

# DATA SHEET

**BFT93W**

**PNP 4 GHz wideband transistor**

Product specification

February 1995

Supersedes data of November 1992

File under Discrete Semiconductors, SC14

**Philips Semiconductors**



**PHILIPS**

# PNP 4 GHz wideband transistor

# BFT93W

## FEATURES

- High power gain
- Gold metallization ensures excellent reliability
- SOT323 (S-mini) package.

## APPLICATIONS

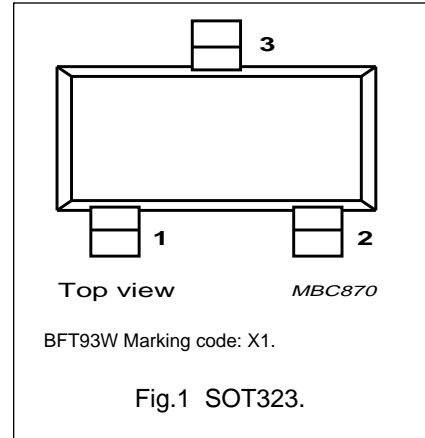
It is intended as a general purpose transistor for wideband applications up to 2 GHz.

## DESCRIPTION

Silicon PNP transistor in a plastic, SOT323 (S-mini) package. The BFT93W uses the same crystal as the SOT23 version, BFT93.

## PINNING

PIN	DESCRIPTION
1	base
2	emitter
3	collector



## QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{CBO}$	collector-base voltage	open emitter	–	–	–15	V
$V_{CEO}$	collector-emitter voltage	open base	–	–	–12	V
$I_C$	collector current (DC)		–	–	–50	mA
$P_{tot}$	total power dissipation	up to $T_s = 93\text{ °C}$ ; note 1	–	–	300	mW
$h_{FE}$	DC current gain	$I_C = -30\text{ mA}$ ; $V_{CE} = -5\text{ V}$	20	50	–	
$C_{re}$	feedback capacitance	$I_C = 0$ ; $V_{CE} = -5\text{ V}$ ; $f = 1\text{ MHz}$	–	1	–	pF
$f_T$	transition frequency	$I_C = -30\text{ mA}$ ; $V_{CE} = -5\text{ V}$ ; $f = 500\text{ MHz}$	–	4	–	GHz
$G_{UM}$	maximum unilateral power gain	$I_C = -30\text{ mA}$ ; $V_{CE} = -5\text{ V}$ ; $f = 500\text{ MHz}$ ; $T_{amb} = 25\text{ °C}$	–	15.5	–	dB
F	noise figure	$I_C = -10\text{ mA}$ ; $V_{CE} = -5\text{ V}$ ; $f = 500\text{ MHz}$	–	2.4	–	dB
$T_j$	junction temperature		–	–	150	°C

### Note

1.  $T_s$  is the temperature at the soldering point of the collector pin.

## PNP 4 GHz wideband transistor

BFT93W

## LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$V_{CBO}$	collector-base voltage	open emitter	–	–15	V
$V_{CEO}$	collector-emitter voltage	open base	–	–12	V
$V_{EBO}$	emitter-base voltage	open collector	–	–2	V
$I_C$	collector current (DC)		–	–50	mA
$P_{tot}$	total power dissipation	up to $T_s = 93\text{ °C}$ ; note 1	–	300	mW
$T_{stg}$	storage temperature		–65	+150	°C
$T_j$	junction temperature		–	150	°C

## THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th\ j-s}$	thermal resistance from junction to soldering point	up to $T_s = 93\text{ °C}$ ; note 1	190	K/W

## Note to the “Limiting values” and “Thermal characteristics”

- $T_s$  is the temperature at the soldering point of the collector pin.

## CHARACTERISTICS

 $T_j = 25\text{ °C}$  (unless otherwise specified).

