



## **1880 MHz PA Driver with BFG480W**

Application Note  
**JL-9902v0**

Author

**Jarek Lucek**

June 1, 1999

Discrete Semiconductors - Mansfield  
171 Forbes Blvd.  
Mansfield, MA 02048

### **Abstract**

BFG480W, the new 5<sup>th</sup> generation transistor from Philips Semiconductors, is well suited for PA driver applications in AMPS, TDMA, CDMA and GSM systems. BFG80W's performance is superior at 1880 MHz, 3.6V applications. Under CW mode, the part is capable of P<sub>1dB</sub>=20dBm, efficiency of over 40% and typical G<sub>p</sub> of 15 dB. BFG480W delivers 20 dBm of linear output power under TDMA with a typical G<sub>p</sub> of 15 dB and efficiency of above 30%. Under CDMA mode, BFG480W delivers 19 dBm of linear output power with a typical G<sub>p</sub> of above 15 dB and efficiency of 30%.



## Philips Semiconductors

### INTRODUCTION

BFG480W is Philips Semiconductors' 5<sup>th</sup> generation silicon bipolar RF wideband transistor in a SOT343R plastic SMD package. The transistor delivers superior performance at frequencies below 3 GHz. It is manufactured according to the *double poly* process and characterised by a high transition frequency ( $f_T > 20$  GHz) at low sub 3 Volt supply voltages. This application notes describes BFG480W performance at 1880 MHz operation under CW, 2 Tone, TDMA and CDMA conditions.

### PERFORMANCE OVERVIEW

The table below summarises BFG480W's typical performance capabilities under different signal conditions.

System	Vsupply	P1dB or Plinear* dBm		Gain** dB		Efficiency*** %	
		Icq=10mA	Icq=20mA	Icq=10mA	Icq=20mA	Icq=10mA	Icq=20mA
CW	3.0 Volts	19	20	14.5	14.7	37	37
	3.6 Volts	21	21	14.9	14.8	38	36
2Tone	3.0 Volts	16	15.5	15	15.5	27	24
	3.6 Volts	17.5	16.5	16	16	27	22
TDMA	3.0 Volts	19	19	14.5	15	35	34
	3.6 Volts	20.5	20	15	14.7	33	33
CDMA	3.0 Volts	17.5	17.5	15	15.5	30	30
	3.6 Volts	19	18.5	15.5	16	30	27

Table 1: BFG480W 1880 MHz PA driver performance summary

- \* - CW - load power @ P1dB  
2Tone - load power represents linear average power @ IMD levels reaching -28dBc.  
TDMA - load power represents linear average power @ ACPR levels reaching -26dBc or ALT levels reaching -45dBc.  
CDMA load power represents linear average power @ ACPR levels reaching -44dBc with 1.25MHz channel offset, 1.25MHz channel bandwidth and 30KHz Adjacent Channel bandwidth
- \*\* - typical Gain at P1dB for CW or Plinear for 2Tone, TDMA, CDMA signals
- \*\*\* - typical Efficiency at P1dB for CW or Plinear for 2Tone, TDMA, CDMA signals.



### CIRCUIT DESCRIPTION

Figure 1 shows a circuit diagram for the 1880 MHz PA driver using the BFG480W. Appendix 1 includes the part list of the demo board.

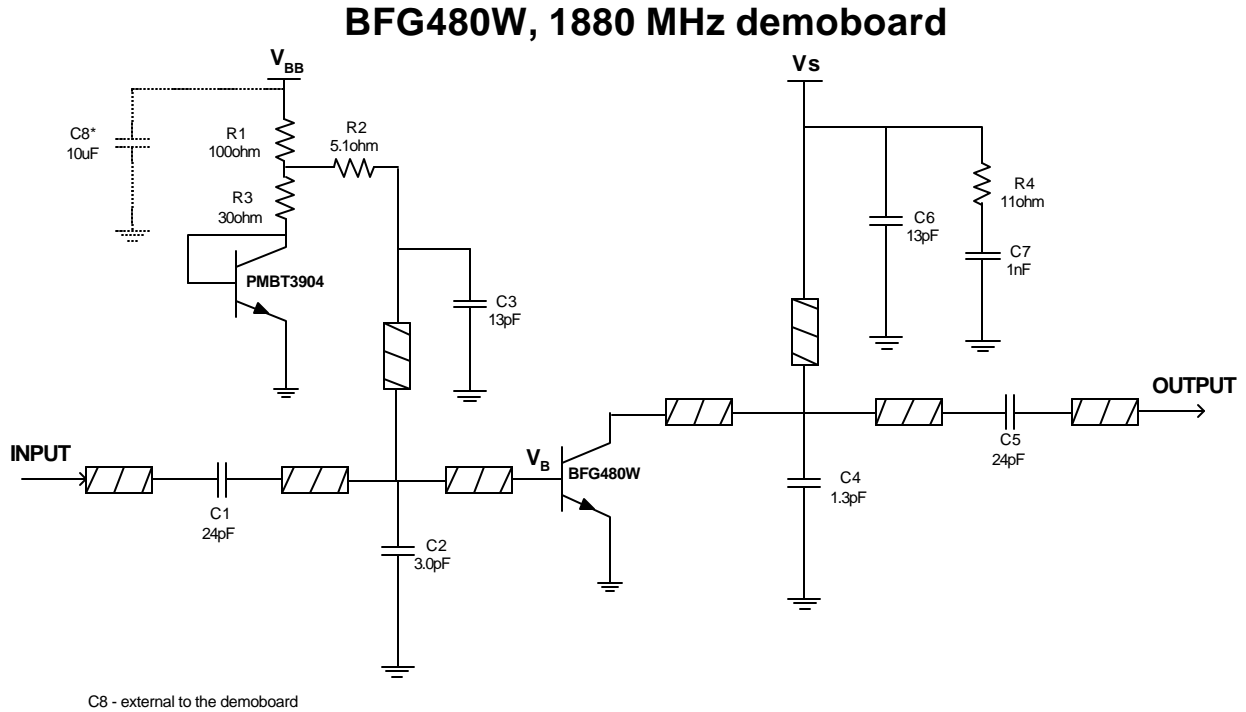


Figure 1: BFG480W common emitter demoboard for class-AB operation at 1880 MHz.



