射频特训班

凡亿教育®
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第二讲 基于SnP文件模型的射频电路开发

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SNP模型的概念

SnP文件仿真

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SnP是什么?

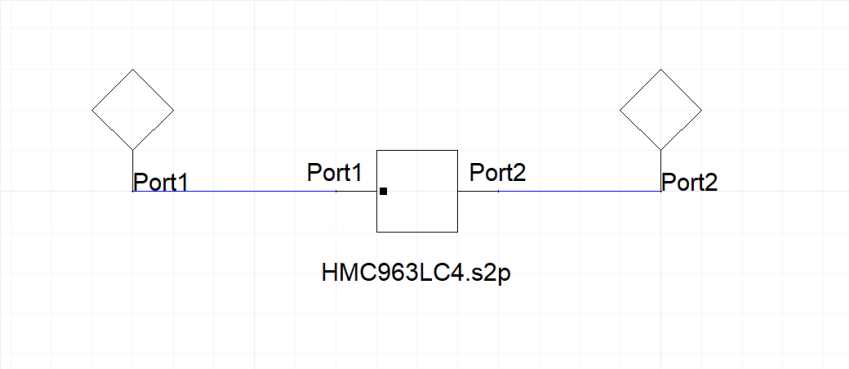
SnP文件模型

线性S参数文件(或Z参数，Y参数，H参数，G参数)，n表示端口数。当n＝2时可以包含噪声参数；

生成.SnP文件有三种方式，如：

[1] 手动编辑文本文件；　[2] 基于HFSS、ADS、AWR等仿真数据导出；　[3] 基于网络分析仪测试数据导出。

Freq	S:T1	Y:T1	Z:T1	Port Zo	Gamma	Lambda	Epsilon
2.1GHz	T1 (0.95802, 132)	(0.044963, -86.7)	(22.24, 86.7)	(50, 0)	(0, 0)	0	0
2.105GHz	T1 (0.95682, 132)	(0.044521, -86.6)	(22.461, 86.6)	(50, 0)	(0, 0)	0	0
2.11GHz	T1 (0.95557, 131)	(0.044078, -86.5)	(22.687, 86.5)	(50, 0)	(0, 0)	0	0
2.115GHz	T1 (0.95427, 131)	(0.043634, -86.5)	(22.918, 86.5)	(50, 0)	(0, 0)	0	0
2.12GHz	T1 (0.95292, 130)	(0.043188, -86.4)	(23.154, 86.4)	(50, 0)	(0, 0)	0	0
2.125GHz	T1 (0.95151, 130)	(0.042742, -86.3)	(23.396, 86.3)	(50, 0)	(0, 0)	0	0
2.13GHz	T1 (0.95003, 129)	(0.042294, -86.2)	(23.644, 86.2)	(50, 0)	(0, 0)	0	0
2.135GHz	T1 (0.9485, 129)	(0.041845, -86.1)	(23.898, 86.1)	(50, 0)	(0, 0)	0	0
2.14GHz	T1 (0.9469, 128)	(0.041395, -86)	(24.158, 86)	(50, 0)	(0, 0)	0	0
2.145GHz	T1 (0.94522, 128)	(0.040943, -85.9)	(24.424, 85.9)	(50, 0)	(0, 0)	0	0
2.15GHz	T1 (0.94347, 127)	(0.040489, -85.8)	(24.698, 85.8)	(50, 0)	(0, 0)	0	0
2.155GHz	T1 (0.94165, 127)	(0.040033, -85.7)	(24.979, 85.7)	(50, 0)	(0, 0)	0	0
2.16GHz	T1 (0.93973, 126)	(0.039576, -85.6)	(25.268, 85.6)	(50, 0)	(0, 0)	0	0
2.165GHz	T1 (0.93774, 126)	(0.039116, -85.5)	(25.565, 85.5)	(50, 0)	(0, 0)	0	0
2.17GHz	T1 (0.93564, 125)	(0.038655, -85.3)	(25.87, 85.3)	(50, 0)	(0, 0)	0	0
2.175GHz	T1 (0.93345, 125)	(0.038191, -85.2)	(26.184, 85.2)	(50, 0)	(0, 0)	0	0
2.18GHz	T1 (0.93115, 124)	(0.037725, -85.1)	(26.508, 85.1)	(50, 0)	(0, 0)	0	0
2.185GHz	T1 (0.92874, 124)	(0.037256, -84.9)	(26.841, 84.9)	(50, 0)	(0, 0)	0	0



SnP文件仿真

SnP是什么?