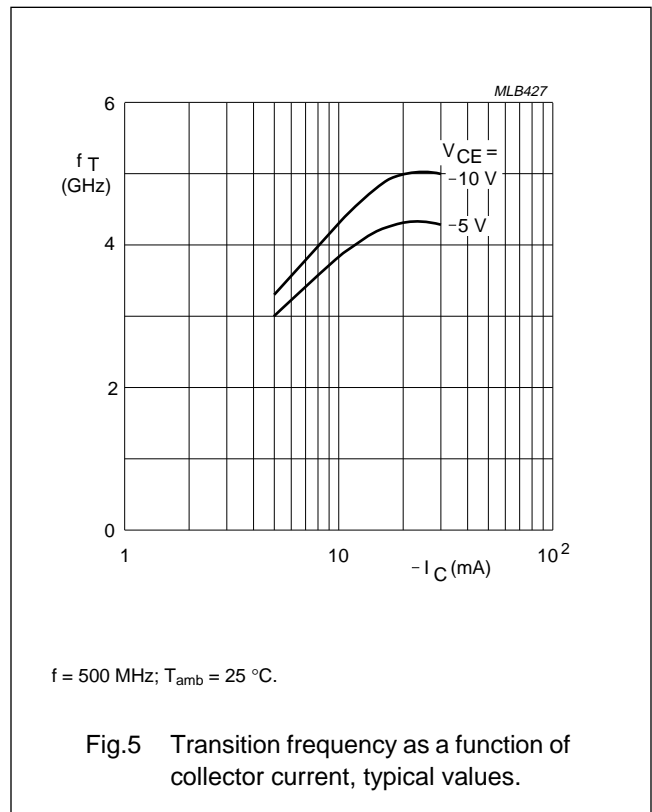
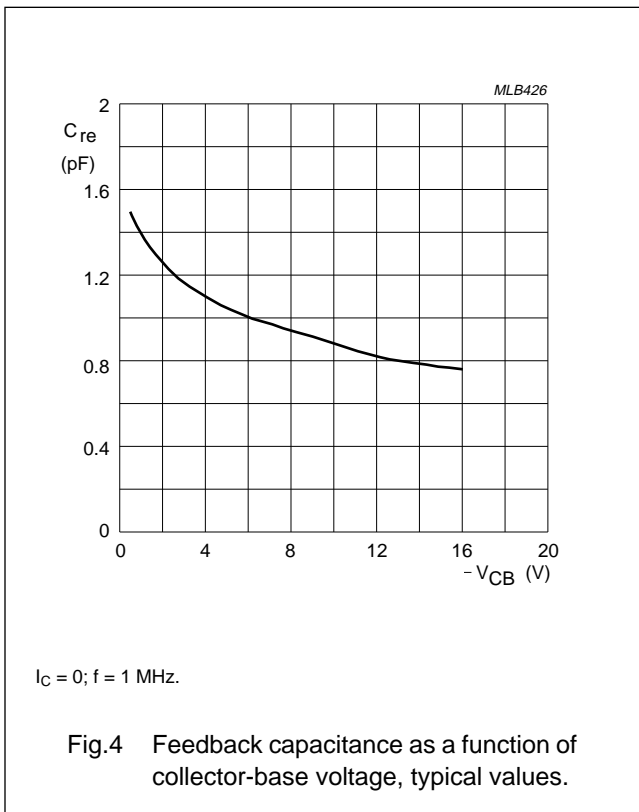
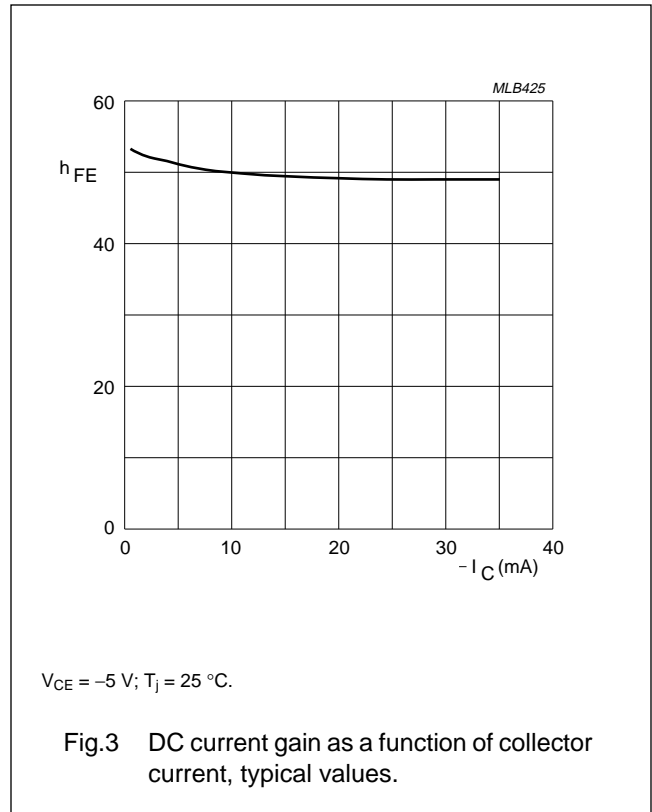
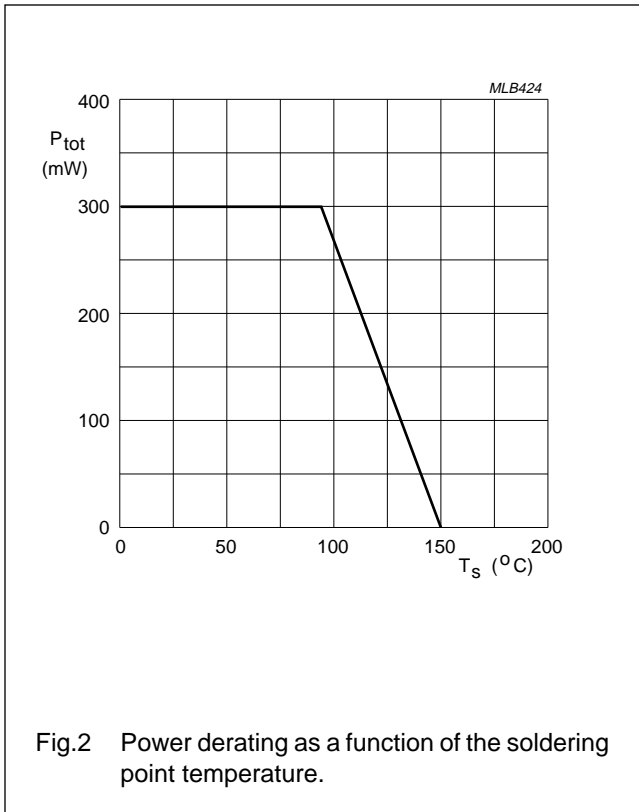
SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$I_{CBO}$	collector cut-off current	$I_E = 0$ ; $V_{CB} = -5\text{ V}$	–	–	–50	nA
$h_{FE}$	DC current gain	$I_C = -30\text{ mA}$ ; $V_{CE} = -5\text{ V}$	20	50	–	
$f_T$	transition frequency	$I_C = -30\text{ mA}$ ; $V_{CE} = -5\text{ V}$ ; $f = 500\text{ MHz}$ ; $T_{amb} = 25\text{ °C}$	–	4	–	GHz
$C_c$	collector capacitance	$I_E = i_e = 0$ ; $V_{CB} = -5\text{ V}$ ; $f = 1\text{ MHz}$	–	1.2	–	pF
$C_e$	emitter capacitance	$I_C = i_c = 0$ ; $V_{EB} = -0.5\text{ V}$ ; $f = 1\text{ MHz}$	–	1.4	–	pF
$C_{re}$	feedback capacitance	$I_C = 0$ ; $V_{CE} = -5\text{ V}$ ; $f = 1\text{ MHz}$	–	1	–	pF
$G_{UM}$	maximum unilateral power gain; note 1	$I_C = -30\text{ mA}$ ; $V_{CE} = -5\text{ V}$ ; $f = 500\text{ MHz}$ ; $T_{amb} = 25\text{ °C}$	–	15.5	–	dB
		$I_C = -30\text{ mA}$ ; $V_{CE} = -5\text{ V}$ ; $f = 1\text{ GHz}$ ; $T_{amb} = 25\text{ °C}$	–	10	–	dB
F	noise figure	$\Gamma_s = \Gamma_{opt}$ ; $I_C = -10\text{ mA}$ ; $V_{CE} = -5\text{ V}$ ; $f = 500\text{ MHz}$	–	2.4	–	dB
		$\Gamma_s = \Gamma_{opt}$ ; $I_C = -10\text{ mA}$ ; $V_{CE} = -5\text{ V}$ ; $f = 1\text{ GHz}$	–	3	–	dB

## Note

- $G_{UM}$  is the maximum unilateral power gain, assuming  $s_{12}$  is zero.  $G_{UM} = 10 \log \frac{|s_{21}|^2}{(1 - |s_{11}|^2)(1 - |s_{22}|^2)} \text{ dB}$ .