## Philips Semiconductors

### BOARD LAYOUT

Figure 3 shows the layout of the PCB, which has the following properties:

type: double copper-clad PTFE fiber-glass (backside ground)

$h = 0.64 \text{ mm}$

$t = 35 \mu\text{m}$  (Cu cladding, not coated)

$\epsilon_r = 6.15$

$\tan\delta = 0.0019$

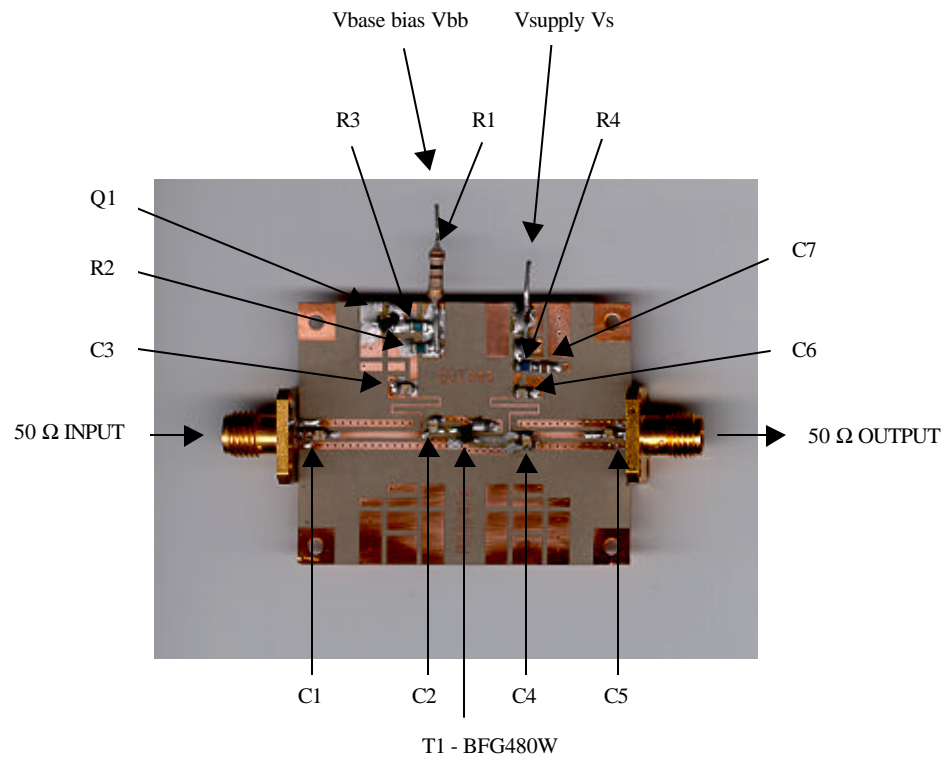


Figure 3: Layout of the 1880 MHz BFG480W PA driver.

Appendix 1 contains the part list for the demo board. The position of C2 and C4 components is critical. The artwork file is available on a floppy disc (DXF or Gerber format). Appendix 2 contains Spice model for BFG480W.



## Philips Semiconductors

### PERFORMANCE

BFG480W was evaluated under 4 different modes of operation. Each mode of operation is summarised below. All measurements were taken with 100% duty cycle signal.

### CW

BFG480W under CW at 1880 MHz and 25 deg. C

Vc=3.6V, Icq=1mA, Vbb=0.9V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-5.2	5	3.16	10.2	13	6.76
-2.3	10	10.00	12.3	22	12.63
1.1	15	31.62	13.9	39	22.52
5.64	20	100.00	14.36	73	38.05
7.1	21	125.89	13.9	86	40.66
8.9	22	158.49	13.1	103	42.74
10.9	23	199.53	12.1	126	43.99
13.28	24	251.19	10.72	150	46.52
16.3	25	316.23	8.7	184	47.74

Vc=3V, Icq=1mA, Vb=0.9V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-4.9	5	3.16	9.9	13	8.11
-2	10	10.00	12	22	15.15
1.46	15	31.62	13.54	39	27.03
6.74	20	100.00	13.26	78	42.74
8.4	21	125.89	12.6	93	45.12
10.4	22	158.49	11.6	113	46.75
12.95	23	199.53	10.05	137	48.55
17.3	24	251.19	6.7	176	47.57

Vc=3.6V, Icq=5mA, Vbb=1.04V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-8.5	5	3.16	13.5	16	5.49
-4.5	10	10.00	14.5	26	10.68
-0.3	15	31.62	15.3	43	20.43
4.7	20	100.00	15.3	78	35.64
6.45	21	125.89	14.55	91	38.43
8.35	22	158.49	13.65	109	40.39
10.47	23	199.53	12.53	132	41.99
12.9	24	251.19	11.1	160	43.61
16	25	316.23	9	193	45.51

Vc=3V, Icq=5mA, Vb=1.05V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-8.1	5	3.16	13.1	16	6.59
-4.1	10	10.00	14.1	25	13.33
0.1	15	31.62	14.9	43	24.51
6	20	100.00	14	82	40.65
7.8	21	125.89	13.2	97	43.26
10	22	158.49	12	118	44.77
12.6	23	199.53	10.4	145	45.87
17.2	24	251.19	6.8	186	45.02

Vc=3.6V, Icq=10mA, Vbb=1.11V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-9.9	5	3.16	14.9	20	4.39
-5.4	10	10.00	15.4	28	9.92
-0.9	15	31.62	15.9	46	19.10
4.5	20	100.00	15.5	80	34.72
6.1	21	125.89	14.9	94	37.20
8.2	22	158.49	13.8	113	38.96
10.4	23	199.53	12.6	136	40.75
12.8	24	251.19	11.2	164	42.55
15.7	25	316.23	9.3	198	44.36