SnP文件模型

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```
# GHz S MA R 50

0.1 0.98794718  9.8267148 0.00023874309 -178.55485  0.00035914568 131.26725 0.98707996  9.2736603
0.2 0.98854632  3.3217511 0.00021992971 -27.549117  5.927042e-005 87.238283 0.9866224 2.0872869
0.3 0.98795583  -3.2260222  0.00011545203 48.88761  4.3220322e-005  -28.98499 0.98621924  -5.1473711
0.4 0.98763708  -9.6814006  0.0001508507  -171.26907  0.0001688405  57.869634 0.98214974  -12.083223
0.5 0.98674686  -12.077274  0.00015477706 137.02836 0.00015136094 92.691164 0.9844888 -15.166084
0.6 0.98595994  -14.4534  0.00015882295 82.487826 0.00012992464 31.554826 0.98334219  -18.270348
0.7 0.98494563  -16.793538  0.00010789751 88.104951 0.00011709391 100.83135 0.98172897  -21.403406
0.8 0.98381871  -19.129132  0.00012630419 73.07317  0.00012976101 81.96227  0.97889525  -24.64127
0.9 0.98312842  -21.397981  0.00013492898 55.93472  0.00011963333 55.25652  0.97543902  -28.029108
1 0.98301866  -23.672657  0.0001803212  56.943816 0.00014944263 55.266016 0.96794317  -31.711465
1.1 0.98232918  -25.885143  0.00019114162 44.822188 0.00014805095 28.501288 0.95228842  -35.872862
1.2 0.9817385 -28.172273  0.0004634066  26.125011 0.00018951717 2.5836113 0.91076855  -40.574731
1.3 0.98115351  -30.405299  0.00061604998 2.0191866 0.00029030629 -8.7383134  0.81357569  -42.698266
1.4 0.98026271  -32.667053  0.00066244809 -51.137301  0.0002143556  -61.177501  0.78796927  -36.977978
1.5 0.97920338  -34.896774  0.00053286155 -73.655979  0.0001505826  -103.95818  0.8546625 -36.562696
1.6 0.9784181 -37.158093  0.00040388408 -100.49977  8.1351332e-005  -79.149069  0.89748222  -39.732425
1.7 0.97704136  -39.398567  0.00034496369 -107.7728 3.6376871e-005  -133.163  0.91652137  -43.39866
1.8 0.97507129  -41.647328  0.00036494756 -110.68184  6.7845453e-005  -134.20794  0.92377634  -46.996173
1.9 0.9728765 -43.908311  0.00032465213 -116.64593  0.00016225327 -125.89223  0.92516747  -50.484873
2 0.97096552  -46.148253  0.00039897564 -114.58059  5.3473192e-005  -176.67129  0.92376848  -53.90327
2.1 0.96844942  -48.442343  0.00040415112 -123.47027  0.00017631861 -138.52167  0.91996684  -57.330536
2.2 0.96590138  -50.705251  0.00027939198 -100.30537  0.00016763732 -93.245875  0.91475975  -60.74549
