

## NPN 6 GHz wideband transistor



BFR91A

PHILIPS INTERNATIONAL

56E D ■ 7110826 0045709 572 ■ PHIN

## FEATURES

- Low noise
- Low intermodulation distortion
- High power gain
- Gold metallization.

## DESCRIPTION

NPN transistor in a plastic SOT37 envelope primarily intended for use in RF wideband amplifiers.

A SOT54 (TO-92) version (ref: ON4185) is available on request.

PNP complement is BFQ23.

## PINNING

PIN	DESCRIPTION
Code: BFR91A/02	
1	base
2	emitter
3	collector

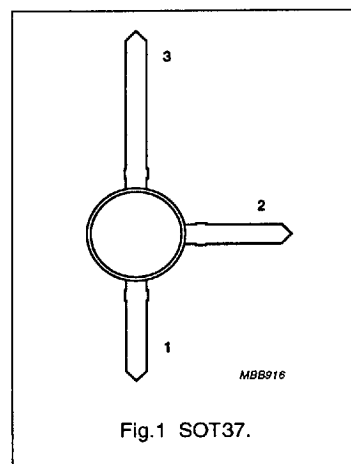


Fig.1 SOT37.

## QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	TYP.	MAX.	UNIT
$V_{CBO}$	collector-base voltage	open emitter	—	15	V
$V_{CEO}$	collector-emitter voltage	open base	—	12	V
$I_C$	DC collector current		—	35	mA
$P_{tot}$	total power dissipation	up to $T_s = 155^\circ\text{C}$ (note 1)	—	300	mW
$f_T$	transition frequency	$I_C = 30\text{ mA}$ ; $V_{CE} = 5\text{ V}$ ; $f = 500\text{ MHz}$ ; $T_j = 25^\circ\text{C}$	6	—	GHz
$C_{re}$	feedback capacitance	$I_C = 0$ ; $V_{CE} = 10\text{ V}$ ; $f = 1\text{ MHz}$ ; $T_{amb} = 25^\circ\text{C}$	0.6	—	pF
$G_{UM}$	maximum unilateral power gain	$I_C = 30\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ; $f = 800\text{ MHz}$ ; $T_{amb} = 25^\circ\text{C}$	14	—	dB
F	noise figure	$I_C = 4\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ; $f = 800\text{ MHz}$ ; $T_{amb} = 25^\circ\text{C}$ ; $Z_S = \text{opt.}$	1.6	—	dB
$V_O$	output voltage	$d_m = -60\text{ dB}$ ; $I_C = 30\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ; $R_L = 75\ \Omega$ ; $T_{amb} = 25^\circ\text{C}$ ; $f_{(p+q-r)} = 793.25\text{ MHz}$	425	—	mV
$P_{L1}$	output power at 1 dB gain compression	$I_C = 30\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ; $R_L = 75\ \Omega$ ; $T_{amb} = 25^\circ\text{C}$ ; measured at $f = 800\text{ MHz}$	17	—	dBm
ITO	third order intercept point	$I_C = 30\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ; $R_L = 75\ \Omega$ ; $T_{amb} = 25^\circ\text{C}$	36	—	dBm

## Note

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

## NPN 6 GHz wideband transistor

T-31-17

BFR91A

PHILIPS INTERNATIONAL

56E D

7110826 0045710 294 PHIN

**LIMITING VALUES**

In accordance with the Absolute Maximum 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
$I_C$	DC collector current		—	35	mA
$P_{tot}$	total power dissipation	up to $T_s = 155\text{ °C}$ (note 1)	—	300	mW
$T_{stg}$	storage temperature		−65	150	°C
$T_j$	junction temperature		—	175	°C

**THERMAL RESISTANCE**

SYMBOL	PARAMETER	CONDITIONS	THERMAL RESISTANCE
$R_{th\ j-s}$	thermal resistance from junction to soldering point	up to $T_s = 155\text{ °C}$ (note 1)	65 K/W