Vc=3V, Icq=10mA, Vb=1.1V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	Ic mA	Eff %
-9.5	5	3.16	14.5	19	5.55
-5	10	10.00	15	27	12.35
-0.4	15	31.62	15.4	44	23.96
5.8	20	100.00	14.2	84	39.68
7.8	21	125.89	13.2	102	41.14
9.9	22	158.49	12.1	121	43.66
12.5	23	199.53	10.5	148	44.94
17.1	24	251.19	6.9	190	44.07

Vc=3.6V, Icq=20mA, Vbb=1.16V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-10.9	5	3.16	15.9	27	3.25
-6.1	10	10.00	16.1	34	8.17
-1.34	15	31.62	16.34	49	17.93
4.27	20	100.00	15.73	83	33.47
6.2	21	125.89	14.8	98	35.68
8.1	22	158.49	13.9	116	37.95
10.4	23	199.53	12.6	135	41.05
12.8	24	251.19	11.2	167	41.78
16.1	25	316.23	8.9	206	42.64

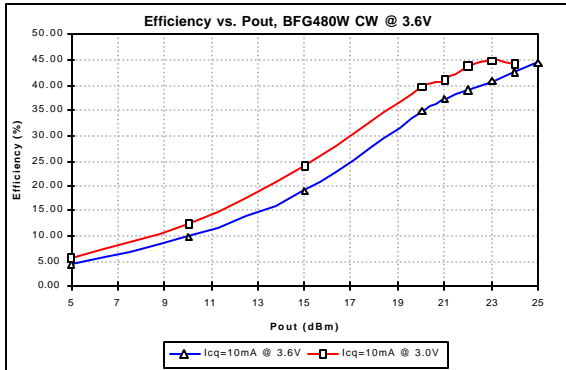
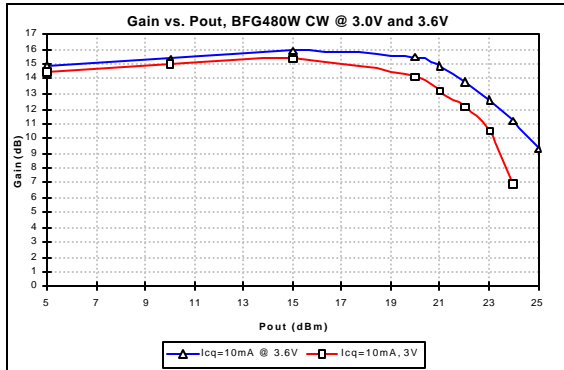
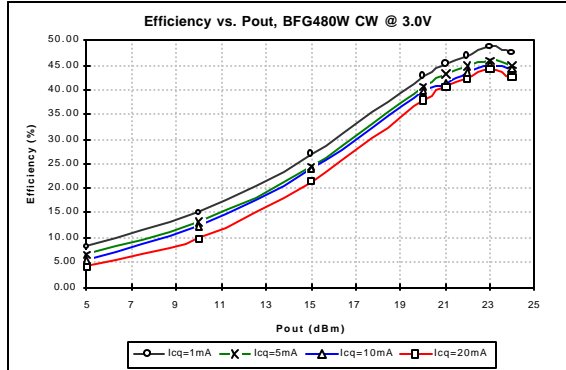
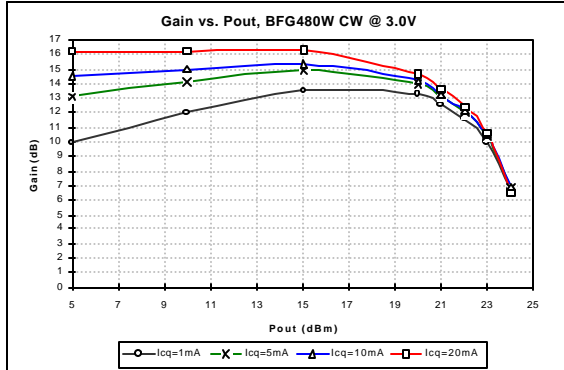
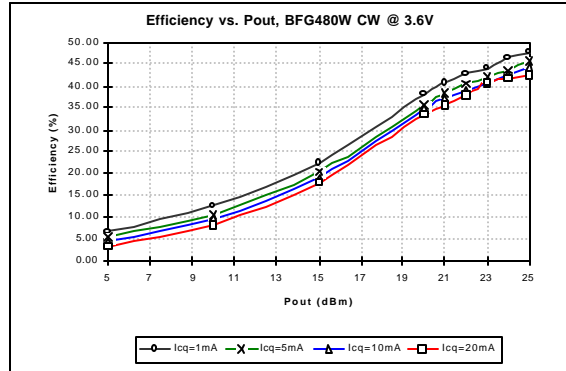
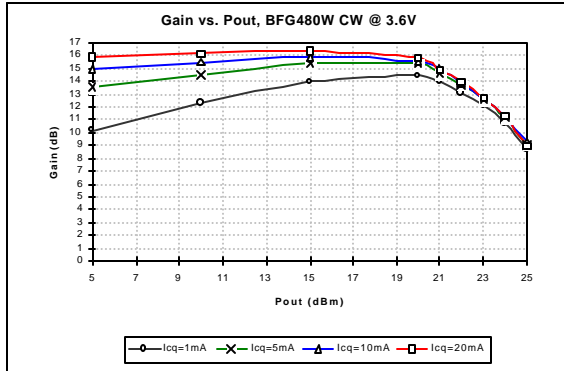
Vc=3V, Icq=20mA, Vb=1.18V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-11.2	5	3.16	16.2	26	4.05
-6.2	10	10.00	16.2	34	9.80
-1.3	15	31.62	16.3	49	21.51
5.3	20	100.00	14.7	88	37.88
7.3	21	125.89	13.7	103	40.74
9.6	22	158.49	12.4	125	42.26
12.33	23	199.53	10.67	151	44.05
17.5	24	251.19	6.5	197	42.50

It=Ic+Ib, total current draw.



