



1880 MHz PA Driver with BFG21W

Application Note
JL-9901v0

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Abstract

BFG21W, the new 5th generation transistor from Philips Semiconductors, is well suited for PA driver applications in AMPS, TDMA, CDMA and GSM systems. BFG21W's performance is superior at 1880 MHz, 3.6V applications. Under CW mode, the part is capable of P1dB=24dBm, efficiency of over 50% and typical G_p of 12 dB. BFG21W delivers 23.5 dBm of linear output power under TDMA with a typical G_p of 12 dB and efficiency of above 45%. Under CDMA mode, BFG21W delivers 21 dBm of linear output power with a typical G_p of above 12 dB and efficiency of 40%.



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INTRODUCTION

BFG21W is Philips Semiconductors' 5th 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 characterized by a high transition frequency ($f_T > 20$ GHz) at low sub 3 Volt supply voltages. This application notes describes BFG21W performance at 1880 MHz operation under CW, 2 Tone, TDMA and CDMA conditions.

PERFORMANCE OVERVIEW

The table below summarizes BFG21W'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	22	22	12	12	56	56
	3.6 Volts	24	24	12	12	52	52
2Tone	3.0 Volts	18	18	12.5	12.5	30	30
	3.6 Volts	19.5	19	12.5	13	35	30
TDMA	3.0 Volts	21	21	11.5	12	45	45
	3.6 Volts	23.5	23.5	11.5	12	49	50
CDMA	3.0 Volts	19	19	12.5	12.5	39	40
	3.6 Volts	21	21	12.5	13	42	39

Table 1: BFG21W 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 BFG21W. Appendix 1 includes the part list of the demo board.

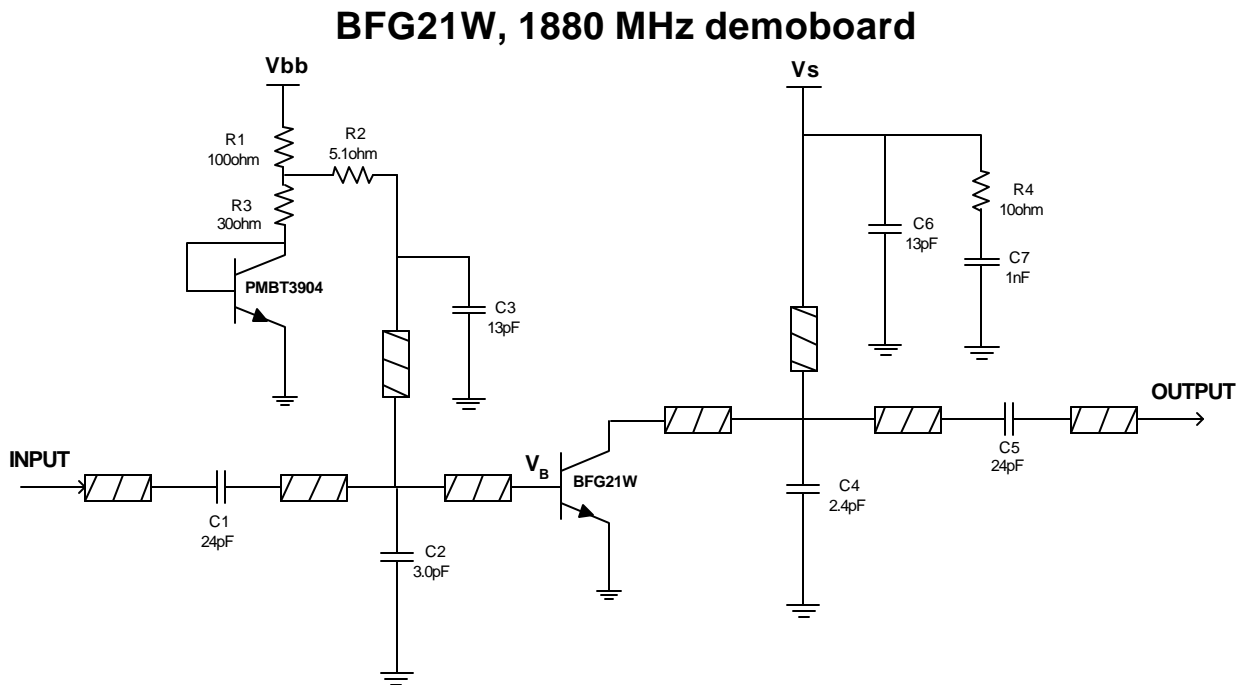


Figure 1: BFG21W common emitter demoboard for class-AB operation at 1880 MHz.