**Note**

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

## NPN 6 GHz wideband transistor

T-31-17

BFR91A

PHILIPS INTERNATIONAL

56E D ■ 7110826 0045711 120 ■ PHIN

## CHARACTERISTICS

 $T_j = 25\text{ }^{\circ}\text{C}$  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	$I_C = 30\text{ mA}; V_{CE} = 5\text{ V}$	40	90	—	
$f_T$	transition frequency	$I_C = 30\text{ mA}; V_{CE} = 5\text{ V}; f = 500\text{ MHz}$	—	6	—	GHz
$C_c$	collector capacitance	$I_E = I_C = 0; V_{CB} = 10\text{ V}; f = 1\text{ MHz}$	—	0.9	—	pF
$C_e$	emitter capacitance	$I_C = I_E = 0; V_{EB} = 0.5\text{ V}; f = 1\text{ MHz}$	—	2.5	—	pF
$C_{re}$	feedback capacitance	$I_C = 0; V_{CE} = 10\text{ V}; f = 1\text{ MHz};$ $T_{amb} = 25\text{ }^{\circ}\text{C}$	—	0.6	—	pF
$G_{UM}$	maximum unilateral power gain (note 1)	$I_C = 30\text{ mA}; V_{CE} = 8\text{ V}; f = 800\text{ MHz};$ $T_{amb} = 25\text{ }^{\circ}\text{C}$	—	14	—	dB
F	noise figure	$I_C = 4\text{ mA}; V_{CE} = 8\text{ V}; f = 800\text{ MHz};$ $T_{amb} = 25\text{ }^{\circ}\text{C}; Z_S = \text{opt.}$	—	1.6	—	dB
		$I_C = 30\text{ mA}; V_{CE} = 8\text{ V}; f = 2\text{ GHz};$ $T_{amb} = 25\text{ }^{\circ}\text{C}; Z_S = \text{opt.}$	—	2.3	—	dB
$V_O$	output voltage	see Figs 2 and 8 and note 2	—	425	—	mV
		see Figs 2 and 12 and note 3	—	200	—	mV
$P_{L1}$	output power at 1 dB gain compression (see Fig.2)	$I_C = 30\text{ mA}; V_{CE} = 8\text{ V}; R_L = 75\text{ }\Omega;$ $T_{amb} = 25\text{ }^{\circ}\text{C};$ measured at $f = 800\text{ MHz}$	—	17	—	dBm
ITO	third order intercept point	see Fig.2 and note 4	—	36	—	dBm

## Notes

- $G_{UM}$  is the maximum unilateral power gain, assuming  $S_{12}$  is zero and  $G_{UM} = 10 \log \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$  dB.
- $d_{im} = -60\text{ dB}$  (DIN 45004B);  $I_C = 30\text{ mA}; V_{CE} = 8\text{ V}; R_L = 75\text{ }\Omega; T_{amb} = 25\text{ }^{\circ}\text{C};$   
 $V_p = V_O$  at  $d_{im} = -60\text{ dB}; f_p = 795.25\text{ MHz};$   
 $V_q = V_O - 6\text{ dB}; f_q = 803.25\text{ MHz};$   
 $V_r = V_O - 6\text{ dB}; f_r = 805.25\text{ MHz};$   
 measured at  $f_{(p+q-r)} = 793.25\text{ MHz}.$
- $d_2 = -50\text{ dB}; I_C = 30\text{ mA}; V_{CE} = 8\text{ V}; R_L = 75\text{ }\Omega; T_{amb} = 25\text{ }^{\circ}\text{C};$   
 $V_p = V_O$  at  $d_2 = -50\text{ dB}; f_p = 250\text{ MHz};$   
 $V_q = V_O$  at  $d_2 = -50\text{ dB}; f_q = 560\text{ MHz};$   
 measured at  $f_{(p+q)} = 810\text{ MHz}.$
- $I_C = 30\text{ mA}; V_{CE} = 8\text{ V}; R_L = 75\text{ }\Omega; T_{amb} = 25\text{ }^{\circ}\text{C};$   
 $P_p = \text{ITO} - 6\text{ dB}; f_p = 800\text{ MHz};$   
 $P_q = \text{ITO} - 6\text{ dB}; f_q = 801\text{ MHz};$   
 measured at  $f_{(2p-q)} = 802\text{ MHz}$  and  $f_{(2p-q)} = 799\text{ MHz}.$

## NPN 6 GHz wideband transistor

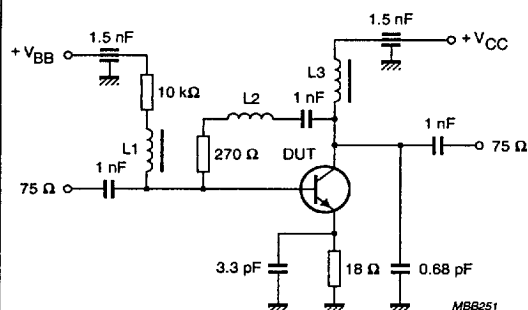
T-31-17

BFR91A

PHILIPS INTERNATIONAL

56E D

7110826 0045712 067 PHIN



$L1 = L3 = 5 \mu\text{H}$  microchoke.