### CW





### 2 TONE

BFG480W under 2Tone at 1880 and 1881 MHz and 25 deg. C

Vc=3.6V, Icq=10mA, Vbb=1.1V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	3rd low dBc	3rd high dBc	5th low dBc	5th high dBc	It mA	Eff %
-10	5	3.16	15	-40	-45	-55	-57	19	4.62
-5.5	10	10.00	15.5	-38	-42	-49	-54	27	10.29
-0.8	15	31.62	15.8	-37	-38	-44	-51	43	20.43
1.4	17	50.12	15.6	-30	-30	-39	-50	53	26.27
2.9	18	63.10	15.1	-25	-25	-35	-36	60	29.21
4.7	19	79.43	14.3	-20.7	-20.6	-27	-29	72	30.65
6.5	20	100.00	13.5	-18	-19	-23	-25	87	31.93

Vc=3.6V, Icq=20mA, Vbb=1.16V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	3rd low dBc	3rd high dBc	5th low dBc	5th high dBc	It mA	Eff %
-11.2	5	3.16	16.2	-46	-50	-57	-57	27	3.25
-6.3	10	10.00	16.3	-38	-45	-57	-57	34	8.17
-1.3	15	31.62	16.3	-32	-40	-52	-47	48	18.30
0.9	17	50.12	16.1	-27	-30	-51	-43	58	24.00
2.4	18	63.10	15.6	-24	-25	-41	-45	64	27.39
4	19	79.43	15	-19	-21	-30	-34	74	29.82
6	20	100.00	14	-17	-19	-25	-28	89	31.21

Vc=3.0V, Icq=10mA, Vbb=1.1V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	3rd low dBc	3rd high dBc	5th low dBc	5th high dBc	It mA	Eff %
-9.8	5	3.16	14.8	-40.9	-44	-55	-56	19	5.55
-5.2	10	10.00	15.2	-38	-40	-49	-57	27	12.35
-0.3	15	31.62	15.3	-34	-31	-42	-50	43	24.51
2.3	17	50.12	14.7	-24	-23	-32	-34	54	30.94
4.1	18	63.10	13.9	-20	-20	-26	-27	63	33.38
6.3	19	79.43	12.7	-17	-18	-22	-23	77	34.39
9.1	20	100.00	10.9	-15	-14	-19	-20	94	35.46

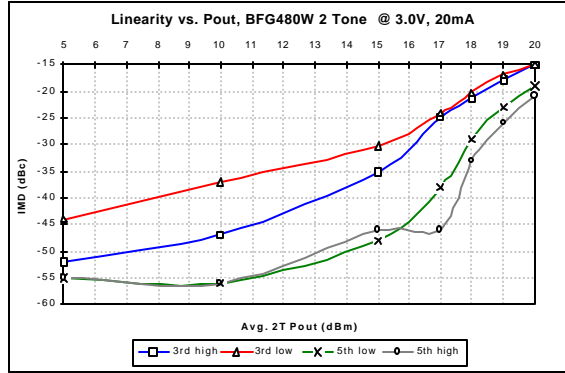
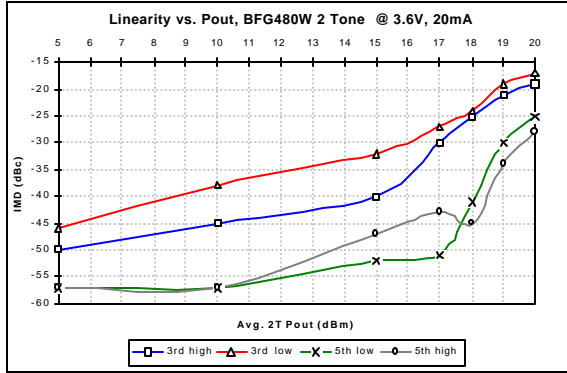
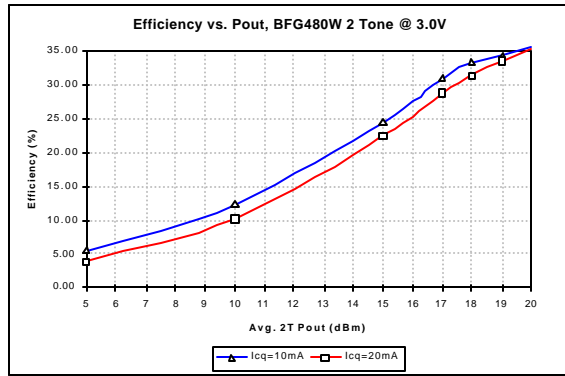
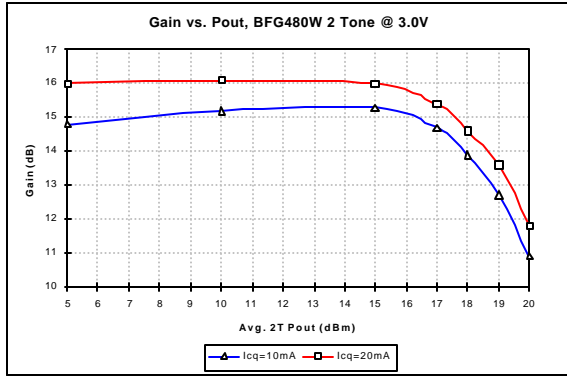
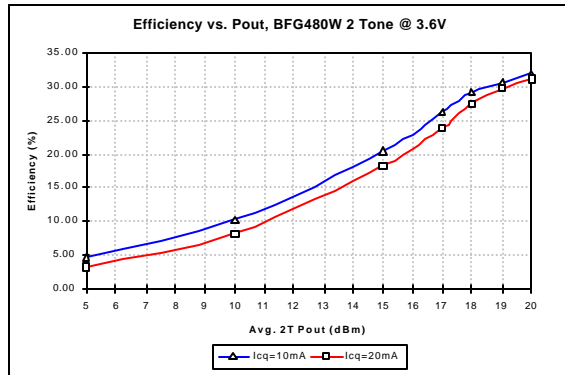
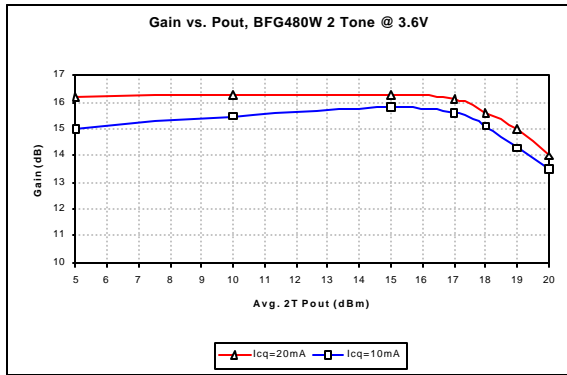
Vc=3.0V, Icq=20mA, Vbb=1.17V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	3rd low dBc	3rd high dBc	5th low dBc	5th high dBc	It mA	Eff %
-11	5	3.16	16	-44	-52	-55	-55	27	3.90
-6.1	10	10.00	16.1	-37	-47	-56	-56	33	10.10
-1	15	31.62	16	-30.2	-35	-48	-46	47	22.43
1.6	17	50.12	15.4	-24	-25	-38	-46	58	28.80
3.4	18	63.10	14.6	-20.3	-21.4	-29	-33	67	31.39
5.4	19	79.43	13.6	-17	-18	-23	-26	79	33.52
8.2	20	100.00	11.8	-15	-15	-19	-21	95	35.09