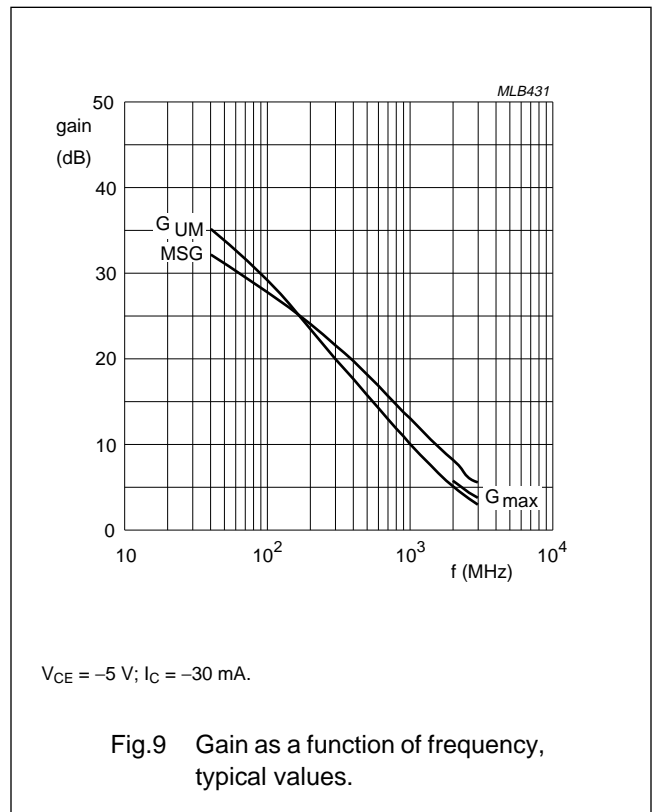
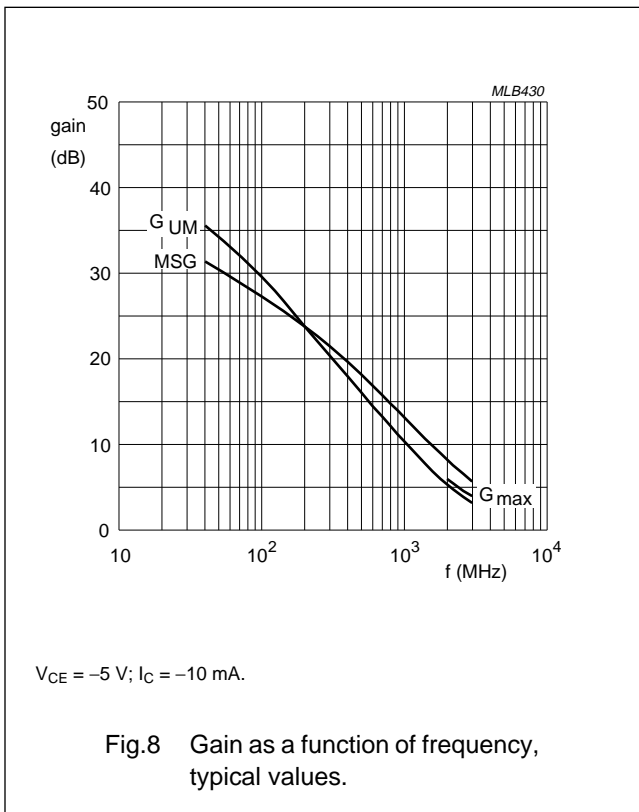
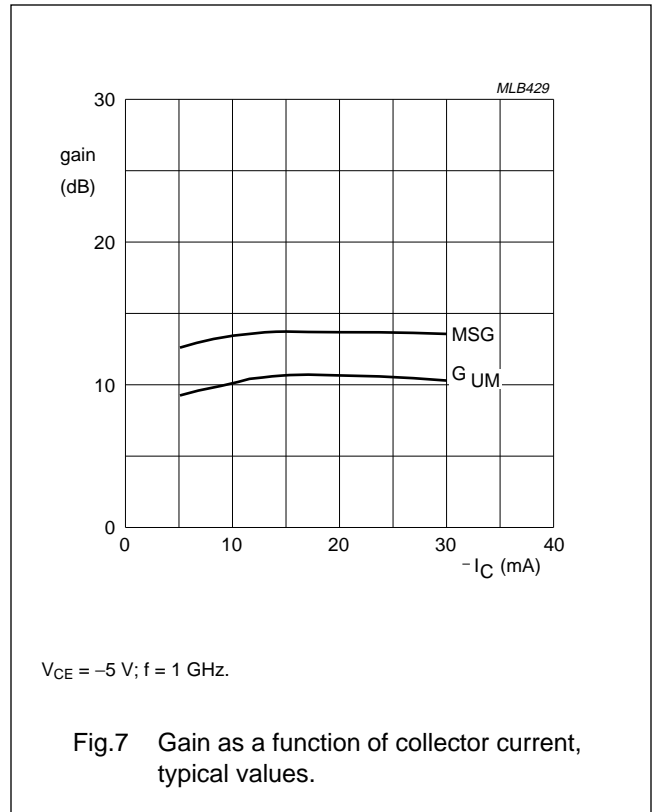
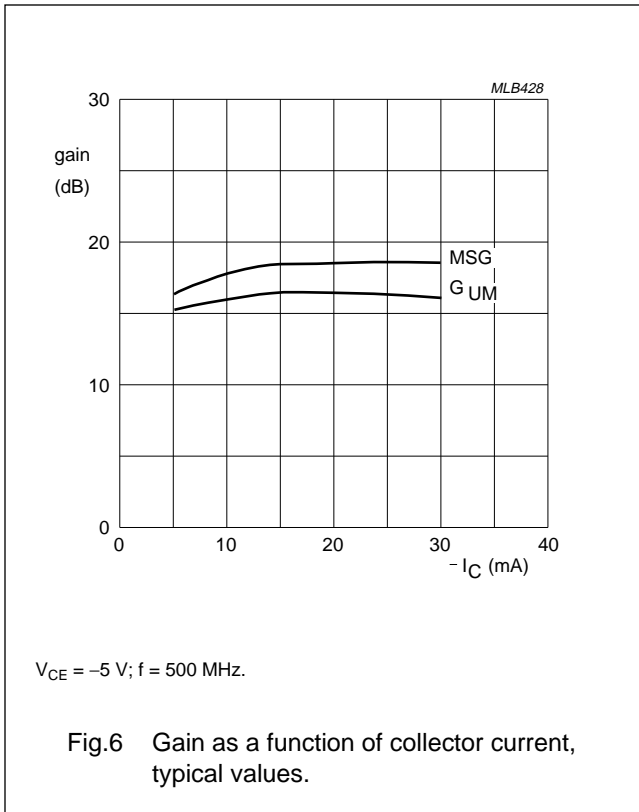
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BFT93W



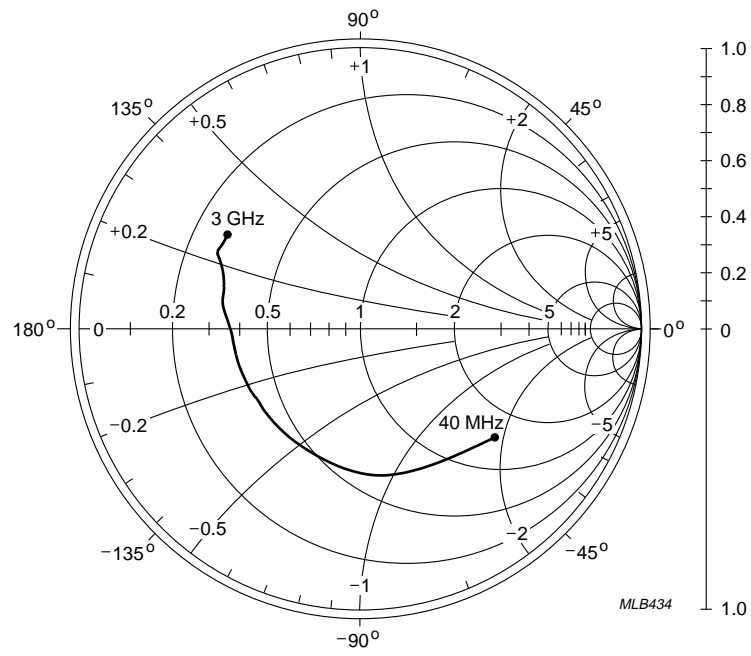
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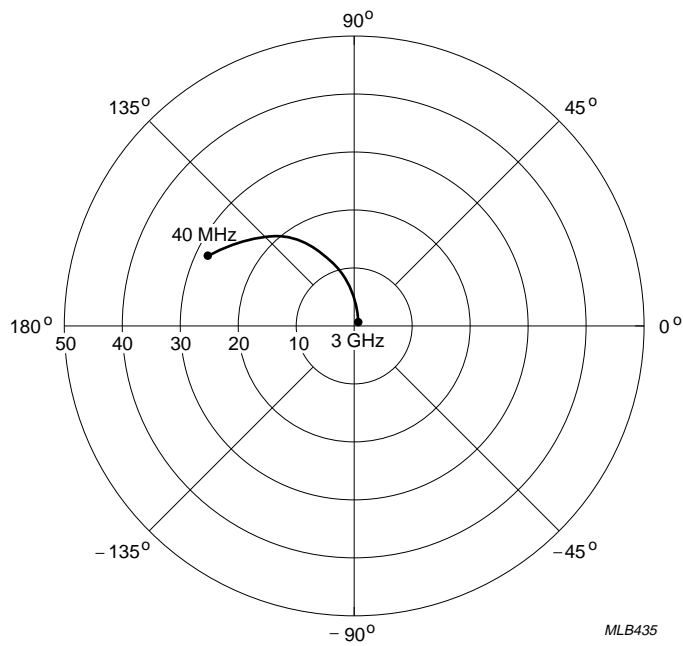
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$V_{CE} = -10\text{ V}; I_C = -30\text{ mA}$ .

