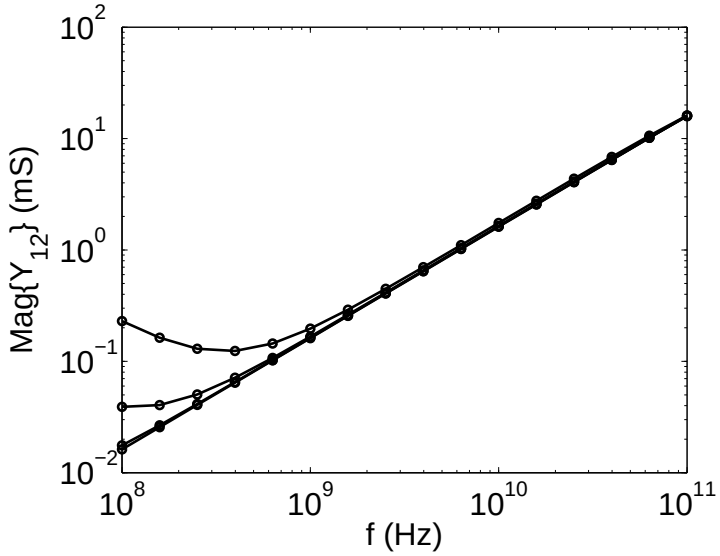


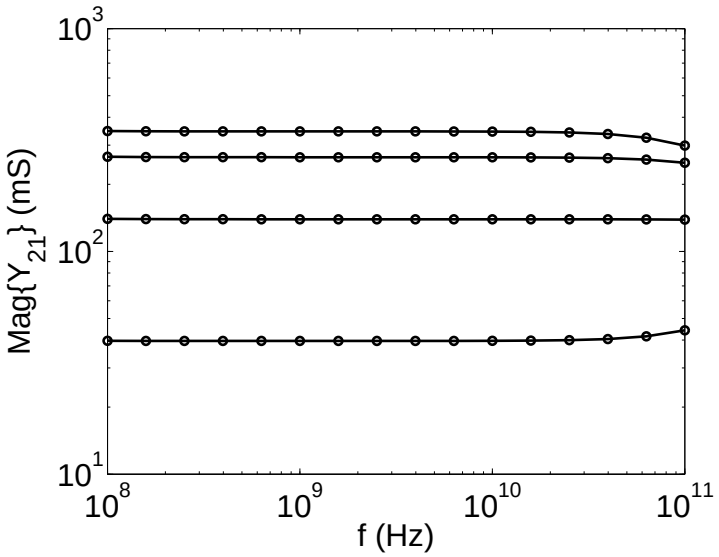
4.7 Reverse gummel

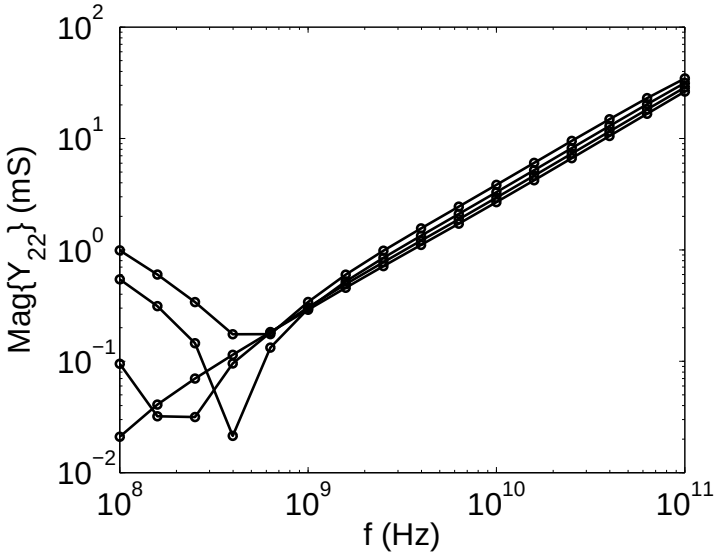


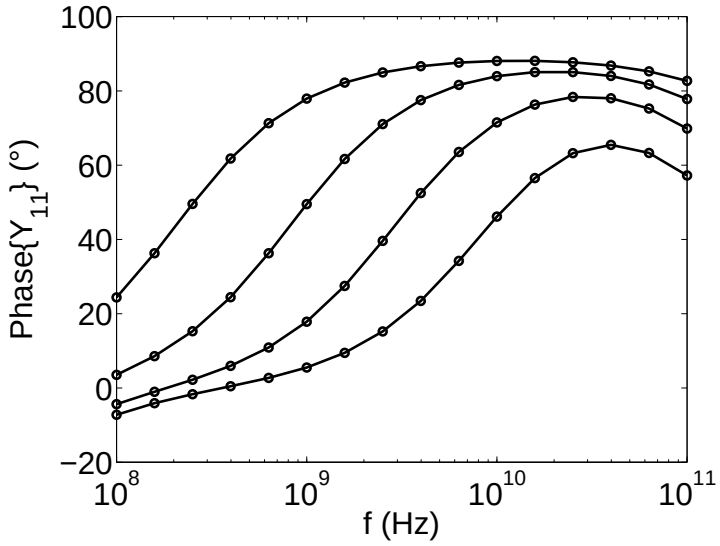
4.8 Small signal parameters

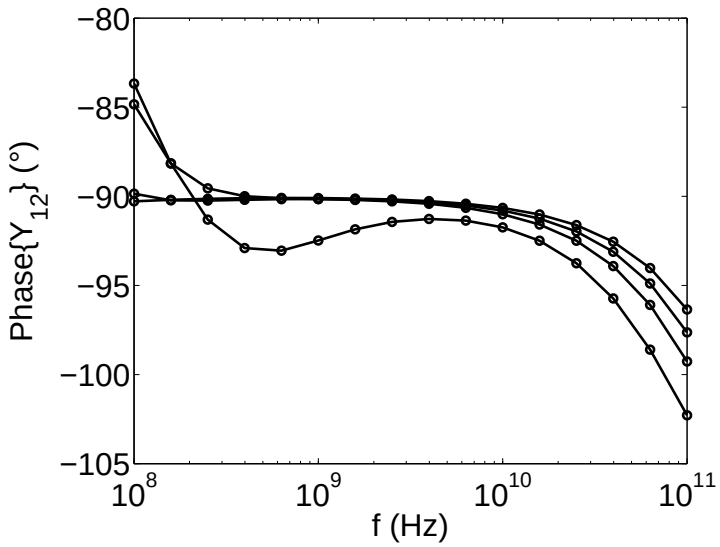


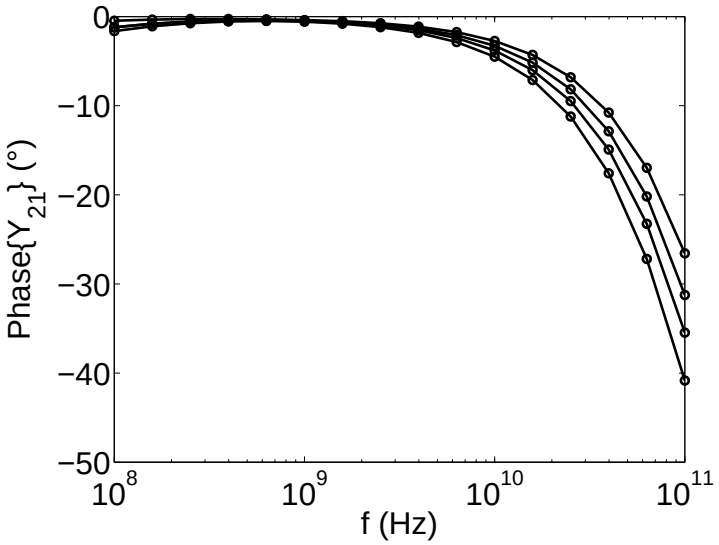


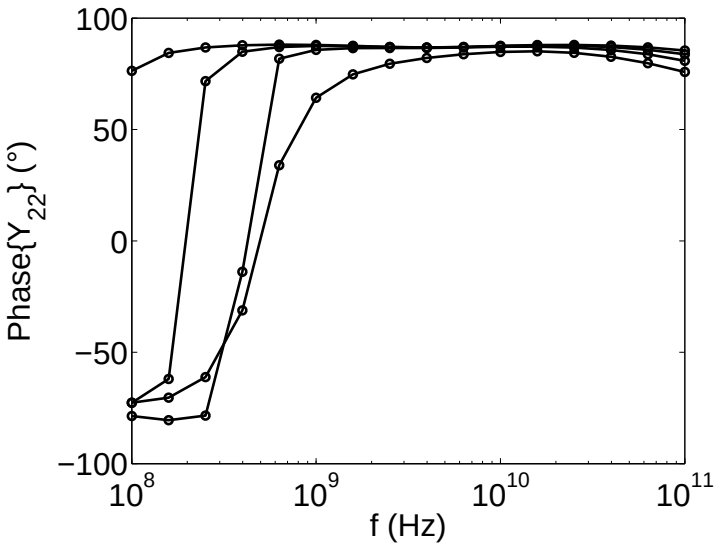

10^3
10^2
10^1
Mag{Y_{21}} (mS)
10^8
10^9
10^{10}
10^{11}
f (Hz)


10^2
10^1
10^0
10^{-1}
10^{-2}
Mag{Y_{22}} (mS)
10^8
10^9
10^{10}
10^{11}
f (Hz)


100
80
60
40
20
0
−20
Phase{Y11} (°)
10^8
10^9
10^10
10^11
f (Hz)


−80
−85
−90
−95
−100
−105
Phase{Y12} (°)
10^8
10^9
10^10
10^11
f (Hz)


0
−10
−20
−30
−40
−50
Phase{Y21} (°)
10^8
10^9
10^10
10^11
f (Hz)


100
50
0
−50
−100
Phase{Y22} (°)
10^8
10^9
10^10
10^11
f (Hz)