It=Ic+Ib, total current draw.



### 2 TONE







### TDMA

BFG480W under TDMA at 1880 MHz and 25 deg. C

Vc=3.6V, Icq=10mA, Vbb=1.1V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	ACPR low dB	ACPR high dB	1st ALT low dB	1st ALT high dB	2nd ALT low dB	2nd ALT high dB	It mA	Eff %
-10	5	3.16	15	-36	-35	-65	-65	-66	-66	19	4.62
-5.6	10	10.00	15.6	-36	-35	-65	-66	-69	-69	27	10.29
-1	15	31.62	16	-36	-36	-61	-62	-66	-66	44	19.96
1	17	50.12	16	-36	-34	-58	-59	-67	-67	54	25.78
3.2	19	79.43	15.8	-31	-31	-51	-52	-64	-64	72	30.65
4.8	20	100.00	15.2	-28	-28.5	-53	-53	-59	-59	82	33.88
6.5	21	125.89	14.5	-25.5	-25	-47	-47	-57	-57	96	36.43
8.6	22	158.49	13.4	-24	-24	-41	-41	-56	-56	114	38.62

Vc=3.6V, Icq=20mA, Vbb=1.16V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	ACPR low dB	ACPR high dB	1st ALT low dB	1st ALT high dB	2nd ALT low dB	2nd ALT high dB	It mA	Eff %
-11.2	5	3.16	16.2	-35.4	-36	-66	-66	-67	-66	26	3.38
-6.2	10	10.00	16.2	-36	-36	-68	-68	-70	-70	33	8.42
-1.3	15	31.62	16.3	-35	-36	-62	-62	-65	-65	47	18.69
0.72	17	50.12	16.28	-36	-36	-59	-59	-67	-67	58	24.00
3.1	19	79.43	15.9	-30	-30	-53	-53	-64	-64	73	30.23
4.7	20	100.00	15.3	-26.5	-26	-52	-52	-58	-58	84	33.07
6.5	21	125.89	14.5	-25	-25	-46	-46	-58	-58	98	35.68
8.5	22	158.49	13.5	-24	-24	-40	-40	-55	-56	116	37.95

Vc=3.0V, Icq=10mA Vbb=1.11V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	ACPR low dB	ACPR high dB	1st ALT low dB	1st ALT high dB	2nd ALT low dB	2nd ALT high dB	It mA	Eff %
-9.7	5	3.16	14.7	-35	-35	-65	-65	-67	-67	19	5.55
-5.2	10	10.00	15.2	-36	-36	-65	-65	-70	-70	27	12.35
-0.5	15	31.62	15.5	-36	-35	-58	-60	-66	-66	43	24.51
1.6	17	50.12	15.4	-33	-33	-52	-52	-66	-66	55	30.37
4.4	19	79.43	14.6	-27	-27	-51	-51	-58	-58	73	36.27
6.1	20	100.00	13.9	-25	-25	-45	-45	-56	-56	86	38.76
8.2	21	125.89	12.8	-24	-23	-40	-40	-55	-55	102	41.14
10.6	22	158.49	11.4	-22	-22	-38	-38	-50	-50	124	42.60