Fig.10 Common emitter input reflection coefficient ( $s_{11}$ ), typical values.

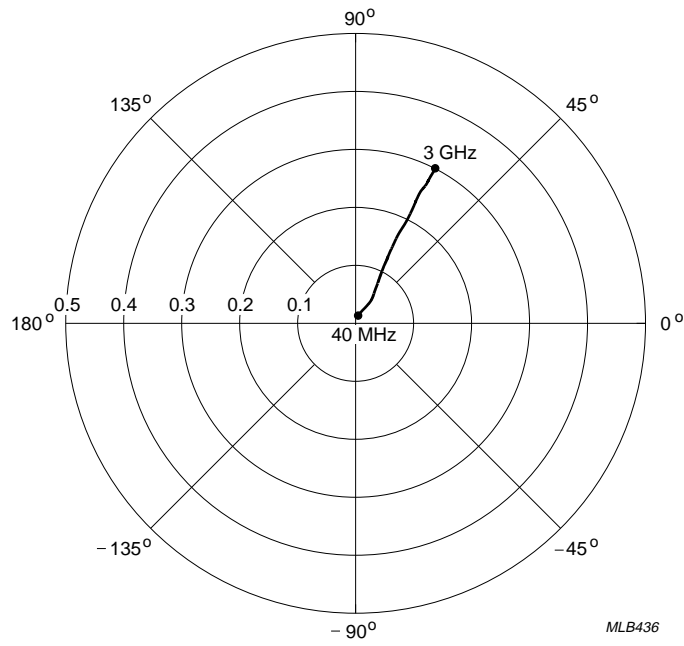


$V_{CE} = -10\text{ V}; I_C = -30\text{ mA}$ .

Fig.11 Common emitter forward transmission coefficient ( $s_{21}$ ), typical values.

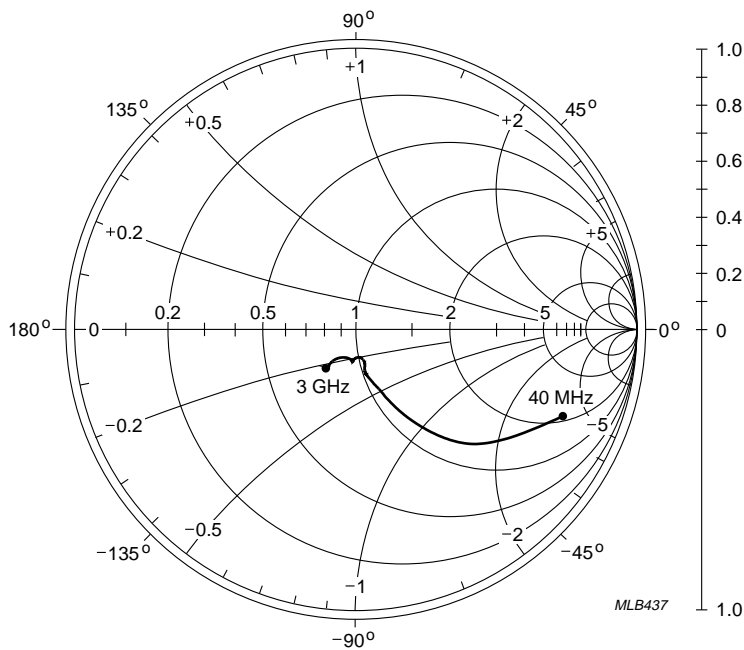
PNP 4 GHz wideband transistor

BFT93W



$V_{CE} = -10\text{ V}; I_C = -30\text{ mA}$ .

Fig.12 Common emitter reverse transmission coefficient ( $s_{12}$ ), typical values.

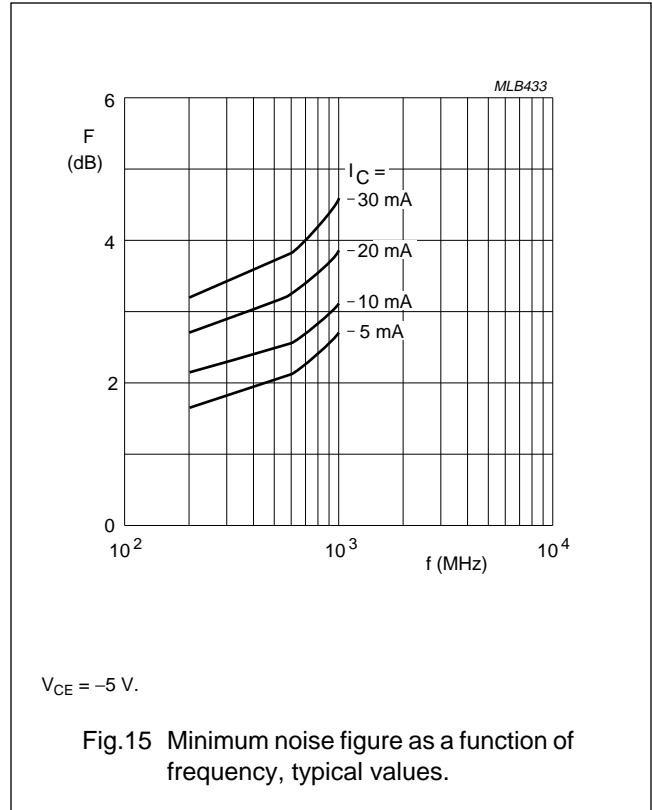
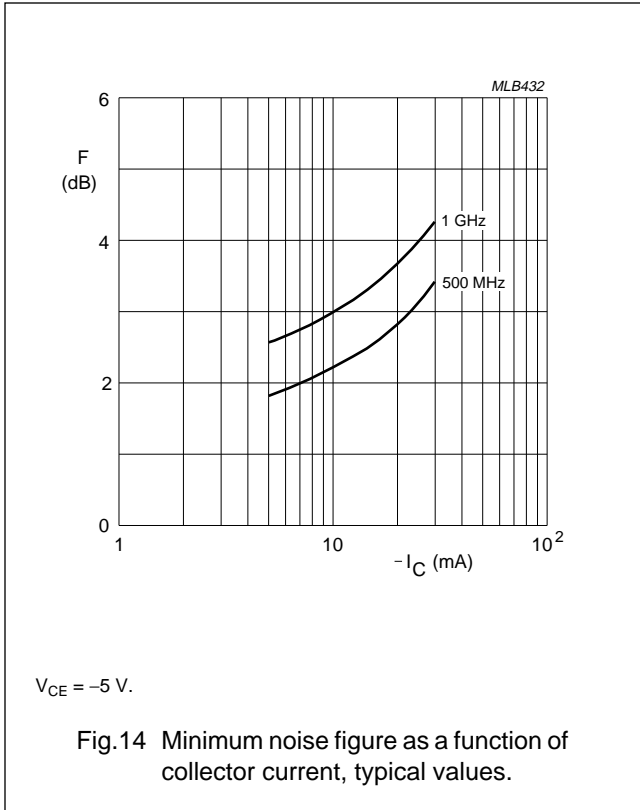


$V_{CE} = -10\text{ V}; I_C = -30\text{ mA}$ .