2.3 0.96332493  -52.981288  0.00023191614 -143.28697  0.00011472424 -104.46227  0.90769312  -64.224529
2.4 0.96032125  -55.294084  0.00019489432 149.85893 0.00022745418 -136.91637  0.89953439  -67.772701
2.5 0.95753491  -57.649127  0.0002632881  78.339464 0.00034779248 -154.86524  0.88993165  -71.446108
2.6 0.95482928  -60.066303  0.00087868946 62.588404 0.00019903205 -153.1154 0.87924122  -75.231432
2.7 0.95300803  -62.485967  0.0014786145  52.719506 0.00032938407 -154.87159  0.867600  -79.148833
```

Part 2

SnP文件的格式和制作

SnP文件仿真

SnP格式

SnP文件格式
模型由以下格式组成
freq_units parameter format Rn
...
说明：
告诉编译器随后的符号是关于参数的
freq_units 设置单位，参数是: GHz,MHz,KHz, 或者Hz
parameter 设置参数，
S1P器件可以设置 S,Y,Z参数
S2P器件可以设置S,Y,Z,H参数
S3P和S4P可以设置S参数
Format 内容格式
DB for dB-angle
MA for magnitude-angle
RI for real-imaginary
R n 阻抗设置，一般是50欧姆

SnP文件仿真

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SnP格式

SNP文件格式

如果文件开头没有以”#”开始的选项标志，则表示采用默认的选项为
GHz S MA R 50
注: S2P中采用”!”表示注释

格式示例：
频率单位为GHz，S参数，用实部-虚部表示，归一化到100欧姆；
GHz S RI R 100
频率单位为KHz，Y参数，用实部-虚部表示，归一化到100欧姆；
KHz Y RI R 100
频率单位为Hz，Z参数，用幅度-角度表示，归一化到1欧姆；
Hz Z MA R 1
频率单位为KHz，H参数，用实部-虚部表示，归一化到1欧姆；
KHz H RI R 1
频率单位为Hz，G参数，用幅度-角度表示，归一化到1欧姆；
Hz G MA R 1

SnP文件仿真

SnP格式

SnP文件格式

实例演示：

! 1-port S-parameter file, single frequency point

GHz S MA R 50

!freq magS11 angS11

2.000 0.894 -12.136

在上例中，2GHz的S11值用幅度-相位表示。参考阻抗为50欧姆。

实例演示：

! 2-port H-parameter file, single frequency point

MHz H MA R 50

! freq magH11 angH11 magH21 angH21 magH12 angH12 magH22 angH22

2 .95 -26 3.57 157 .04 76 .66 – 14

在上例中H参数是幅度-相位格式，参考电阻为50欧姆。

SnP文件仿真

SnP制作

ATF-54143 Typical Scattering Parameters, V_{DS} = 3V, I_{DS} = 60 mA

Freq.	S_{11}		S_{21}			S_{12}		S_{22}		MSG/MAG
GHz	Mag.	Ang.	dB	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	dB
0.1	0.99	-18.9	28.84	27.66	167.6	0.01	80.0	0.54	-14.0	34.88
0.5	0.81	-80.8	26.04	20.05	128.0	0.03	52.4	0.40	-58.8	27.84
0.9	0.71	-117.9	22.93	14.01	106.2	0.04	41.8	0.29	-83.8	25.13
1.0	0.69	-124.4	22.24	12.94	102.2	0.05	40.4	0.27	-88.5	24.59
1.5	0.64	-149.8	19.40	9.34	86.1	0.05	36.1	0.21	-105.2	22.46
1.9	0.62	-164.9	17.66	7.64	75.6	0.06	33.8	0.17	-114.7	21.05
2.0	0.62	-168.3	17.28	7.31	73.3	0.06	33.3	0.17	-117.0	20.71
2.5	0.60	176.2	15.58	6.01	61.8	0.07	30.1	0.13	-129.7	19.34
3.0	0.60	162.3	14.15	5.10	51.0	0.08	26.5	0.11	-146.5	18.15
4.0	0.62	137.1	11.81	3.90	30.8	0.09	17.1	0.10	165.2	16.17

SnP文件