$L2 = 3$  turns  $0.4 \text{ mm}$  copper wire; winding pitch  $1 \text{ mm}$ ; internal diameter  $3 \text{ mm}$ .

Fig.2 Intermodulation distortion and second order intermodulation distortion test circuit.

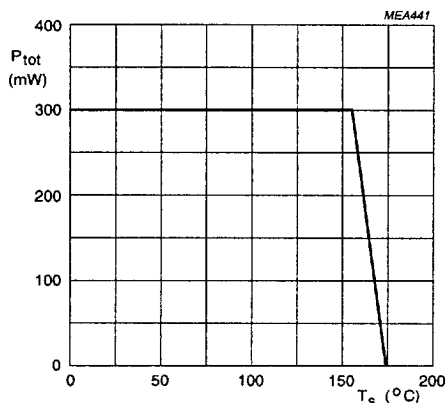
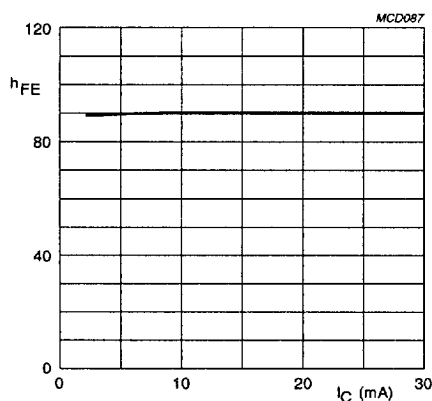
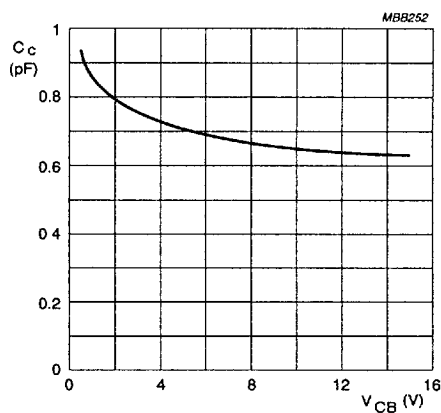


Fig.3 Power derating curve.



$V_{CE} = 5 \text{ V}$ ;  $T_j = 25^\circ\text{C}$ .

Fig.4 DC current gain as a function of collector current.



$I_E = I_B = 0$ ;  $f = 1 \text{ MHz}$ ;  $T_j = 25^\circ\text{C}$ .

Fig.5 Collector capacitance as a function of collector-base voltage.