Fig.13 Common emitter output reflection coefficient ( $s_{22}$ ), typical values.

PNP 4 GHz wideband transistor

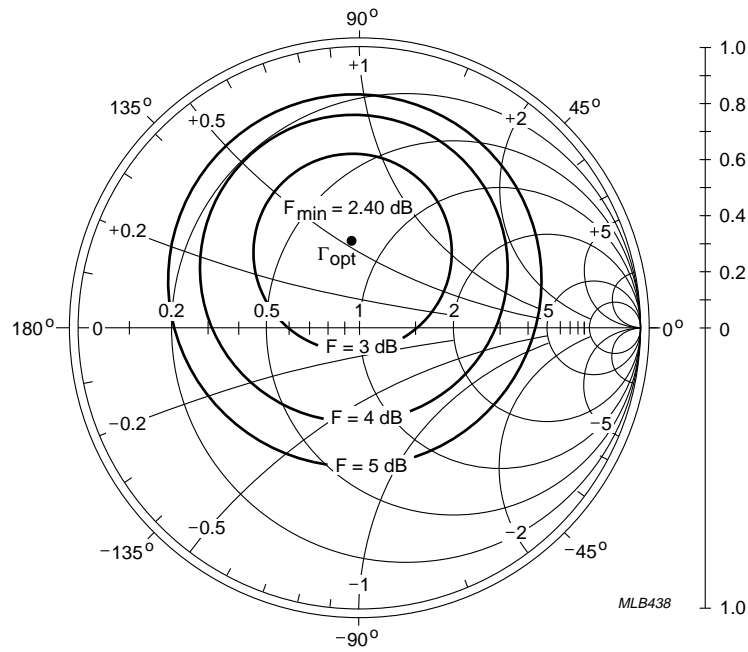
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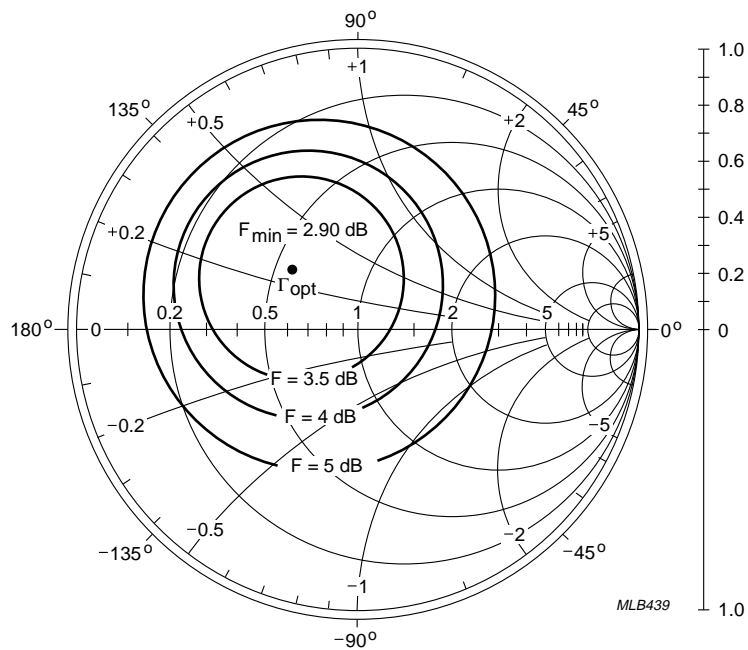
PNP 4 GHz wideband transistor

BFT93W



$V_{CE} = -5\text{ V}$ ;  $I_C = -10\text{ mA}$ ;  $f = 500\text{ MHz}$ ;  $Z_o = 50\ \Omega$ .

Fig.16 Common emitter noise figure circles, typical values.



$V_{CE} = -5\text{ V}$ ;  $I_C = -10\text{ mA}$ ;  $f = 1\text{ GHz}$ ;  $Z_o = 50\ \Omega$ .

Fig.17 Common emitter noise figure circles, typical values.

## PNP 4 GHz wideband transistor

## BFT93W

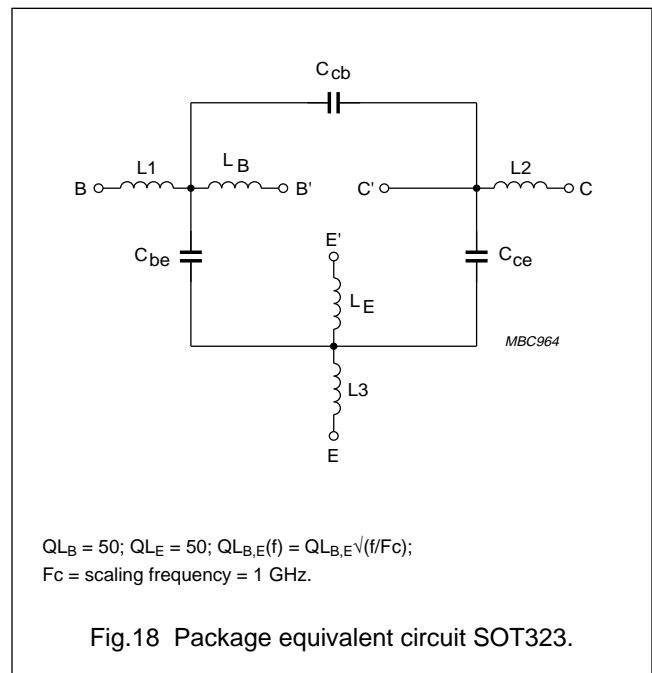
## SPICE parameters for the BFT93W crystal

SEQUENCE No.	PARAMETER	VALUE	UNIT
1	IS	835.1	aA
2	BF	48.56	–
3	NF	1.000	–
4	VAF	19.01	V
5	IKF	146.8	mA
6	ISE	90.94	fA
7	NE	1.749	–
8	BR	12.18	–
9	NR	997.6	m
10	VAR	3.374	V
11	IKR	6.742	mA
12	ISC	23.42	fA
13	NC	1.449	–
14	RB	10.00	$\Omega$
15	IRB	1.000	$\mu$ A
16	RBM	10.00	$\Omega$
17	RE	200.0	m $\Omega$
18	RC	3.800	$\Omega$
19 <sup>(1)</sup>	XTB	0.000	–
20 <sup>(1)</sup>	EG	1.110	EV
21 <sup>(1)</sup>	XTI	3.000	–
22	CJE	1.570	pF
23	VJE	600.0	mV
24	MJE	382.2	m
25	TF	14.85	ps
26	XTF	2.209	–
27	VTF	2.989	V
28	ITF	14.37	mA
29	PTF	0.000	deg
30	CJC	1.995	pF
31	VJC	584.4	mV
32	MJC	281.3	m
33	XCJC	120.0	m
34	TR	3.000	ns
35 <sup>(1)</sup>	CJS	0.000	F