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BOARD LAYOUT

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

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

$h = 0.64 \text{ mm}$

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

$\epsilon_r = 6.15$

$\tan\delta = 0.0019$

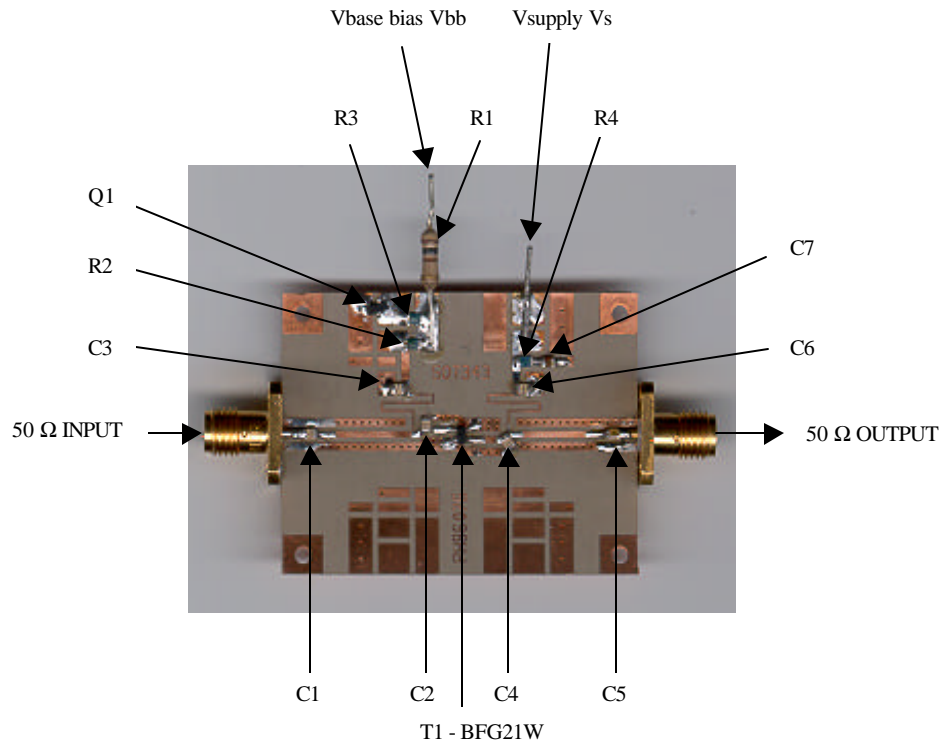


Figure 3: Layout of the 1880 MHz BFG21W PA driver.

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 BFG21W.



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PERFORMANCE

BFG21W was evaluated under 4 different modes of operation. Each mode of operation is summarized below. All measurements were taken with 100% duty cycle signal.

CW

BFG21W 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 %
-3.3	5	3.16	8.3	13	6.95
0	10	10.00	10	22	12.99
3.6	15	31.62	11.4	39	23.17
7.88	20	100.00	12.12	70	40.82
9.9	22	158.49	12.1	89	50.88
11.3	23	199.53	11.7	102	55.89
13.2	24	251.19	10.8	120	59.81
15.7	25	316.23	9.3	143	63.18
19	26	398.11	7	182	62.50

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

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-2.9	5	3.16	7.9	13	8.11
0.4	10	10.00	9.6	22	15.15
4	15	31.62	11	39	27.03
8.4	20	100.00	11.6	70	47.62
11	22	158.49	11	93	56.81
13	23	199.53	10	109	61.02
16.3	24	251.19	7.7	137	61.12
20.3	25	316.23	4.7	180	58.56

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

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-5.6	5	3.16	10.6	16	5.65
-1.7	10	10.00	11.7	26	10.99
2.6	15	31.62	12.4	43	21.01
7.23	20	100.00	12.77	74	38.61
9.3	22	158.49	12.7	94	48.17
10.7	23	199.53	12.3	107	53.28
12.4	24	251.19	11.6	124	57.88
14.8	25	316.23	10.2	150	60.23
18.3	26	398.11	7.7	188	60.50

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

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-5.6	5	3.16	10.6	16	6.59
-1.4	10	10.00	11.4	25	13.33
2.9	15	31.62	12.1	42	25.10
7.6	20	100.00	12.4	74	45.05
10.3	22	158.49	11.7	96	55.03
12.2	23	199.53	10.8	114	58.34
15.1	24	251.19	8.9	144	58.15
19.6	25	316.23	5.4	187	56.37

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

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-7.1	5	3.16	12.1	20	4.52
-2.5	10	10.00	12.5	29	9.85
2.06	15	31.62	12.94	47	19.22
6.92	20	100.00	13.08	77	37.11
9.1	22	158.49	12.9	100	45.28
10.55	23	199.53	12.45	110	51.82
12.2	24	251.19	11.8	127	56.51
14.5	25	316.23	10.5	153	59.05
18.2	26	398.11	7.8	194	58.63