T-31-17

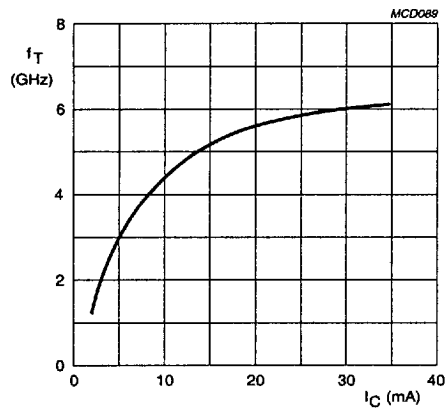
## NPN 6 GHz wideband transistor

BFR91A

PHILIPS INTERNATIONAL

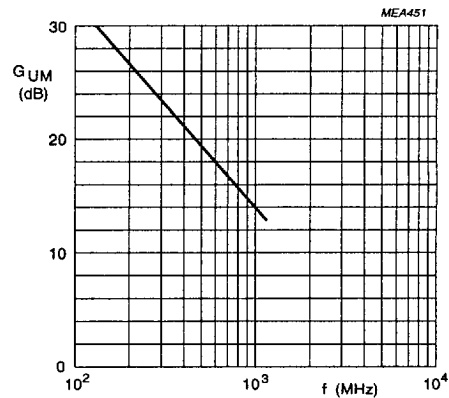
56E D

7110826 0045713 TT3 PHIN



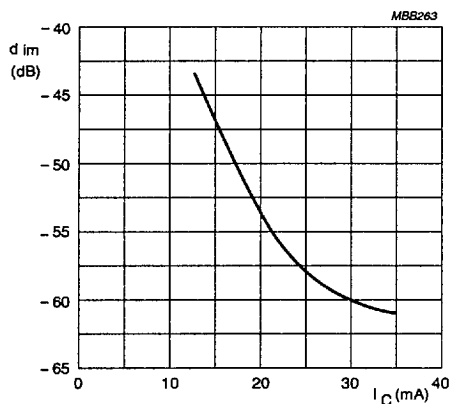
$V_{CE} = 5 \text{ V}$ ;  $f = 500 \text{ MHz}$ ;  $T_j = 25^\circ \text{C}$ .

Fig.6 Transition frequency as a function of collector current.



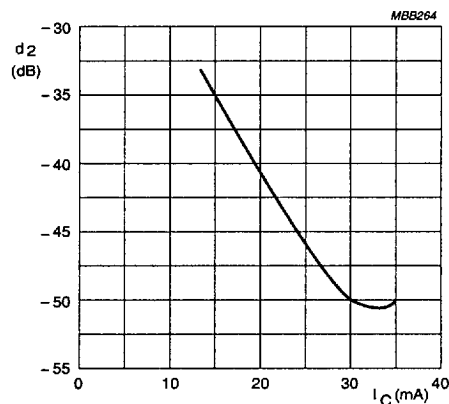
$I_C = 30 \text{ mA}$ ;  $V_{CE} = 8 \text{ V}$ ;  $T_{amb} = 25^\circ \text{C}$ .

Fig.7 Maximum unilateral power gain as a function of frequency.



$V_{CE} = 8 \text{ V}$ ;  $V_O = 425 \text{ mV} = 52.60 \text{ dBmV}$ ;  
 $f_{(p+q-r)} = 793.25 \text{ MHz}$ ;  $T_{amb} = 25^\circ \text{C}$ ;  
 measured in test circuit (see Fig.2).

Fig.8 Intermodulation distortion as a function of collector current.



$V_{CE} = 8 \text{ V}$ ;  $V_O = 200 \text{ mV} = 46 \text{ dBmV}$ ;  
 $f_{(p+q)} = 810 \text{ MHz}$ ;  $T_{amb} = 25^\circ \text{C}$ ;  
 measured in test circuit (see Fig.2).

Fig.9 Second order intermodulation distortion as a function of collector current.

## NPN 6 GHz wideband transistor

BFR91A

PHILIPS INTERNATIONAL

56E D

7110826 0045714 93T PHIN

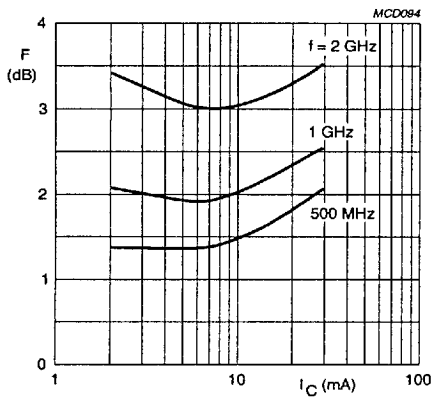
 $V_{CE} = 8$  V;  $T_{amb} = 25$  °C.

Fig.10 Minimum noise figure as a function of collector current.

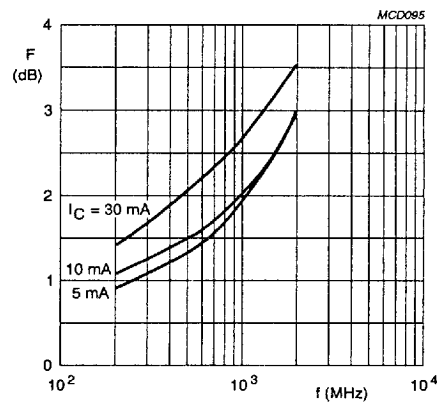
 $V_{CE} = 8$  V;  $T_{amb} = 25$  °C.

Fig.11 Minimum noise figure as a function of frequency.