SEQUENCE No.	PARAMETER	VALUE	UNIT
36 <sup>(1)</sup>	VJS	750.0	mV
37 <sup>(1)</sup>	MJS	0.000	–
38	FC	811.6	m

## Note

1. These parameters have not been extracted, the default values are shown.



## List of components (see Fig.18).

DESIGNATION	VALUE	UNIT
$C_{be}$	2	fF
$C_{cb}$	100	fF
$C_{ce}$	100	fF
L1	0.34	nH
L2	0.10	nH
L3	0.34	nH
$L_B$	0.60	nH
$L_E$	0.60	nH

## PNP 4 GHz wideband transistor

## BFT93W

**Table 1** Common emitter scattering parameters:  $V_{CE} = -5$  V;  $I_C = -5$  mA.

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		G <sub>UM</sub> (dB)
	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	
40	0.759	-20.5	11.294	165.0	0.023	78.5	0.945	-12.3	34.5
100	0.711	-49.0	10.079	147.7	0.050	64.5	0.834	-27.8	28.3
200	0.630	-88.0	8.082	126.7	0.076	51.2	0.631	-44.0	22.5
300	0.586	-113.6	6.355	113.1	0.090	45.1	0.491	-52.8	19.1
400	0.566	-130.5	5.116	104.1	0.099	42.9	0.403	-58.5	16.6
500	0.557	-141.8	4.266	97.5	0.107	42.8	0.349	-62.5	14.8
600	0.551	-150.5	3.653	92.2	0.113	43.7	0.316	-65.2	13.3
700	0.546	-157.1	3.193	87.7	0.120	44.9	0.293	-66.8	12.0
800	0.543	-162.7	2.838	83.9	0.127	46.2	0.277	-67.7	10.9
900	0.541	-167.6	2.551	80.4	0.133	47.6	0.263	-68.1	9.9
1000	0.541	-172.0	2.323	77.4	0.140	49.1	0.249	-68.7	9.1
1200	0.549	-179.4	1.975	71.7	0.153	51.6	0.223	-71.8	7.7
1400	0.559	174.8	1.737	66.4	0.168	53.8	0.212	-78.3	6.6
1600	0.565	170.3	1.555	61.7	0.183	55.2	0.215	-84.5	5.7
1800	0.566	165.6	1.420	57.7	0.197	56.8	0.220	-87.5	4.9
2000	0.575	160.5	1.310	54.2	0.213	58.3	0.215	-91.0	4.3
2200	0.594	156.3	1.217	51.1	0.228	59.7	0.208	-98.1	3.8
2400	0.613	153.7	1.135	47.7	0.242	60.6	0.217	-107.7	3.4
2600	0.623	151.4	1.064	44.8	0.255	60.9	0.242	-114.1	2.9
2800	0.618	148.2	1.019	41.7	0.271	61.5	0.264	-116.9	2.6
3000	0.621	144.5	0.975	39.3	0.289	61.9	0.275	-119.3	2.2

**Table 2** Noise data:  $V_{CE} = -5$  V;  $I_C = -5$  mA.

f (MHz)	F <sub>min</sub> (dB)	Γ <sub>opt</sub>		R <sub>n</sub>
		(ratio)	(deg)	
500	1.80	0.307	86.5	0.320
1000	2.55	0.358	121.0	0.280

## PNP 4 GHz wideband transistor

## BFT93W

**Table 3** Common emitter scattering parameters:  $V_{CE} = -5$  V;  $I_C = -10$  mA.

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		G <sub>UM</sub> (dB)
	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	
40	0.608	-31.5	18.195	160.2	0.020	75.6	0.900	-18.0	34.4
100	0.571	-72.1	15.044	138.8	0.041	60.6	0.725	-38.4	28.5
200	0.538	-114.5	10.475	117.4	0.059	51.1	0.490	-56.6	23.1
300	0.531	-136.1	7.676	106.0	0.070	49.3	0.360	-66.3	19.7
400	0.531	-149.0	5.989	98.6	0.079	50.2	0.287	-73.0	17.4
500	0.532	-157.3	4.907	93.2	0.088	51.8	0.245	-77.9	15.5
600	0.534	-163.6	4.161	88.9	0.097	53.8	0.221	-81.4	14.1
700	0.533	-168.6	3.613	85.1	0.106	55.4	0.204	-83.2	12.8
800	0.532	-172.9	3.195	81.8	0.116	56.9	0.192	-84.2	11.7
900	0.534	-176.8	2.866	78.8	0.125	58.1	0.179	-84.5	10.7
1000	0.535	179.7	2.603	76.2	0.135	59.3	0.167	-85.3	9.9
1200	0.545	173.7	2.206	71.2	0.153	61.0	0.145	-90.1	8.5
1400	0.557	169.2	1.931	66.6	0.172	62.0	0.140	-98.7	7.4
1600	0.561	165.5	1.724	62.2	0.191	62.3	0.149	-104.6	6.5
1800	0.563	161.2	1.570	58.5	0.208	62.7	0.154	-106.3	5.7
2000	0.574	156.6	1.447	55.2	0.227	63.2	0.150	-109.4	5.0
2200	0.593	153.0	1.343	52.4	0.244	63.7	0.148	-117.9	4.5
2400	0.612	150.6	1.251	49.2	0.260	64.0	0.165	-127.5	4.1
2600	0.620	148.8	1.171	46.3	0.274	63.5	0.192	-131.8	3.6
2800	0.616	146.0	1.122	43.2	0.290	63.3	0.213	-132.1	3.3
3000	0.618	142.3	1.074	40.7	0.309	63.2	0.223	-133.3	2.9

**Table 4** Noise data:  $V_{CE} = -5$  V;  $I_C = -10$  mA.

f (MHz)	F <sub>min</sub> (dB)	Γ <sub>opt</sub>		R <sub>n</sub>
		(ratio)	(deg)	
500	2.40	0.304	94.7	0.430
1000	2.90	0.321	136.9	0.270

## PNP 4 GHz wideband transistor

## BFT93W

**Table 5** Common emitter scattering parameters:  $V_{CE} = -5$  V;  $I_C = -20$  mA.

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		G <sub>UM</sub> (dB)
	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	
40	0.450	-49.1	25.274	154.6	0.018	72.5	0.830	-24.1	34.1
100	0.475	-99.1	18.682	130.2	0.034	59.2	0.608	-47.9	28.5
200	0.502	-135.9	11.661	110.7	0.047	54.5	0.379	-67.2	23.3
300	0.516	-151.8	8.244	101.0	0.058	55.6	0.270	-77.9	20.0
400	0.526	-161.1	6.342	94.7	0.068	58.1	0.215	-86.1	17.7
500	0.530	-167.1	5.156	90.2	0.079	60.1	0.185	-92.5	15.8
600	0.534	-171.9	4.350	86.3	0.089	61.9	0.169	-96.7	14.4
700	0.535	-175.7	3.768	83.0	0.101	63.2	0.157	-98.7	13.1
800	0.536	-179.1	3.326	80.1	0.112	64.0	0.147	-99.8	12.0
900	0.538	177.7	2.980	77.3	0.123	64.8	0.137	-100.5	11.1
1000	0.541	174.9	2.703	74.9	0.134	65.4	0.127	-101.9	10.2
1200	0.554	169.8	2.285	70.3	0.154	66.2	0.111	-109.1	8.8
1400	0.566	166.1	1.995	65.9	0.175	66.6	0.112	-118.8	7.7
1600	0.571	162.6	1.777	61.7	0.195	66.0	0.125	-122.9	6.8
1800	0.573	158.8	1.616	58.2	0.214	66.0	0.130	-123.1	6.0
2000	0.585	154.4	1.488	55.0	0.234	66.1	0.127	-126.2	5.3
2200	0.604	151.0	1.380	52.4	0.252	66.2	0.130	-135.1	4.8
2400	0.624	148.8	1.285	49.4	0.268	66.2	0.152	-143.0	4.4
2600	0.633	147.1	1.200	46.6	0.282	65.5	0.180	-144.7	3.9
2800	0.626	144.3	1.148	43.5	0.299	65.0	0.199	-143.3	3.5
3000	0.629	140.8	1.100	41.0	0.319	64.7	0.208	-143.7	3.2