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

Pin dBm	Pout dBm	Pout mWatt	Gain dB	Ic mA	Eff %
-6.8	5	3.16	11.8	19	5.55
-2.2	10	10.00	12.2	27	12.35
2.4	15	31.62	12.6	44	23.96
7.4	20	100.00	12.6	76	43.86
10	22	158.49	12	99	53.36
12	23	199.53	11	116	57.34
14.8	24	251.19	9.2	146	57.35
19.4	25	316.23	5.6	193	54.62

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

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-7.9	5	3.16	12.9	28	3.23
-3.1	10	10.00	13.1	33	8.66
1.7	15	31.62	13.3	49	18.44
6.7	20	100.00	13.3	80	35.71
8.9	22	158.49	13.1	98	46.21
10.28	23	199.53	12.72	110	51.82
12.1	24	251.19	11.9	129	55.63
14.4	25	316.23	10.6	156	57.92
17.9	26	398.11	8.1	196	58.03

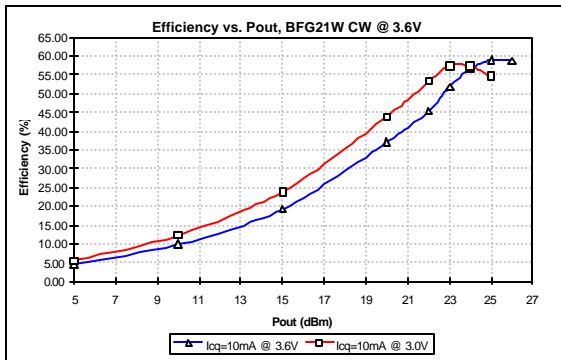
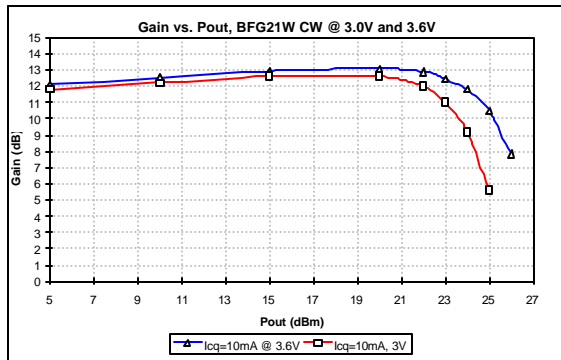
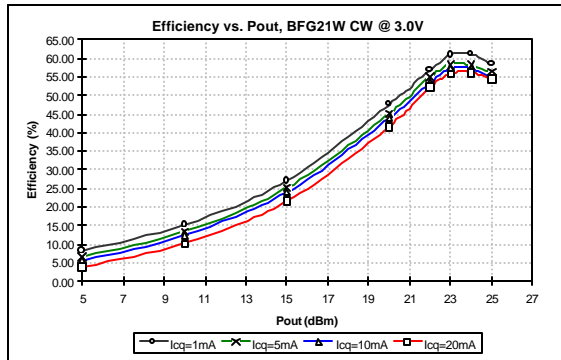
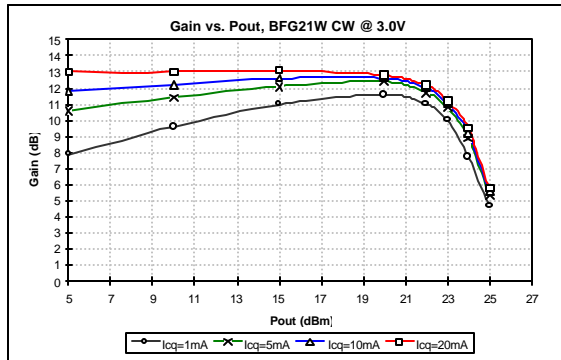
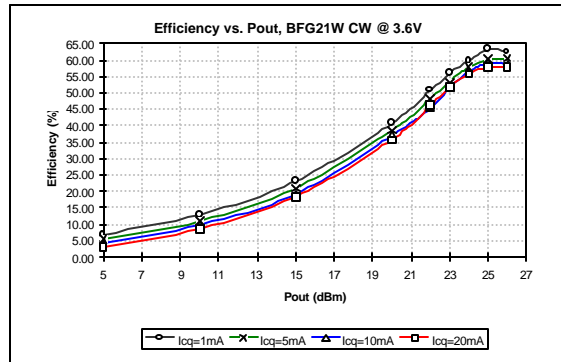
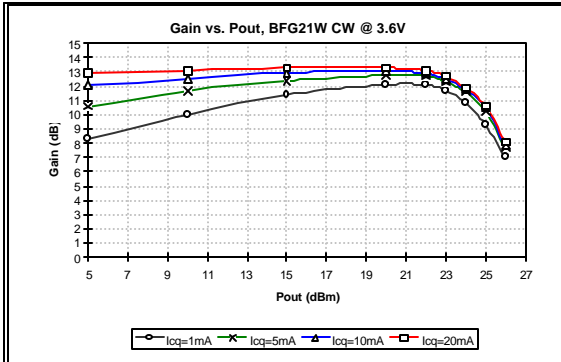
Vc=3V, Icq=20mA, Vb=1.18V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	It mA	Eff %
-8	5	3.16	13	27	3.90
-3	10	10.00	13	33	10.10
1.9	15	31.62	13.1	49	21.51
7.2	20	100.00	12.8	80	41.67
9.8	22	158.49	12.2	101	52.31
11.8	23	199.53	11.2	119	55.89
14.5	24	251.19	9.5	149	56.19
19.2	25	316.23	5.8	194	54.33

It=Ic+Ib, total current draw.