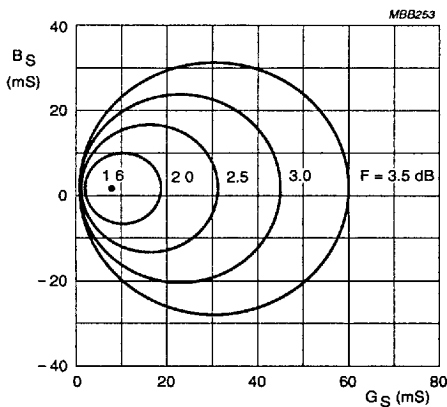
 $I_C = 4$  mA;  $V_{CE} = 8$  V;  $f = 800$  MHz;  $T_{amb} = 25$  °C.

Fig.12 Noise circle figure.

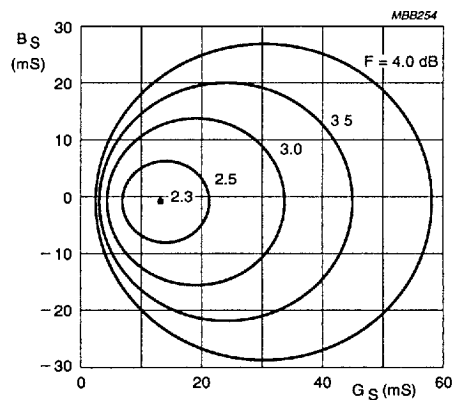
 $I_C = 30$  mA;  $V_{CE} = 8$  V;  $f = 800$  MHz;  $T_{amb} = 25$  °C.

Fig.13 Noise circle figure.

## NPN 6 GHz wideband transistor

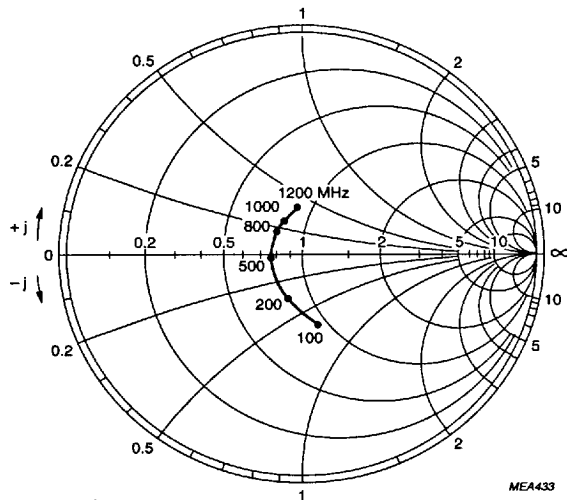
BFR91A

PHILIPS INTERNATIONAL

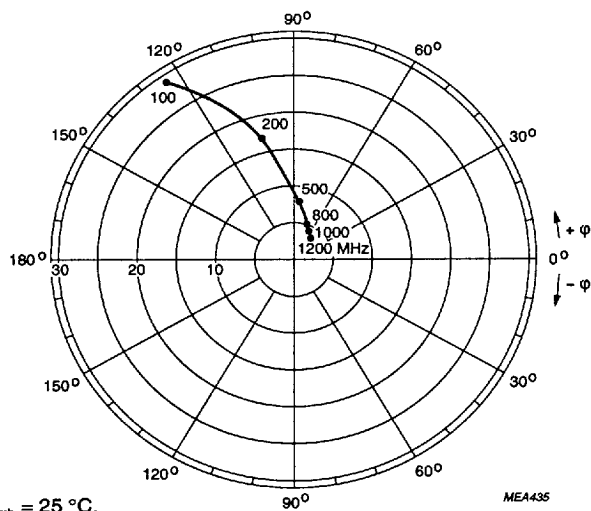
56E D

7110826 0045715 876 PHIN

## PHIN

 $I_C = 30 \text{ mA}; V_{CE} = 8 \text{ V}; T_{\text{amb}} = 25^\circ \text{C}.$ 

**Fig.14 Common emitter input reflection coefficient ( $S_{11}$ ).**


$$I_C = 30 \text{ mA}; V_{CE} = 8 \text{ V}; T_{\text{amb}} = 25^\circ \text{C}.$$