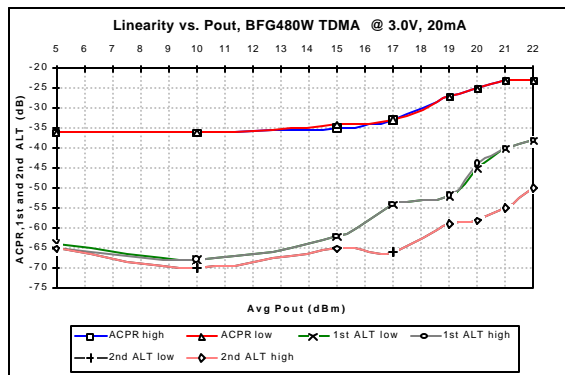
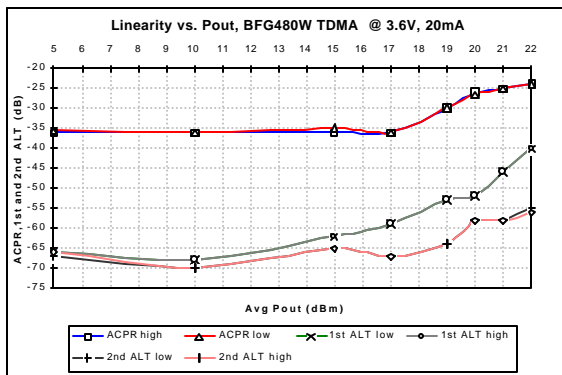
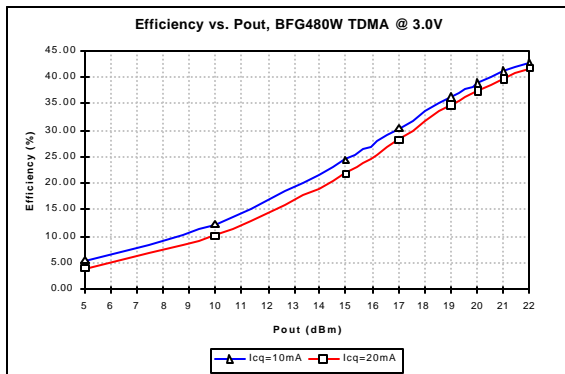
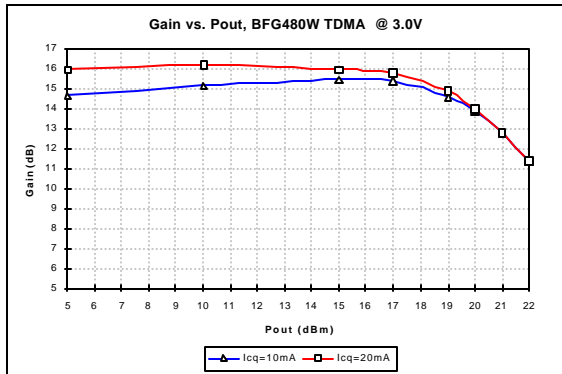
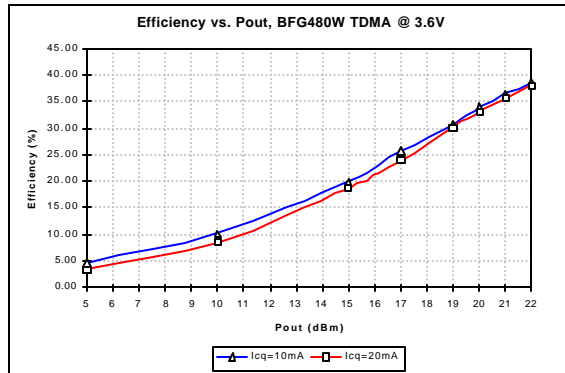
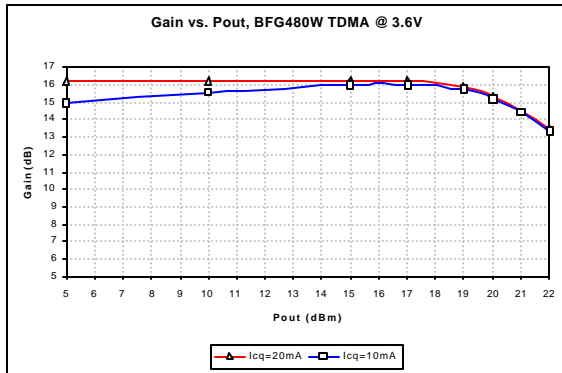
Vc=3.0V, Icq=20mA Vbb=1.17V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	ACPR low dB	ACPR high dB	1st ALT low dB	1st ALT high dB	2nd ALT low dB	2nd ALT high dB	It mA	Eff %
-11	5	3.16	16	-36	-36	-64	-65	-65	-65	26	4.05
-6.2	10	10.00	16.2	-36	-36	-68	-68	-70	-70	33	10.10
-1	15	31.62	16	-34	-35	-62	-62	-65	-65	48	21.96
1.2	17	50.12	15.8	-33	-33	-54	-54	-66	-66	59	28.32
4.1	19	79.43	14.9	-27	-27	-52	-52	-59	-59	76	34.84
6	20	100.00	14	-25	-25	-45	-44	-58	-58	89	37.45
8.2	21	125.89	12.8	-23	-23	-40	-40	-55	-55	106	39.59
10.6	22	158.49	11.4	-23	-23	-38	-38	-50	-50	127	41.60

It=Ic+Ib, total current draw.



### TDMA





## Philips Semiconductors

### CDMA

BFG480W under CDMA at 1.88GHz and 25 deg. C

Vc=3.6V. Icq=10mA. Vbb=1.07V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	ACPR low dB	ACPR high dB	It mA	Eff %
-10.1	5	3.16	15.1	-64	-70	20	4.39
-5.6	10	10.00	15.6	-62	-69	28	9.92
-1	15	31.62	16	-59	-61	44	19.96
1	17	50.12	16	-51	-51	55	25.31
2.2	18	63.10	15.8	-47	-47	62	28.27
3.4	19	79.43	15.6	-44	-44	70	31.52
4.9	20	100.00	15.1	-42	-42	81	34.29

Vc=3.6V. Icq=20mA. Vbb=1.15V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	ACPR low dB	ACPR high dB	It mA	Eff %
-11.7	5	3.16	16.7	-70	-74	34	2.58
-6.8	10	10.00	16.8	-61	-66	39	7.12
-1.7	15	31.62	16.7	-54	-59	52	16.89
0.5	17	50.12	16.5	-49	-52	62	22.45
1.7	18	63.10	16.3	-46	-48	68	25.77
3.1	19	79.43	15.9	-43	-44	76	29.03
4.6	20	100.00	15.4	-41	-41	86	32.30

Vc=3.0V. Icq=10mA. Vbb=1.11V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	ACPR low dB	ACPR high dB	It mA	Eff %
-9.7	5	3.16	14.7	-62	-64	19	5.55
-5.2	10	10.00	15.2	-62	-60	27	12.35
-0.5	15	31.62	15.5	-55	-53	43	24.51
1.7	17	50.12	15.3	-46	-46	55	30.37
3	18	63.10	15	-43	-43	62	33.92
4.5	19	79.43	14.5	-41	-41	72	36.77
6.3	20	100.00	13.7	-39	-39	86	38.76