**Table 6** Noise data:  $V_{CE} = -5$  V;  $I_C = -20$  mA.

f (MHz)	F <sub>min</sub> (dB)	Γ <sub>opt</sub>		R <sub>n</sub>
		(ratio)	(deg)	
500	2.80	0.301	100.8	0.610
1000	3.60	0.356	152.2	0.280

## PNP 4 GHz wideband transistor

## BFT93W

**Table 7** Common emitter scattering parameters:  $V_{CE} = -5$  V;  $I_C = -30$  mA.

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		G <sub>UM</sub> (dB)
	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	
40	0.382	-62.3	28.063	151.4	0.016	71.2	0.781	-27.1	33.7
100	0.453	-113.1	19.479	126.1	0.030	58.8	0.543	-51.8	28.3
200	0.502	-144.8	11.682	107.7	0.043	56.8	0.327	-70.7	23.1
300	0.521	-158.0	8.162	98.8	0.054	58.9	0.232	-81.5	19.8
400	0.532	-165.8	6.248	92.9	0.065	61.4	0.185	-89.9	17.5
500	0.537	-170.8	5.069	88.6	0.076	63.4	0.161	-96.5	15.7
600	0.542	-174.9	4.269	84.9	0.088	65.0	0.148	-100.5	14.2
700	0.543	-178.2	3.692	81.7	0.099	65.8	0.139	-102.3	13.0
800	0.545	178.7	3.258	78.8	0.111	66.4	0.131	-103.2	11.9
900	0.548	176.0	2.917	76.1	0.122	67.0	0.123	-103.6	10.9
1000	0.552	173.2	2.644	73.8	0.133	67.4	0.114	-104.8	10.1
1200	0.565	168.6	2.233	69.2	0.154	68.0	0.101	-112.5	8.7
1400	0.577	165.0	1.948	64.9	0.175	68.2	0.105	-121.9	7.6
1600	0.584	161.7	1.734	60.8	0.195	67.5	0.119	-125.4	6.7
1800	0.586	157.9	1.577	57.3	0.214	67.3	0.125	-125.0	5.8
2000	0.598	153.6	1.451	54.2	0.234	67.3	0.124	-128.3	5.2
2200	0.620	150.3	1.345	51.5	0.252	67.5	0.129	-137.0	4.8
2400	0.639	148.1	1.251	48.7	0.269	67.5	0.152	-144.6	4.3
2600	0.646	146.3	1.169	46.0	0.284	66.6	0.181	-146.1	3.8
2800	0.642	143.4	1.118	43.0	0.300	66.2	0.200	-144.7	3.4
3000	0.644	139.8	1.071	40.5	0.321	65.7	0.210	-145.0	3.1

**Table 8** Noise data:  $V_{CE} = -5$  V;  $I_C = -30$  mA.

f (MHz)	F <sub>min</sub> (dB)	Γ <sub>opt</sub>		R <sub>n</sub>
		(ratio)	(deg)	
500	3.40	0.308	104.2	0.830
1000	4.20	0.380	164.0	0.310

## PNP 4 GHz wideband transistor

## BFT93W

**Table 9** Common emitter scattering parameters:  $V_{CE} = -10$  V;  $I_C = -5$  mA.

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		G <sub>UM</sub> (dB)
	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	
40	0.837	-16.8	11.098	166.4	0.020	80.4	0.947	-10.2	36.0
100	0.781	-40.2	10.061	150.4	0.046	67.6	0.856	-23.6	29.9
200	0.670	-73.9	8.331	130.4	0.073	54.7	0.674	-38.2	23.6
300	0.592	-98.6	6.727	116.7	0.088	48.3	0.537	-46.3	19.9
400	0.547	-116.1	5.490	107.3	0.098	45.8	0.447	-51.2	17.3
500	0.523	-128.7	4.616	100.5	0.106	45.2	0.389	-54.5	15.4
600	0.507	-138.6	3.971	94.9	0.114	45.6	0.352	-56.5	13.8
700	0.495	-146.1	3.476	90.3	0.121	46.4	0.327	-57.6	12.5
800	0.487	-152.5	3.094	86.3	0.129	47.3	0.309	-58.0	11.4
900	0.481	-158.1	2.782	82.6	0.136	48.2	0.294	-57.8	10.4
1000	0.478	-163.1	2.532	79.5	0.143	49.3	0.279	-57.8	9.5
1200	0.483	-171.8	2.155	73.7	0.156	51.0	0.250	-59.2	8.1
1400	0.493	-178.2	1.895	68.4	0.171	52.4	0.234	-63.8	7.0
1600	0.499	176.9	1.694	63.6	0.185	53.2	0.232	-69.2	6.1
1800	0.501	172.0	1.541	59.6	0.198	54.4	0.233	-71.8	5.3
2000	0.509	166.5	1.418	55.9	0.212	55.5	0.227	-74.1	4.6
2200	0.529	161.8	1.317	52.6	0.224	56.5	0.215	-79.5	4.0
2400	0.550	158.8	1.228	49.0	0.236	57.2	0.215	-88.7	3.6
2600	0.564	156.7	1.148	45.9	0.246	57.5	0.232	-96.4	3.1
2800	0.564	153.7	1.100	42.8	0.259	58.2	0.253	-100.1	2.8
3000	0.569	150.0	1.051	40.2	0.274	58.9	0.262	-102.7	2.4

**Table 10** Noise data:  $V_{CE} = -10$  V;  $I_C = -5$  mA.

f (MHz)	F <sub>min</sub> (dB)	Γ <sub>opt</sub>		R <sub>n</sub>
		(ratio)	(deg)	
500	2.00	0.340	73.0	0.440
1000	2.50	0.380	105.0	0.360