CW





2 TONE

BFG21W 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 %
-7.4	5	3.16	12.4	-40	-40	-57	-57	16.3	5.39
-2.8	10	10.00	12.8	-37	-40.8	-52	-63	27	10.29
1.9	15	31.62	13.1	-36	-39	-48	-52	42	20.91
3.9	17	50.12	13.1	-34.7	-37.3	-45	-45	51	27.30
6.1	19	79.43	12.9	-30.7	-32.5	-38	-39	64	34.48
7.23	20	100.00	12.77	-26.5	-27	-34.6	-34.2	71	39.12
8.66	21	125.89	12.34	-22	-22	-27	-28	81	43.17

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 %
-8.3	5	3.16	13.3	-46	-53	-60	-60	27	3.25
-3.4	10	10.00	13.4	-40	-49	-58	-60	34	8.17
1.45	15	31.62	13.55	-35	-58	-50	-51	48	18.30
3.5	17	50.12	13.5	-32	-48	-46	-49	57	24.42
5.8	19	79.43	13.2	-28.9	-35	-41	-43	69	31.98
7	20	100.00	13	-25	-29	-36	-37	76	36.55
8.43	21	125.89	12.57	-21	-23	-29	-32	84	41.63

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 %
-7	5	3.16	12	-38	-39	-56	-55	16	5.65
-2.5	10	10.00	12.5	-36	-37	-51	-54	26	10.99
2.2	15	31.62	12.8	-34	-35	-45	-42	41	22.04
4.3	17	50.12	12.7	-33	-31	-39	-37	51	28.08
6.9	19	79.43	12.1	-24	-23	-29	-29	64	35.46
8.6	20	100.00	11.4	-21	-18	-24	-25	74	38.61
10.8	21	125.89	10.2	-16	-16	-20	-20	90	39.97