```
# GHz S MA R 50
0.1 0.99 -18.9  27.66  167.6 0.01 80.0 0.54 -14.0
0.5 0.81 -80.8   20.05 128.0 0.03 52.4 0.40 -58.8
0.9 0.71 -117.9   14.01 106.2 0.04 41.8 0.29 -83.8
1.0 0.69 -124.4   12.94 102.2 0.05 40.4 0.27 -88.5
1.5 0.64 -149.8   9.34 86.1 0.05 36.1 0.21 -105.2
1.9 0.62 -164.9   7.64 75.6 0.06 33.8 0.17 -114.7
2.0 0.62 -168.3   7.31 73.3 0.06 33.3 0.17 -117.0
2.5 0.60 176.2   6.01 61.8 0.07 30.1 0.13 -129.7
3.0 0.60 162.3   5.10 51.0 0.08 26.5 0.11 -146.5
4.0 0.62 137.1   3.90 30.8 0.09 17.1 0.10 165.2
```

SnP文件仿真

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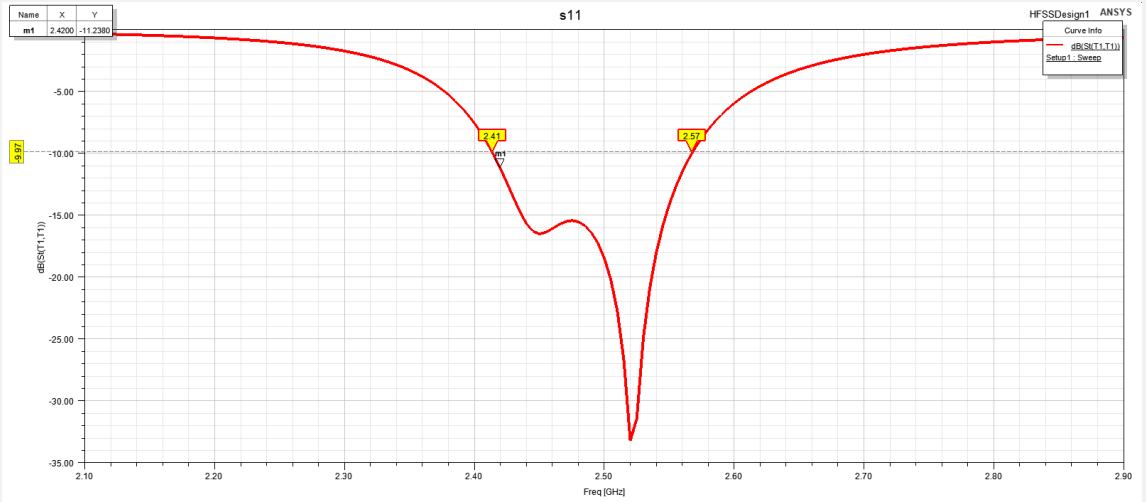
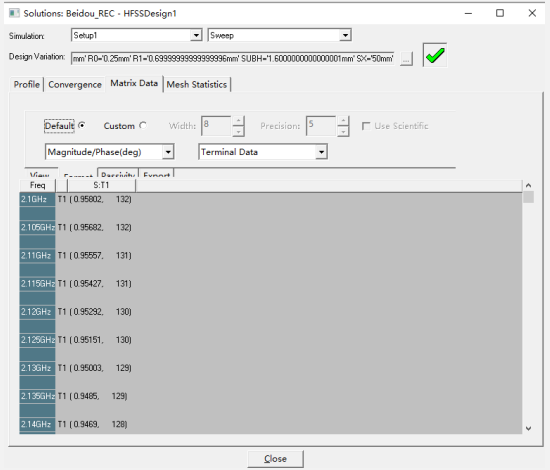
SnP导出

HFSS仿真数据SNP文件导出



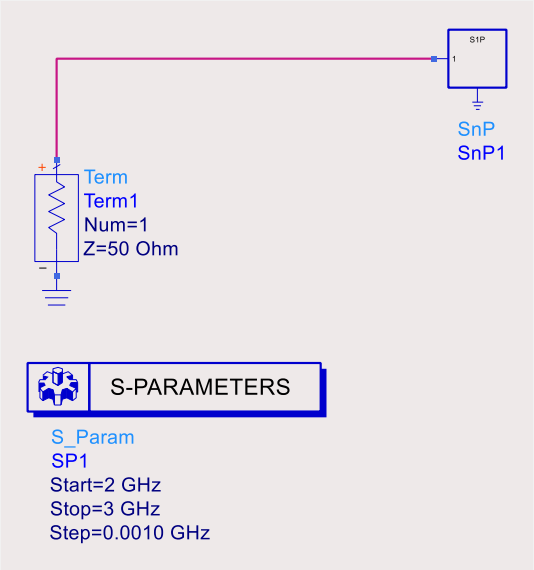