**Fig.15 Common emitter forward transmission coefficient ( $S_{21}$ ).**

## NPN 6 GHz wideband transistor

T-31-17

BFR91A

PHILIPS INTERNATIONAL

56E D



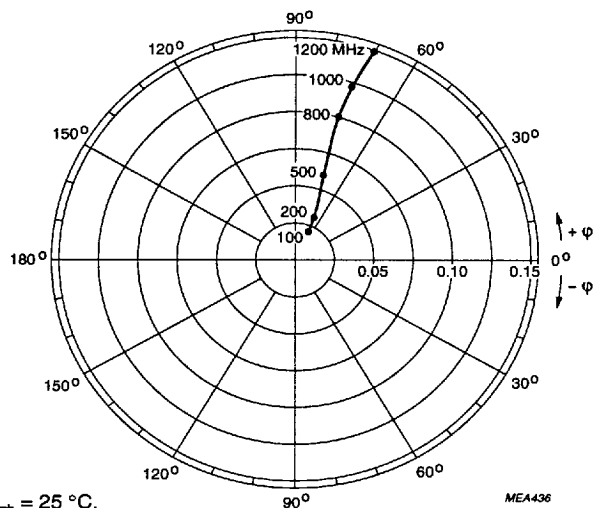
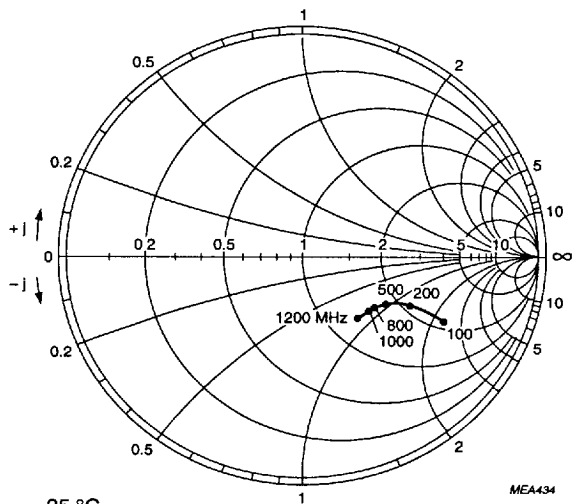
7110826

0045716

702



PHIN

Fig.16 Common emitter reverse transmission coefficient ( $S_{12}$ ).Fig.17 Common emitter output reflection coefficient ( $S_{22}$ ).



## NPN 6 GHz wideband transistor

T-31-17

BFR91A

PHILIPS INTERNATIONAL

56E D

7110826 0045717 649 PHIN

Table 1 Common emitter scattering parameters,  $I_C = 20$  mA;  $V_{CE} = 5$  V

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		G <sub>UM</sub> (dB)
	MAG. (RAT)	ANG. (DEG)	MAG. (RAT)	ANG. (DEG)	MAG. (RAT)	ANG. (DEG)	MAG. (RAT)	ANG. (DEG)	
40	0.479	-33.9	36.860	152.9	0.010	78.4	0.894	-16.9	39.4
100	0.350	-71.5	26.190	127.3	0.020	70.2	0.683	-29.3	31.7
200	0.234	-109.6	15.844	107.9	0.034	70.3	0.501	-32.4	25.5
300	0.194	-136.0	11.107	98.3	0.046	72.0	0.429	-31.9	22.0
400	0.180	-154.6	8.502	91.9	0.059	73.3	0.396	-31.8	19.5
500	0.177	-168.1	6.879	87.2	0.072	73.4	0.377	-32.5	17.6
600	0.175	-179.6	5.792	83.4	0.085	73.2	0.367	-33.9	16.0
700	0.173	170.2	5.017	79.6	0.098	72.5	0.360	-35.5	14.7
800	0.174	160.3	4.427	76.2	0.110	71.7	0.355	-37.2	13.6
900	0.178	149.6	3.945	72.8	0.123	71.2	0.349	-38.8	12.6
1000	0.188	140.5	3.563	70.0	0.136	70.1	0.342	-40.6	11.7
1200	0.220	127.1	3.008	64.3	0.161	68.0	0.324	-45.4	10.3
1400	0.252	118.4	2.641	58.9	0.184	65.8	0.305	-51.6	9.1
1600	0.267	111.7	2.332	53.7	0.209	63.8	0.297	-58.9	8.1
1800	0.282	102.8	2.103	49.2	0.231	61.2	0.288	-65.6	7.2
2000	0.311	93.0	1.928	44.2	0.254	58.8	0.278	-71.3	6.5
2200	0.356	86.3	1.800	39.9	0.275	56.2	0.257	-77.9	6.0
2400	0.396	82.0	1.671	34.7	0.296	54.5	0.230	-87.8	5.4
2600	0.418	78.9	1.560	31.5	0.318	51.4	0.217	-100.5	4.9
2800	0.428	73.2	1.486	26.6	0.332	49.0	0.221	-112.7	4.5
3000	0.451	66.5	1.383	22.5	0.352	47.7	0.224	-121.9	4.0