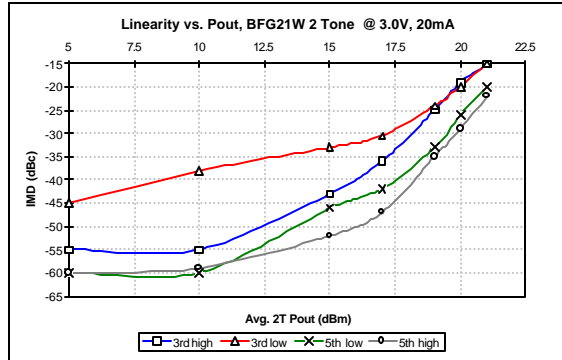
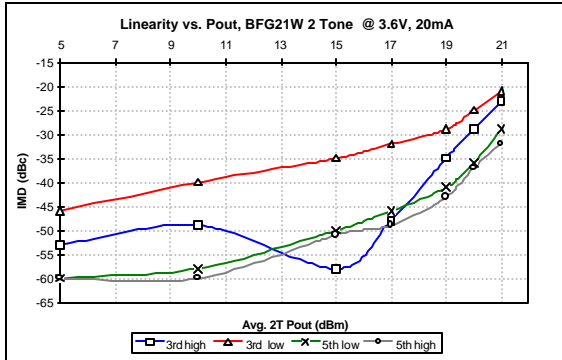
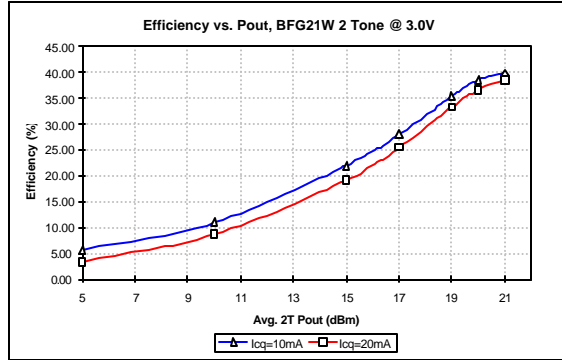
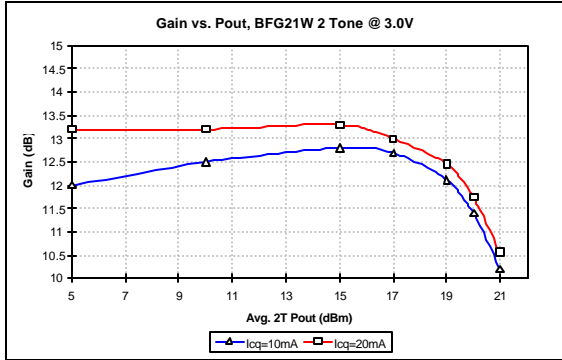
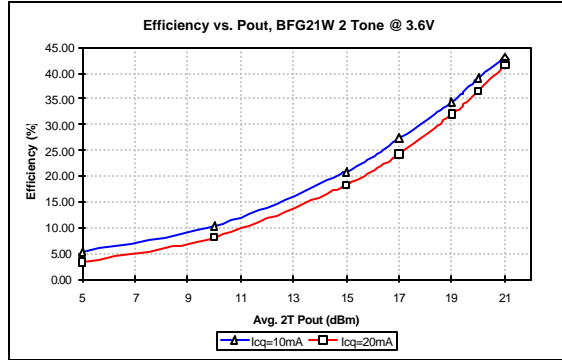
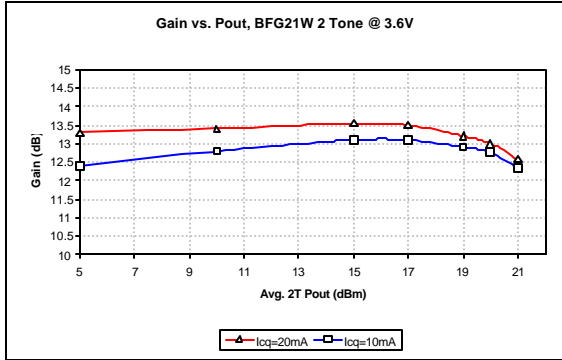
Vc=3.0V, Icq=20mA, Vbb=1.17V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	3rd low dBc	3rd high dBc	5th low dBc	5th high dBc	It mA	Eff %
-8.2	5	3.16	13.2	-45	-55	-60	-60	27	3.35
-3.2	10	10.00	13.2	-38	-55	-60	-59	33	8.66
1.7	15	31.62	13.3	-33	-43	-46	-52	47	19.22
4	17	50.12	13	-30.5	-36	-42	-47	56	25.57
6.55	19	79.43	12.45	-24	-25	-33	-35	68	33.38
8.26	20	100.00	11.74	-20	-19	-26	-29	78	36.63
10.44	21	125.89	10.56	-15	-15	-20	-22	93	38.68

It=Ic+Ib, total current draw.



2 TONE





TDMA

BFG21W 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 %
-6.9	5	3.16	11.9	-36	-36	-72	-72	-77	-77	19	4.62
-2.4	10	10.00	12.4	-36	-36	-66	-67	-76	-76	27	10.29
2.6	15	31.62	12.4	-36	-36	-62	-62	-75	-76	43	20.43
7	20	100.00	13	-35	-36	-56	-56	-71	-72	74	37.54
9.4	22	158.49	12.6	-30	-30	-49	-49	-64	-64	95	46.34
11	23	199.53	12	-26.7	-27	-51	-51	-57	-57	110	50.39
12.8	24	251.19	11.2	-24.4	-24	-47	-47	-56	-56	129	54.09
15.3	25	316.23	9.7	-22	-22	-39	-39	-55	-55	154	57.04

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 %
-8	5	3.16	13	-36	-36	-74	-74	-78	-78	28	3.14
-3.1	10	10.00	13.1	-36	-36	-72	-72	-77	-77	34	8.17
1.7	15	31.62	13.3	-36	-36	-65	-65	-78	-78	49	17.93
6.7	20	100.00	13.3	-35	-34	-58	-58	-72	-72	78	35.61
9.2	22	158.49	12.8	-29	-29	-50	-50	-62	-62	98	44.92
10.7	23	199.53	12.3	-27	-27	-52	-52	-58	-59	111	49.93
12.6	24	251.19	11.4	-24	-24	-46.8	-46.6	-57	-57	130	53.67
15.1	25	316.23	9.9	-22	-22	-39	-39	-56	-56	160	54.90

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 %
-6.7	5	3.16	11.7	-36	-36	-72	-73	-78	-78	19	5.55
-2.2	10	10.00	12.2	-35	-35	-66	-66	-75	-76	27	12.35
2.4	15	31.62	12.6	-36	-35	-62	-62	-75	-75	43	24.51
7.6	20	100.00	12.4	-31	-31	-50.1	-50	-68	-69	76	43.86
10.7	22	158.49	11.3	-25.2	-25.4	-49	-49	-56	-56	100	52.83
12.7	23	199.53	10.3	-23.4	-23.2	-43	-43	-56	-56	119	55.89
15.8	24	251.19	8.2	-22	-22	-36	-36	-52	-51	150	55.82
20	25	316.23	5	-20	-20	-32	-32	-42	-42	193	54.62