## PNP 4 GHz wideband transistor

## BFT93W

**Table 11** Common emitter scattering parameters:  $V_{CE} = -10$  V;  $I_C = -10$  mA.

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		G <sub>UM</sub> (dB)
	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	
40	0.744	-24.2	18.034	162.0	0.019	77.2	0.902	-15.2	35.9
100	0.666	-56.4	15.339	142.3	0.040	63.6	0.757	-33.0	30.0
200	0.556	-95.4	11.171	121.0	0.059	53.5	0.533	-49.6	24.0
300	0.507	-119.1	8.353	109.0	0.071	50.8	0.398	-57.9	20.5
400	0.485	-134.4	6.576	101.2	0.081	51.0	0.319	-63.2	18.0
500	0.474	-144.5	5.412	95.6	0.090	52.2	0.272	-66.9	16.1
600	0.469	-152.4	4.597	91.1	0.099	53.7	0.243	-69.2	14.6
700	0.465	-158.4	3.997	87.2	0.108	54.9	0.224	-70.3	13.3
800	0.461	-163.5	3.537	83.9	0.118	56.1	0.209	-70.3	12.2
900	0.459	-168.1	3.170	80.8	0.128	57.0	0.196	-69.7	11.2
1000	0.460	-172.3	2.875	78.2	0.137	57.8	0.183	-69.3	10.4
1200	0.469	-179.3	2.435	73.1	0.155	59.1	0.157	-71.0	8.9
1400	0.482	175.4	2.130	68.4	0.173	59.8	0.144	-77.4	7.8
1600	0.488	171.5	1.898	64.1	0.191	59.7	0.147	-83.7	6.8
1800	0.489	167.2	1.723	60.4	0.207	59.9	0.150	-85.2	6.0
2000	0.501	162.2	1.584	57.0	0.224	60.3	0.144	-87.1	5.3
2200	0.522	158.0	1.469	54.0	0.239	60.6	0.134	-94.3	4.8
2400	0.543	155.4	1.367	50.7	0.253	60.7	0.140	-106.3	4.3
2600	0.557	153.8	1.278	47.8	0.264	60.3	0.162	-113.7	3.9
2800	0.556	151.0	1.222	44.7	0.278	60.4	0.183	-115.3	3.5
3000	0.560	147.6	1.168	42.1	0.295	60.4	0.192	-116.6	3.1

**Table 12** Noise data:  $V_{CE} = -10$  V;  $I_C = -10$  mA.

f (MHz)	F <sub>min</sub> (dB)	Γ <sub>opt</sub>		R <sub>n</sub>
		(ratio)	(deg)	
500	2.40	0.270	83.0	0.400
1000	2.90	0.350	115.0	0.350



## PNP 4 GHz wideband transistor

## BFT93W

**Table 13** Common emitter scattering parameters:  $V_{CE} = -10$  V;  $I_C = -20$  mA.

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		G <sub>UM</sub> (dB)
	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	
40	0.655	-33.6	25.207	156.9	0.018	74.2	0.840	-20.3	35.8
100	0.568	-73.8	19.459	133.9	0.035	61.0	0.644	-41.3	29.8
200	0.487	-113.4	12.634	113.7	0.050	54.9	0.416	-58.0	24.0
300	0.463	-134.1	9.050	103.5	0.061	55.1	0.299	-66.3	20.6
400	0.456	-146.7	6.997	96.9	0.072	56.9	0.236	-72.0	18.2
500	0.453	-154.7	5.702	92.1	0.082	58.5	0.200	-76.3	16.3
600	0.453	-161.0	4.818	88.2	0.093	60.0	0.179	-79.0	14.8
700	0.451	-165.7	4.171	84.8	0.104	61.0	0.165	-79.9	13.5
800	0.451	-169.9	3.683	81.8	0.115	61.8	0.155	-79.9	12.4
900	0.452	-173.7	3.297	79.0	0.126	62.4	0.143	-79.0	11.4
1000	0.454	-177.3	2.986	76.6	0.137	62.9	0.132	-78.5	10.6
1200	0.467	176.6	2.521	71.9	0.157	63.4	0.110	-81.6	9.2
1400	0.482	172.4	2.200	67.6	0.176	63.4	0.103	-90.5	8.0
1600	0.490	168.8	1.956	63.6	0.195	62.8	0.110	-97.4	7.1
1800	0.493	164.8	1.774	60.1	0.212	62.7	0.114	-98.0	6.2
2000	0.505	159.8	1.630	56.8	0.230	62.7	0.109	-100.1	5.6
2200	0.528	155.9	1.509	54.1	0.245	62.8	0.103	-109.7	5.0
2400	0.550	153.6	1.405	51.0	0.260	62.7	0.115	-122.8	4.6
2600	0.563	151.9	1.312	48.1	0.273	62.2	0.141	-128.2	4.1
2800	0.562	149.2	1.253	45.2	0.287	62.0	0.160	-127.8	3.7
3000	0.565	145.8	1.199	42.6	0.305	61.7	0.169	-128.3	3.4

**Table 14** Noise data:  $V_{CE} = -10$  V;  $I_C = -20$  mA.

f (MHz)	F <sub>min</sub> (dB)	Γ <sub>opt</sub>		R <sub>n</sub>
		(ratio)	(deg)	
500	3.00	0.240	98.0	0.440
1000	3.60	0.320	131.0	0.400

## PNP 4 GHz wideband transistor

## BFT93W

**Table 15** Common emitter scattering parameters:  $V_{CE} = -10$  V;  $I_C = -30$  mA.

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		G <sub>UM</sub> (dB)
	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	MAGNITUDE (ratio)	ANGLE (deg)	
40	0.617	-39.1	28.045	153.9	0.017	73.1	0.797	-22.6	35.4
100	0.529	-82.4	20.389	129.6	0.032	60.3	0.583	-44.1	29.4
200	0.464	-120.8	12.630	110.4	0.047	56.4	0.364	-59.3	23.7
300	0.449	-139.7	8.920	101.0	0.058	57.3	0.259	-66.3	20.3
400	0.446	-151.0	6.853	94.8	0.069	59.4	0.204	-71.2	17.9
500	0.446	-158.1	5.569	90.3	0.081	60.9	0.174	-75.0	16.0
600	0.448	-163.5	4.694	86.5	0.092	62.2	0.158	-77.2	14.5
700	0.449	-167.8	4.060	83.3	0.103	63.0	0.147	-77.7	13.2
800	0.450	-171.7	3.579	80.4	0.115	63.6	0.139	-77.1	12.1
900	0.452	-175.1	3.204	77.7	0.126	63.8	0.131	-75.9	11.2
1000	0.456	-178.5	2.902	75.4	0.136	64.1	0.122	-75.0	10.3
1200	0.472	175.9	2.448	70.8	0.157	64.3	0.103	-77.7	8.9
1400	0.488	171.7	2.134	66.6	0.176	64.2	0.097	-87.1	7.8
1600	0.498	168.1	1.898	62.5	0.194	63.6	0.106	-94.6	6.9
1800	0.502	164.0	1.721	59.1	0.211	63.4	0.112	-95.7	6.0
2000	0.516	159.3	1.580	56.0	0.229	63.5	0.108	-98.0	5.4
2200	0.539	155.4	1.464	53.2	0.245	63.7	0.103	-108.1	4.8
2400	0.562	152.9	1.362	50.2	0.260	63.6	0.116	-121.5	4.4
2600	0.575	151.2	1.273	47.4	0.272	63.0	0.141	-127.4	3.9
2800	0.573	148.4	1.217	44.5	0.287	62.9	0.162	-127.3	3.5
3000	0.576	144.7	1.164	42.0	0.305	62.6	0.172	-128.1	3.2

**Table 16** Noise data:  $V_{CE} = -10$  V;  $I_C = -30$  mA.

f (MHz)	F <sub>min</sub> (dB)	Γ <sub>opt</sub>		R <sub>n</sub>
		(ratio)	(deg)	
500	3.60	0.250	101.0	0.550
1000	4.20	0.310	143.0	0.480



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