T-31-17

## NPN 6 GHz wideband transistor

BFR91A

PHILIPS INTERNATIONAL

56E D ■ 7110826 0045718 585 ■ PHIN

Table 2 Common emitter scattering parameters,  $I_C = 30$  mA;  $V_{CE} = 5$  V

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		G <sub>UM</sub> (dB)
	MAG. (RAT)	ANG. (DEG)	MAG. (RAT)	ANG. (DEG)	MAG. (RAT)	ANG. (DEG)	MAG. (RAT)	ANG. (DEG)	
40	0.377	-40.1	43.686	148.7	0.009	77.3	0.858	-19.8	39.3
100	0.262	-81.4	28.795	122.5	0.019	72.9	0.621	-31.5	31.6
200	0.181	-120.9	16.681	104.7	0.032	74.4	0.452	-32.5	25.6
300	0.160	-147.3	11.556	96.0	0.046	74.9	0.391	-31.3	22.1
400	0.156	-164.4	8.808	90.3	0.059	76.0	0.364	-31.2	19.6
500	0.158	-176.4	7.109	86.0	0.073	75.7	0.348	-32.1	17.7
600	0.158	173.5	5.977	82.4	0.087	74.8	0.340	-33.6	16.2
700	0.158	164.1	5.171	78.9	0.100	74.0	0.334	-35.3	14.9
800	0.161	154.8	4.562	75.6	0.113	73.0	0.330	-37.2	13.8
900	0.166	144.6	4.065	72.3	0.127	72.1	0.325	-38.9	12.8
1000	0.178	135.7	3.670	69.6	0.140	70.8	0.318	-40.9	11.9
1200	0.209	123.8	3.097	64.2	0.165	68.3	0.300	-45.8	10.4
1400	0.242	115.9	2.718	58.9	0.190	66.0	0.281	-52.3	9.3
1600	0.257	109.9	2.399	53.9	0.215	63.8	0.273	-60.1	8.2
1800	0.272	101.3	2.164	49.5	0.237	60.9	0.264	-67.1	7.4
2000	0.301	91.6	1.982	44.6	0.261	58.4	0.254	-72.8	6.6
2200	0.346	85.2	1.849	40.3	0.281	55.8	0.233	-79.9	6.1
2400	0.386	81.2	1.717	35.2	0.302	53.9	0.206	-90.6	5.6
2600	0.407	78.4	1.604	31.9	0.325	50.6	0.194	-104.4	5.1
2800	0.419	73.0	1.524	27.2	0.338	48.2	0.200	-117.5	4.7
3000	0.442	66.3	1.422	23.1	0.358	46.7	0.203	-127.2	4.2