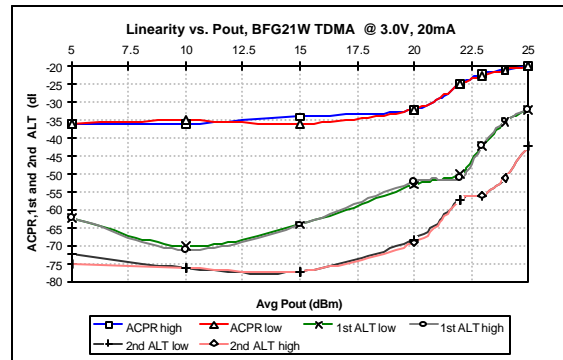
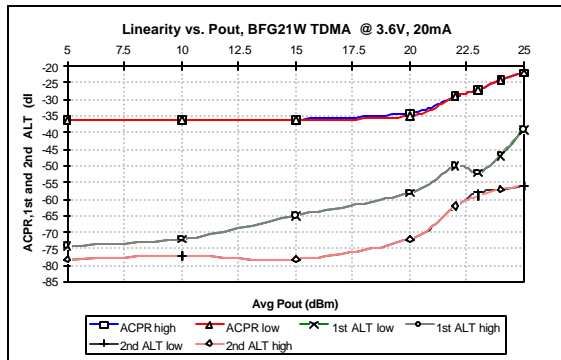
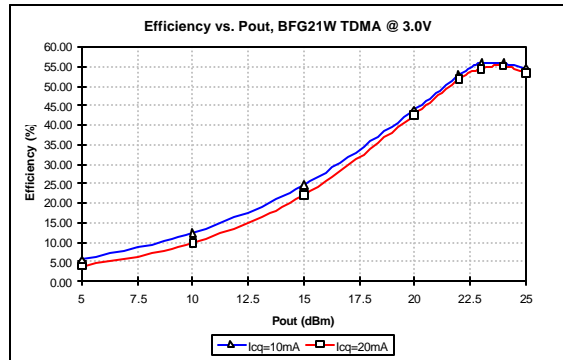
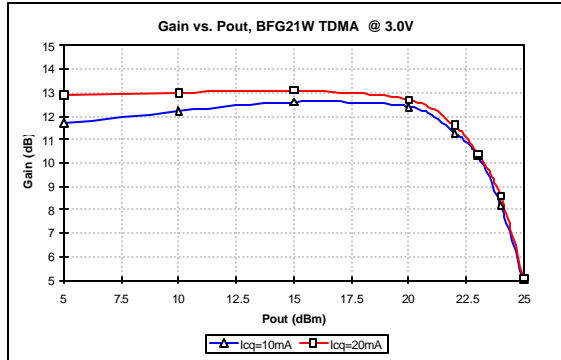
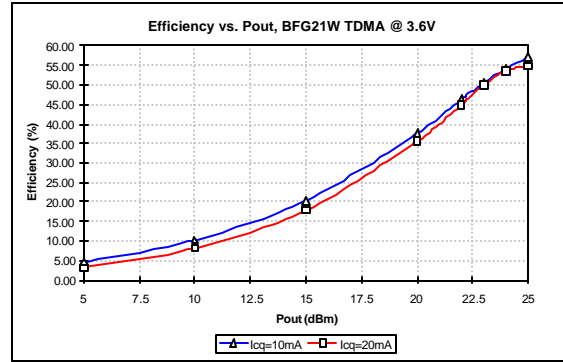
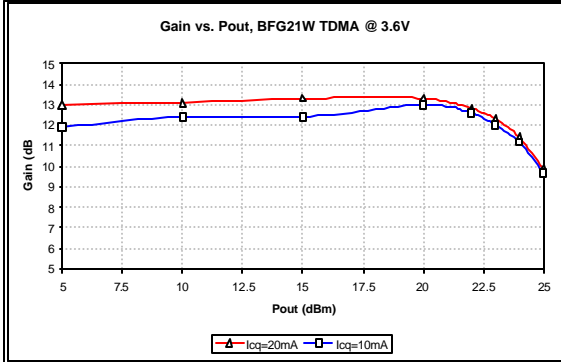
Vc=3.0V, Icq=20mA Vbb=1.17V

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 %
-7.9	5	3.16	12.9	-36	-36	-62	-62	-72	-75	27	3.90
-3	10	10.00	13	-35	-36	-70	-71	-76	-76	34	9.80
1.9	15	31.62	13.1	-36	-34	-64	-64	-77	-77	48	21.96
7.3	20	100.00	12.7	-32	-32	-53	-52	-68	-69	78	42.74
10.4	22	158.49	11.6	-25	-25	-50	-51	-57	-57	102	51.79
12.6	23	199.53	10.4	-22.6	-22	-42	-42	-55.9	-55.8	122	54.52
15.4	24	251.19	8.6	-21	-20.9	-35.6	-35.2	-51	-51	152	55.09
19.9	25	316.23	5.1	-20	-20	-32	-32	-42	-42	197	53.51

It=Ic+Ib, total current draw.