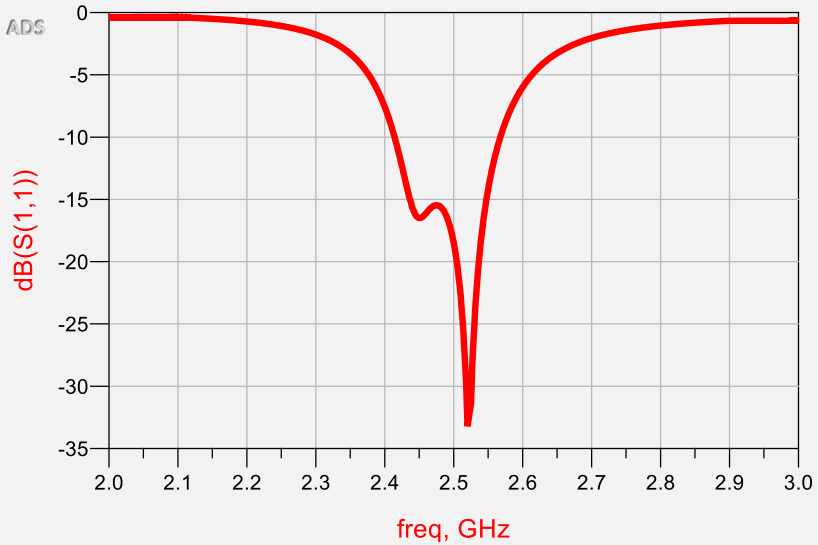
S_Parameter.s1p

SnP文件仿真

SnP仿真

HFSS仿真数据SNP文件导出





Part 3

基于SnP文件模型的PA设计

SnP文件仿真

PA的SNP文件

PA驱动放大器HMC1082

Typical Applications

The HMC1082LP4E is ideal for:

- Point-to-Point Radios
- Point-to-Multi-Point Radios
- VSAT & SATCOM
- Marine Radar
- Military EW & ECM

Features

High Saturated Output Power: 26 dBm @ 26% PAE

High Output IP3: 35 dBm

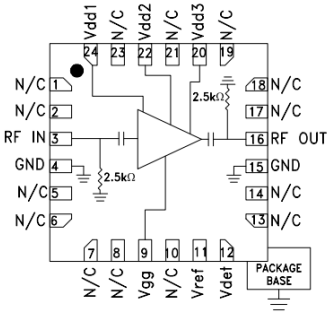
High Gain: 22 dB

High P1dB Output Power: 24 dBm

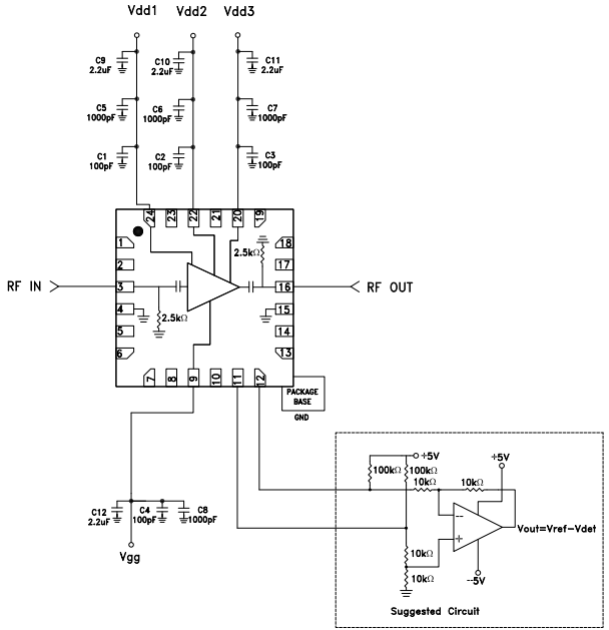
DC Supply: +5V @ 220 mA

Compact 24 Lead 4x4 mm SMT Package: 16 mm^2

Functional Diagram



Application Circuit



SnP文件仿真

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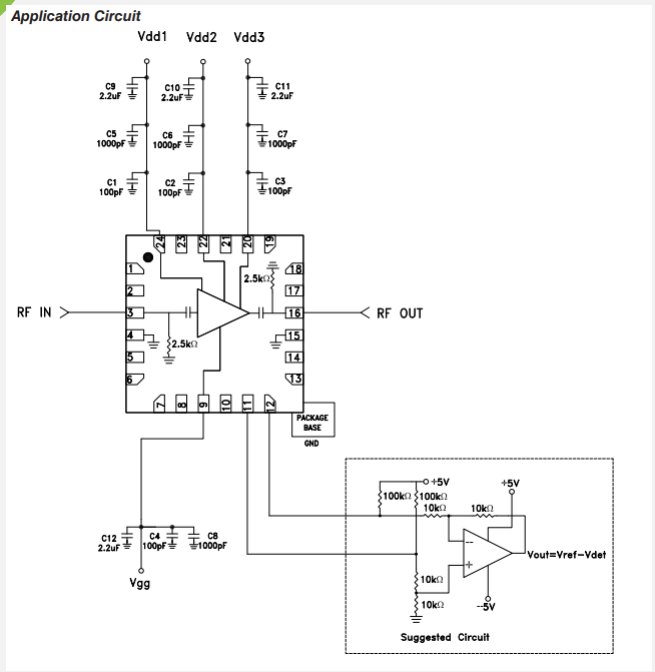
PA的SNP文件

PA驱动放大器HMC1082