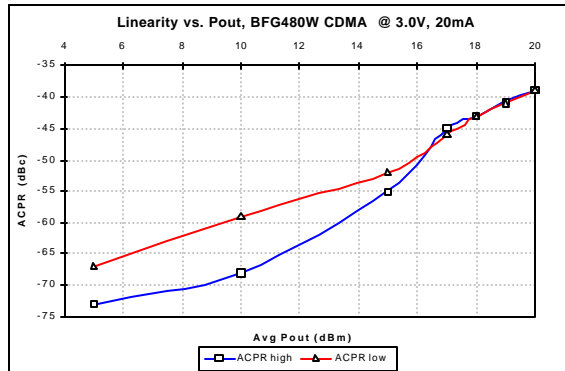
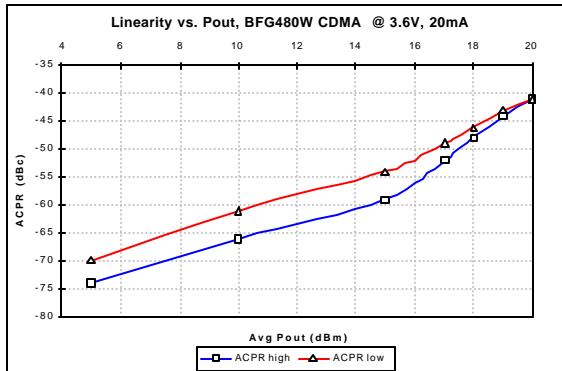
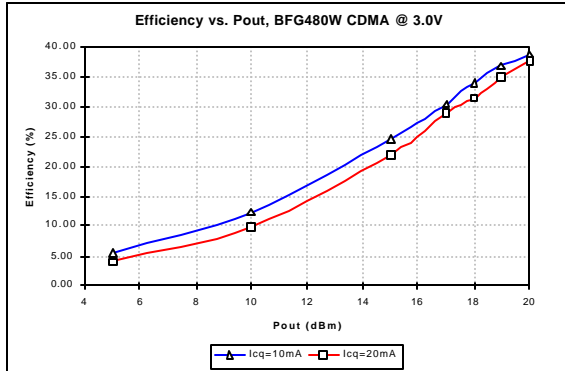
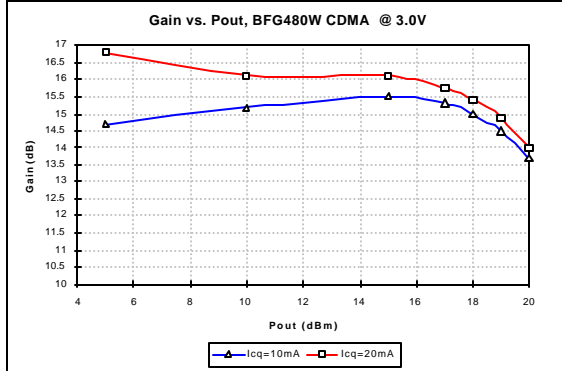
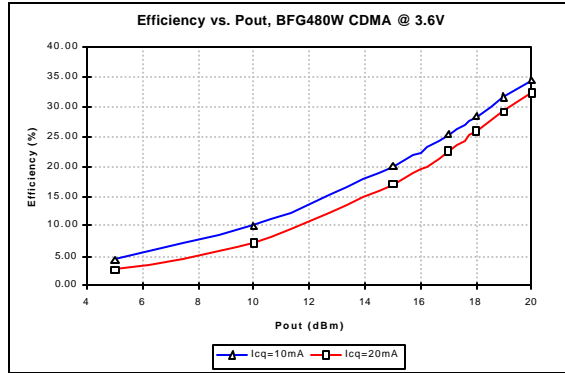
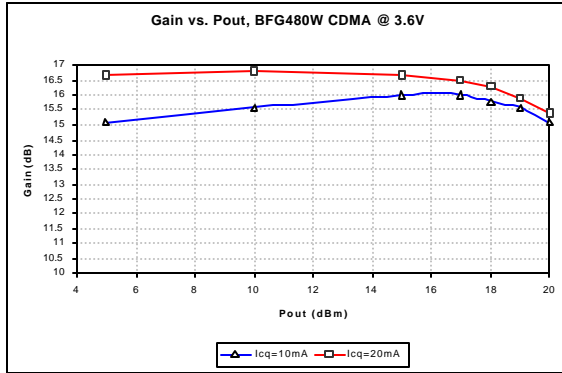
Vc=3.0V. Icq=20mA. Vbb=1.17V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	ACPR low dB	ACPR high dB	It mA	Eff %
-11.8	5	3.16	16.8	-67	-73	27	3.90
-6.1	10	10.00	16.1	-59	-68	34	9.80
-1.1	15	31.62	16.1	-52	-55	48	21.96
1.26	17	50.12	15.74	-46	-45	58	28.80
2.6	18	63.10	15.4	-43	-43	67	31.39
4.1	19	79.43	14.9	-41	-40.8	76	34.84
6	20	100.00	14	-39	-39	89	37.45

It=Ic+Ib, total current draw.



### CDMA





### APPENDIX 1: Part list for BFG480W 1880 MHz PA driver

#### Resistors

R1	100 $\Omega$	Leaded wirewound, 0.1W.
R2	5.1 $\Omega$	Philips 0805, 0.1W metal film resistor.
R3	30 $\Omega$	Philips 0805, 0.1W metal film resistor.
R4	11 $\Omega$	Philips 0805, 0.1W metal film resistor.

#### Capacitors

C1,C5	24 pF	ATC100A, DC blocking capacitor
C2	3.0 pF	ATC100A, matching capacitor
C3,C6	13 pF	ATC100A, bias and supply decoupling capacitor.
C4	1.3 pF	ATC100A, matching capacitor
C7	1.0 nF	Philips 0805, supply low frequency decoupling capacitor.
C8	10 $\mu$ F	Philips electrolytic low frequency decoupling capacitor – <b>not part of the demoboard.</b>