TDMA





CDMA

BFG21W 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 %
-6.7	5	3.16	11.7	-58	-58	17	5.17
-2.3	10	10.00	12.3	-57	-58	26	10.68
2.3	15	31.62	12.7	-58	-62	42	20.91
5	18	63.10	13	-56	-58	58	30.22
7.1	20	100.00	12.9	-49	-49	73	38.05
8.23	21	125.89	12.77	-45	-45	82	42.65
9.6	22	158.49	12.4	-41	-42	94	46.83

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 %
-8.2	5	3.16	13.2	-73	-67	27	3.25
-3.4	10	10.00	13.4	-70	-62	33	8.42
1.4	15	31.62	13.6	-73	-57	48	18.30
4.5	18	63.10	13.5	-61	-54	63	27.82
6.7	20	100.00	13.3	-49	-48	78	35.61
7.9	21	125.89	13.1	-45	-45	88	39.74
9.2	22	158.49	12.8	-42	-41	98	44.92

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 %
-6.7	5	3.16	11.7	-62	-65	19	5.55
-2.4	10	10.00	12.4	-59	-59	27	12.35
2.3	15	31.62	12.7	-58	-60	43	24.51
5.3	18	63.10	12.7	-50	-51	59	35.65
7.7	20	100.00	12.3	-43	-43	75	44.44
9.12	21	125.89	11.88	-40	-40	85	49.37
10.9	22	158.49	11.1	-37	-38	101	52.31

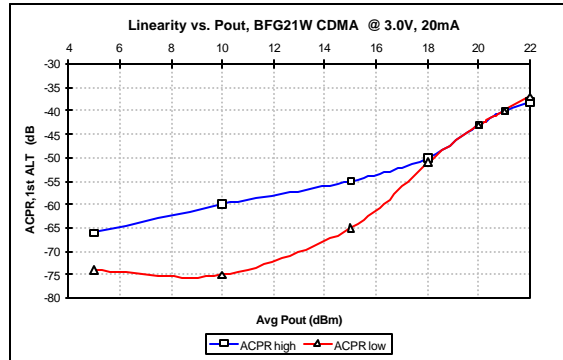
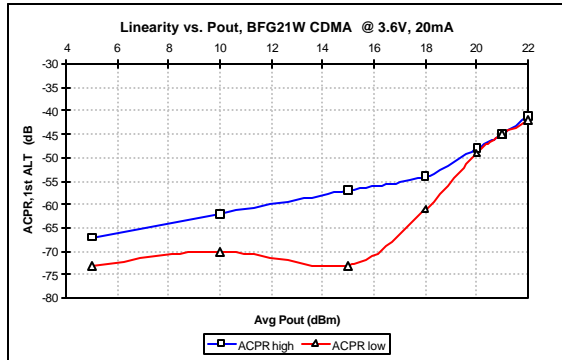
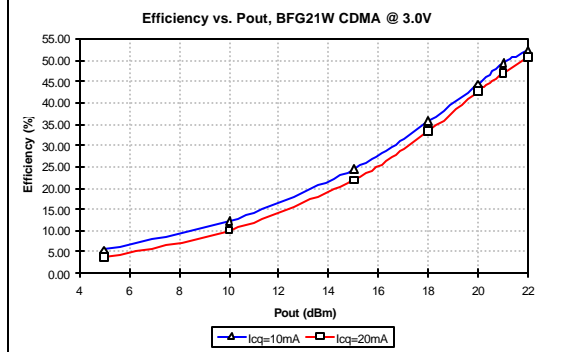
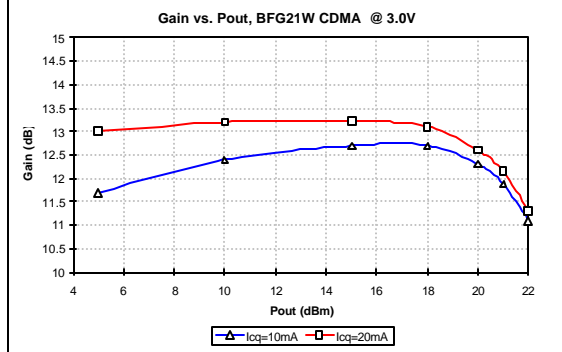
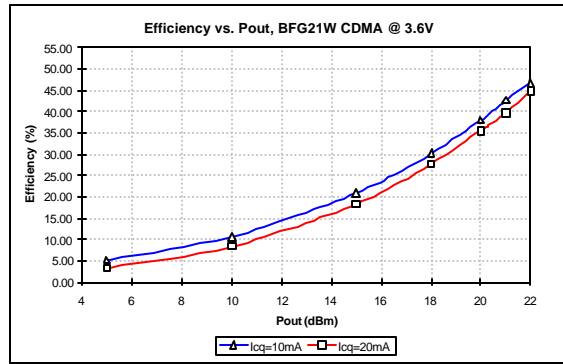
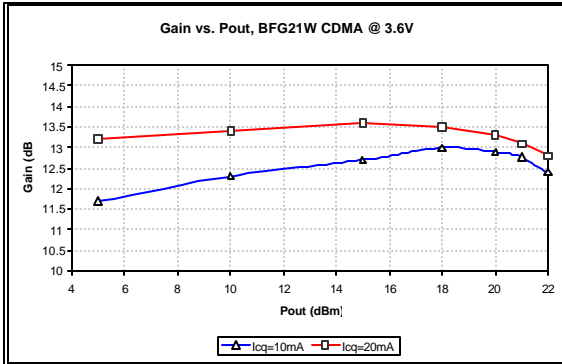
Vc=3.0V, Icq=20mA, Vbb=1.17V