```
!Hittite Microwave Corporation
!2 Elizabeth Drive
!Chelmsford, MA 01824
!Tel: 978-250-3343
!Fax: 978-250-3373
!Device: HMC1082LP4, GaAs pHEMT MMIC Medium Power Amplifier, 5.5 - 18 GHz
!Misc: Vdd1=Vdd2=Vdd3=5 V, Idd=220 mA, data includes evaluation board with coaxial connectors, room temperature
# GHZ S DB R 50
0.1 -0.317  -6.358  -66.638 -59.168 -70.752 -57.787 -0.347  -6.794
0.2 -0.336  -32.426 -74.511 -82.103 -86.757 -35.137 -0.349  -33.824
0.4 -0.374  -58.577 -81.174 143.180 -92.493 -69.976 -0.395  -61.215
0.6 -0.430  -84.887 -80.671 -115.620  -80.177 117.718 -0.463  -89.131
0.8 -0.512  -111.562  -55.329 -151.288  -73.520 53.765  -0.697  -117.825
1.0 -0.611  -138.550  -36.807 92.846  -73.334 -48.572 -1.206  -146.648
1.2 -0.722  -165.807  -33.355 -62.514 -83.804 -71.563 -2.167  -171.894
1.4 -0.831  166.742 -42.252 -154.267  -84.255 -172.915  -1.971  167.380
1.6 -0.933  139.291 -51.652 174.675 -83.910 42.168  -1.506  140.213
1.8 -1.030  111.819 -59.085 176.768 -81.535 -42.904 -1.341  111.899
2.0 -1.115  84.126  -66.380 -143.871  -79.878 -68.473 -1.284  83.618
2.2 -1.202  56.390  -65.474 -23.720 -87.060 -82.836 -1.299  55.362
2.4 -1.310  28.496  -49.587 2.169 -79.434 -87.241 -1.372  27.193
2.6 -1.440  0.354 -37.219 -5.488  -74.285 -88.413 -1.511  -1.367
2.8 -1.612  -28.044 -26.691 -30.868 -72.265 -111.498  -1.774  -30.028
3.0 -1.852  -56.916 -17.732 -66.433 -67.860 -147.510  -2.141  -58.905
3.2 -2.179  -86.229 -9.916  -107.912  -64.769 -173.799  -2.680  -88.099
3.4 -2.622  -116.374  -3.182  -154.047  -62.883 147.933 -3.348  -117.185
3.6 -3.197  -147.173  2.564 157.147 -63.887 117.495 -4.194  -146.320
3.8 -3.917  -178.526  7.419 106.651 -62.613 97.820  -5.206  -175.087
4.0 -4.812  149.886 11.558  55.763  -61.051 58.693  -6.429  156.187
4.2 -5.906  118.157 15.111  4.525 -61.497 37.306  -7.987  128.234