T-31-17

## NPN 6 GHz wideband transistor

BFR91A

PHILIPS INTERNATIONAL

56E D ■ 7110826 0045719 411 ■ PHIN

**Table 3** Common emitter scattering parameters,  $I_C = 20$  mA;  $V_{CE} = 8$  V

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		G <sub>UM</sub> (dB)
	MAG. (RAT)	ANG. (DEG)	MAG. (RAT)	ANG. (DEG)	MAG. (RAT)	ANG. (DEG)	MAG. (RAT)	ANG. (DEG)	
40	0.506	-31.1	37.283	153.0	0.009	78.6	0.902	-15.6	40.0
100	0.364	-64.6	26.682	127.0	0.019	70.0	0.701	-27.0	32.1
200	0.225	-99.3	16.147	106.7	0.033	69.9	0.528	-29.5	25.8
300	0.170	-125.8	11.336	96.4	0.045	70.4	0.461	-29.2	22.3
400	0.151	-143.9	8.697	89.5	0.058	70.3	0.430	-29.4	19.8
500	0.138	-159.6	7.070	83.7	0.071	70.0	0.414	-30.9	17.9
600	0.138	-173.7	5.958	78.9	0.083	68.9	0.406	-32.5	16.4
700	0.131	173.4	5.122	74.5	0.096	67.7	0.402	-34.1	15.0
800	0.132	161.9	4.530	70.7	0.109	66.3	0.398	-35.9	13.9
900	0.136	150.8	4.039	66.6	0.121	64.5	0.393	-37.3	12.9
1000	0.150	141.8	3.665	63.0	0.133	63.0	0.386	-38.9	12.1
1200	0.178	124.3	3.117	55.5	0.158	59.2	0.362	-43.4	10.6
1400	0.215	116.2	2.709	48.8	0.181	55.3	0.337	-50.1	9.4
1600	0.236	108.2	2.408	42.2	0.205	51.9	0.329	-58.4	8.4
1800	0.247	99.7	2.211	35.5	0.229	48.2	0.329	-65.3	7.7
2000	0.283	91.4	2.018	29.1	0.251	43.8	0.317	-70.5	6.9
2200	0.318	85.1	1.855	23.1	0.271	40.1	0.293	-76.0	6.2
2400	0.362	80.5	1.750	17.8	0.292	36.4	0.265	-85.4	5.8
2600	0.388	76.7	1.661	11.2	0.312	32.4	0.250	-97.8	5.4
2800	0.407	70.0	1.562	5.0	0.332	28.3	0.251	-108.8	4.9
3000	0.426	64.3	1.474	0.0	0.349	24.8	0.253	-116.4	4.5

T-31-17

## NPN 6 GHz wideband transistor

BFR91A

PHILIPS INTERNATIONAL

56E D ■ 7110826 0045720 133 ■ PHIN

**Table 4** Common emitter scattering parameters,  $I_C = 30 \text{ mA}$ ;  $V_{CE} = 8 \text{ V}$ 

f (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		G <sub>UM</sub> (dB)
	MAG. (RAT)	ANG. (DEG)	MAG. (RAT)	ANG. (DEG)	MAG. (RAT)	ANG. (DEG)	MAG. (RAT)	ANG. (DEG)	
40	0.414	-36.1	44.351	148.8	0.009	77.3	0.867	-18.2	39.8
100	0.279	-71.3	29.406	122.0	0.018	71.7	0.641	-28.7	32.0
200	0.167	-106.9	17.042	103.4	0.032	73.3	0.482	-29.1	25.9
300	0.131	-134.2	11.814	94.1	0.045	73.4	0.426	-28.3	22.4
400	0.120	-152.4	9.011	87.8	0.058	73.0	0.399	-28.7	19.9
500	0.114	-167.4	7.315	82.5	0.072	72.0	0.388	-30.1	18.0
600	0.118	178.3	6.152	77.9	0.085	70.6	0.382	-31.9	16.5
700	0.115	166.1	5.295	73.6	0.099	68.8	0.378	-34.0	15.2
800	0.117	155.2	4.665	70.1	0.111	67.3	0.374	-35.7	14.1
900	0.121	145.0	4.162	66.1	0.124	65.4	0.370	-37.3	13.1
1000	0.135	136.8	3.770	62.6	0.137	63.7	0.363	-38.8	12.2
1200	0.167	121.0	3.213	55.6	0.162	59.3	0.341	-43.5	10.8
1400	0.203	113.0	2.789	48.8	0.187	55.5	0.316	-50.5	9.5
1600	0.223	106.7	2.478	42.4	0.211	51.6	0.306	-59.0	8.5
1800	0.236	98.2	2.277	35.9	0.235	47.7	0.305	-66.4	7.8
2000	0.266	90.1	2.073	29.6	0.257	43.4	0.294	-71.5	7.0
2200	0.309	83.4	1.913	23.4	0.278	39.5	0.269	-77.2	6.4
2400	0.347	79.5	1.802	18.0	0.298	35.8	0.241	-87.0	5.9
2600	0.381	76.0	1.706	11.8	0.319	31.5	0.227	-100.4	5.6
2800	0.397	70.2	1.606	5.3	0.337	27.3	0.228	-112.0	5.1
3000	0.420	64.7	1.528	0.6	0.355	23.7	0.230	-119.8	4.8