Pin dBm	Pout dBm	Pout mWatt	Gain dB	ACPR low dB	ACPR high dB	It mA	Eff %
-8	5	3.16	13	-74	-66	28	3.76
-3.2	10	10.00	13.2	-75	-60	33	10.10
1.77	15	31.62	13.23	-65	-55	48	21.96
4.9	18	63.10	13.1	-51	-50	63	33.38
7.4	20	100.00	12.6	-43	-43	78	42.74
8.85	21	125.89	12.15	-40	-40	89	47.15
10.7	22	158.49	11.3	-37	-38	104	50.80

It=Ic+Ib, total current draw.



CDMA





APPENDIX 1: Part list for BFG21W 1880 MHz PA driver

Resistors

R1	100 Ω	Leaded wirewound, 0.1W.
R2	5.1 Ω	Philips 0805, 0.1W metal film resistor.
R3	30 Ω	Philips 0805, 0.1W metal film resistor.
R4	10 Ω	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	2.4 pF	ATC100A, matching capacitor
C7	1.0 nF	ATC100A, supply low frequency decoupling capacitor.

Transistors

T1	BFG21W	RF amplifying transistor.
Q1	PMBT3904	Biasing and thermal tracking small signal transistor.



Philips Semiconductors

APPENDIX 2:

Spice parameters of the BFG21W

```
.SUBCKT BFG21W 10 11 12
Lbbond 2 5 7.209E-10
Lblead 5 8 2.251E-10
Lbfoot 8 11 1.1E-10
Cbfoot 8 12 1.17E-13
Lebond 3 6 5.15E-11
Lelead 6 9 6.914E-11
Lefoot 9 12 1.739E-10
Cefoot 9 12 1.95E-13
Lcbond 1 4 5.711E-10
Lclead 4 7 2.251E-10
Lcfoot 7 10 1.1E-10
Ccfoot 7 12 1.17E-13
Cbc 5 4 2E-15
Cbe 5 6 8E-14
Cce 4 6 8E-14
Cbbp 2 14 3.3E-13
Cbpc 1 13 3.47E-13
Cmet 1 3 1.7E-12
Rsub1 14 15 249.2
Rsub2 13 15 464.4
Rmut 3 15 100
Dio 16 1
+ D1
Rs 15 16 3.5
.MODEL D1 D
+ IS = 4.99E-13
+ N = 1.189

Q1 1 2 3 3 NPN
+ AREA = 1
.MODEL NPN NPN
+ IS = 3.835E-16
+ BF = 92
+ NF = 1
+ VAF = 35
+ IKF = 2.8
+ ISE = 9.005E-13
+ NE = 2.262
+ BR = 8.9
+ NR = 1.009
+ VAR = 2.25
+ IKR = 0.6507
+ ISC = 2.503E-15
+ NC = 1.209
+ RB = 1.492
+ IRB = 0
+ RBM = 0.3202
+ RE = 0.3429
+ RC = 0.8
+ CJE = 3.026E-12
+ VJE = 0.9
+ MJE = 0.2861
+ CJC = 1.041E-12
+ VJC = 0.6964
+ MJC = 0.308
+ CJS = 1.844E-12
+ VJS = 0.4237
+ MJS = 0.2606
+ XCJC = 0.5
+ TR = 1.5E-10
+ TF = 5.05E-12
+ XTF = 74
+ VTF = 0.8
+ ITF = 6.5
+ PTF = 0
+ FC = 0.875
+ EG = 1.11
+ XTI = 4.3
+ XTB = 0.5
.END
```