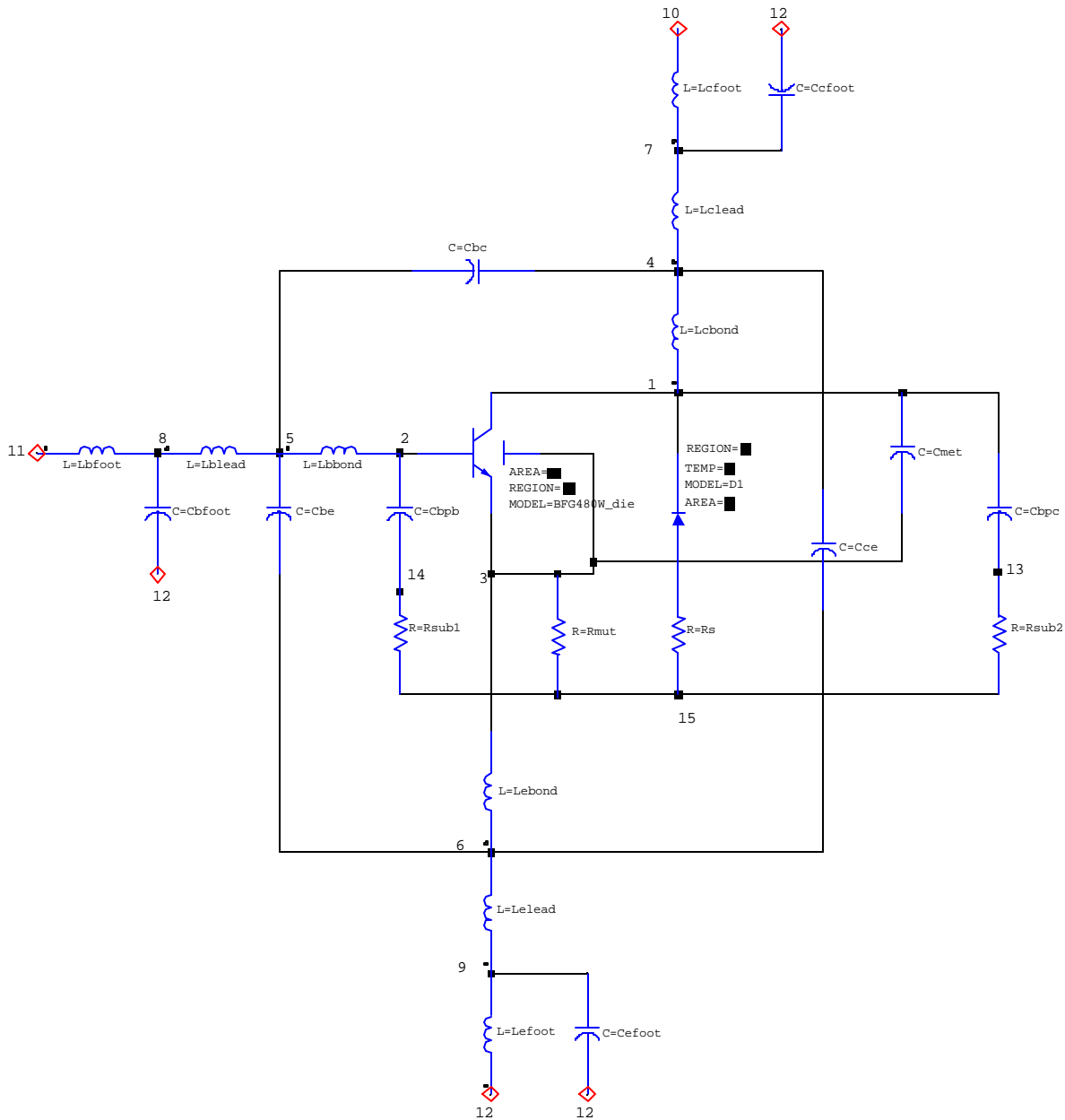
#### Transistors

T1	BFG480W	RF amplifying transistor.
Q1	PMBT3904	Biasing and thermal tracking small signal transistor.



### APPENDIX 2:

### BFG480W Spice and package model (preliminary)



This model is valid from 540MHz to 6GHz. The reference plane has been put at the test substrate for the package (SOT343R). In the next page you can see the test substrate definition. If you want to use this model without the footprint, just use the model at the node points 7,8, and 9.



## Philips Semiconductors

### Spice parameters of the BFG480W

param Lbbond " 709.0p"  
param Lblead " 281.0p"  
param Lbfoot " 55.00p"  
param Cbfoot " 58.50f"  
param Lebond " 57.13p"  
param Lelead " 69.14p"  
param Lefoot " 173.9p"  
param Cefoot " 195.0f"  
param Lcbond " 559.3p"  
param Lclead " 280.0p"  
param Lcfoot " 55.00p"  
param Ccfoot " 58.50f"  
param Cbc " 2.000f"  
param Cbe " 80.00f"  
param Cce " 80.00f"  
param Cbpb " 330.0f"  
param Cbpc " 347.0f"  
param Cmet " 883.7f"  
param Rsub1 " 214.7 "  
param Rsub2 " 321.4 "  
param Rsub3 " 1.000MEG"  
param Rmut " 98.84 "  
param Rs " 217.5u"  
param D1.IS " 976.6f"  
param D1.N " 1.272 "  
param Q1.AREA " 1.000 "  
param NPN.IS " 176.9a"  
param NPN.BF " 136.5 "  
param NPN.NF " 986.3m"  
param NPN.VAF " 23.00 "  
param NPN.IKF " 5.900 "  
param NPN.ISE " 1.189p"  
param NPN.NE " 2.817 "

param NPN.BR " 9.000 "  
param NPN.NR " 996.8m"  
param NPN.VAR " 1.750 "  
param NPN.IKR " 558.5m"  
param NPN.ISC " 20.66f"  
param NPN.NC " 1.916 "  
param NPN.RB " 2.985 "  
param NPN.IRB " 0.000 "  
param NPN.RBM " 640.5m"  
param NPN.RE " 114.5m"  
param NPN.RC " 967.0m"  
param NPN.CJE " 1.643p"  
param NPN.VJE " 900.0m"  
param NPN.MJE " 267.4m"  
param NPN.CJC " 545.2f"  
param NPN.VJC " 504.2m"  
param NPN.MJC " 254.1m"  
param NPN.CJS " 917.8f"  
param NPN.VJS " 421.8m"  
param NPN.MJS " 57.54m"  
param NPN.XCJC " 500.0m"  
param NPN.TR " 150.0p"  
param NPN.TF " 3.680p"  
param NPN.XTF " 1.000K"  
param NPN.VTF " 652.5m"  
param NPN.ITF " 11.13 "  
param NPN.PTF " 0.000 "  
param NPN.FC " 910.0m"  
param NPN.EG " 1.110 "  
param NPN.XTI " 4.300 "  
param NPN.XTB " 500.0m"