4.4 -7.231  86.920  18.145  -47.156 -61.415 11.012  -10.071 102.174
4.6 -8.960  55.619  20.663  -99.208 -60.925 -9.604  -12.772 82.094
4.8 -11.255 24.280  22.643  -151.865  -61.167 -35.574 -15.457 76.211
5.0 -14.438 -6.263  23.964  155.700 -60.357 -60.365 -15.124 80.685
5.2 -19.645 -36.056 24.638  104.630 -59.665 -79.955 -12.765 70.207
5.4 -31.621 -48.908 24.790  56.307  -59.624 -108.480  -10.792 48.456
5.6 -27.163 64.375  24.609  10.940  -59.321 -130.212  -9.911  22.141
5.8 -20.288 44.317  24.275  -31.446 -59.740 -155.118  -9.615  -2.745
6.0 -17.336 20.256  23.889  -71.335 -59.859 -173.911  -9.722  -28.412
6.2 -15.706 -5.412  23.512  -109.437  -58.507 163.871 -10.212 -51.589
6.4 -15.033 -32.720 23.178  -145.747  -58.861 137.281 -10.610 -76.203
6.6 -14.913 -61.154 22.878  178.939 -59.089 111.644 -11.730 -99.156
6.8 -15.141 -90.268 22.684  144.681 -58.254 94.969  -12.046 -121.533
7.0 -15.287 -122.015  22.489  110.858 -58.152 73.727  -13.579 -146.485
7.2 -15.334 -155.906  22.369  77.368  -57.981 48.617  -13.587 -166.701
7.4 -15.124 168.440 22.242  44.554  -57.422 27.246  -15.038 164.852
7.6 -14.532 134.645 22.127  11.887  -57.902 3.841  -14.837 147.583
7.8 -13.877 102.293 22.090  -20.046 -58.830 -19.264 -15.845 117.091
8.0 -13.021 72.812  22.068  -51.866 -58.846 -21.515 -15.477 104.184
```

SnP文件仿真

PA的SNP文件

SNP仿真的意义

[1] 基于S参数验证器件的端口输入和输出VSWR；

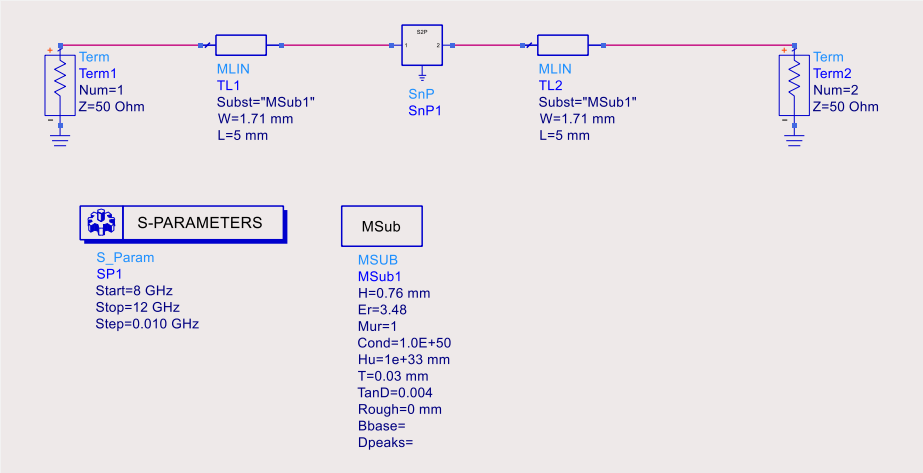
[2] 基于S参数分析增益；

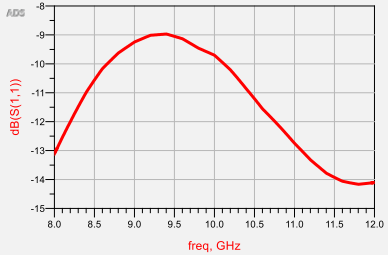
[3] 验证传输线对端口VSWR的影响；

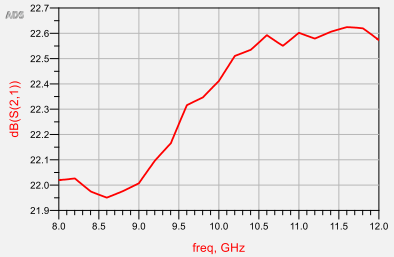
[4] 端口阻抗匹配；

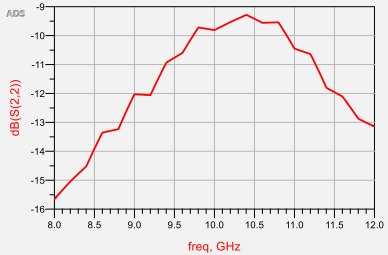
[5] 设计器件间的传输线；

[6] 验证偏置对射频器件的影响。









SnP文件仿真

PA的SNP文件仿真

BFU610F晶体管设计工作于10GHz的LNA，要求增益大于10dB;

基于阻抗参数的SNP模型可以做什么？

[1] 求解输入和输出端的电压驻波比;

[2] 进行输入和输出端的阻抗匹配;

[3] 偏置电路设计;

[4] 增益及增益平坦度求解。

THANK YOU !!