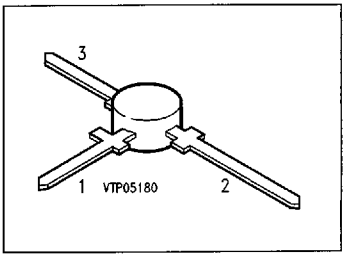
SIEMENS

NPN Silicon RF Transistor

BFR 96S

- For low-noise, low-distortion broadband amplifiers in antenna and telecommunications systems up to 2 GHz at collector currents from 10 mA to 70 mA.



ESD: Electrostatic discharge sensitive device, observe handling precautions!

Type	Marking	Ordering Code	Pin Configuration 1	2	3	Package[1]
BFR 96S	BFR 96S	Q68000-A5689	E	C	B	T-plast

Maximum Ratings

Parameter	Symbol	Values	Unit
Collector-emitter voltage	V_{CE0}	15	V
Collector-base voltage	V_{CB0}	20	
Emitter-base voltage	V_{EB0}	3	
Collector current	I_C	100	mA
Total power dissipation, $T_S \leq 87$ °C[3]	P_{tot}	700	mW
Junction temperature	T_j	150	°C
Ambient temperature range	T_A	– 65 ... + 150	
Storage temperature range	T_{stg}	– 65 ... + 150	
Thermal Resistance			
Junction - ambient [2]	$R_{th\,JA}$	≤ 170	K/W
Junction - soldering point [3]	$R_{th\,JS}$	≤ 90	

1) For detailed dimensions see chapter Package Outlines.
2) Package mounted on alumina 15 mm × 16.7 mm × 0.7 mm.
3) T_S is measured on the collector lead at the soldering point to the pcb.

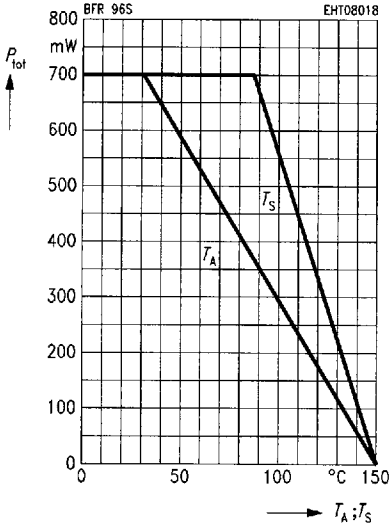
Electrical Characteristics
at T_A = 25 °C, unless otherwise specified.

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
DC Characteristics					
Collector-emitter breakdown voltage I_C = 1 mA, I_B = 0	$V_{(BR)CE0}$	15	–	–	V
Collector-base cutoff current V_{CB} = 10 V, I_E = 0	I_{CB0}	–	–	100	nA
Emitter-base cutoff current V_{EB} = 3 V, I_C = 0	I_{EB0}	–	–	100	µA
DC current gain I_C = 70 mA, V_{CE} = 10 V	h_{FE}	25	75	–	–
Collector-emitter saturation voltage I_C = 75 mA, I_B = 7.5 mA	V_{CEsat}	–	0.13	0.5	V

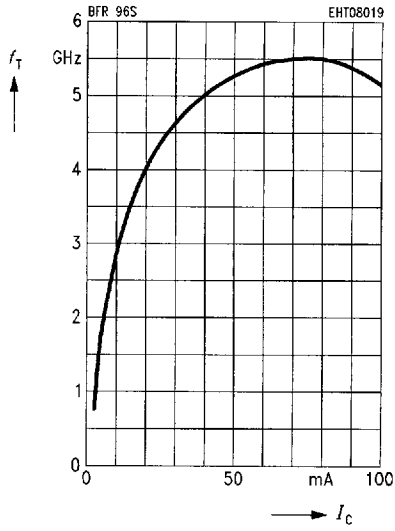
Electrical Characteristics
at T_A = 25 °C, unless otherwise specified.

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
AC Characteristics					
Transition frequency I_C = 50 mA, V_{CE} = 10 V, f = 200 MHz I_C = 70 mA, V_{CE} = 10 V, f = 200 MHz	f_T	 – –	 5.3 5.5	 – –	GHz
Collector-base capacitance V_{CB} = 10 V, V_{BE} = v_{be} = 0, f = 1 MHz	C_{cb}	–	0.95	–	pF
Collector-emitter capacitance V_{CE} = 10 V, V_{BE} = v_{be} = 0, f = 1 MHz	C_{ce}	–	0.3	–	
Input capacitance V_{EB} = 0.5 V, I_C = i_c = 0, f = 1 MHz	C_{ibo}	–	5	–	
Output capacitance V_{CE} = 10 V, V_{BE} = v_{be} = 0, f = 1 MHz	C_{obs}	–	1.25	–	
Noise figure I_C = 5 mA, V_{CE} = 10 V, f = 10 MHz, Z_S = 50 Ω I_C = 70 mA, V_{CE} = 10 V, f = 800 MHz, Z_S = Z_{Sopt}	F	 – –	 0.9 2.9	 – –	dB
Power gain I_C = 70 mA, V_{CE} = 10 V, f = 800 MHz, Z_S = Z_{Sopt}, Z_L = Z_{Lopt}	G_{pe}	–	11.5	–	
Transducer gain I_C = 70 mA, V_{CE} = 10 V, f = 500 MHz, Z_0 = 50 Ω	$\lvert S_{21e} \rvert^2$	–	14.8	–	
Linear output voltage two-tone intermodulation test I_C = 70 mA, V_{CE} = 10 V, d_{IM} = 60 dB f_1 = 806 MHz, f_2 = 810 MHz, Z_S = Z_L = 50 Ω	V_{o1} = V_{o2}	–	500	–	mV
Third order intercept point I_C = 70 mA, V_{CE} = 10 V, f = 800 MHz	IP_3	–	37	–	dBm

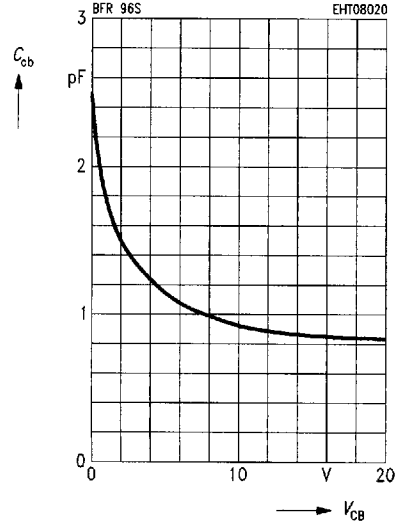
Total power dissipation $P_{tot} = f(T_A^*; T_S)$
* Package mounted on alumina



Transition frequency $f_T = f(I_C)$
V_{CE} = 10 V, f = 200 MHz



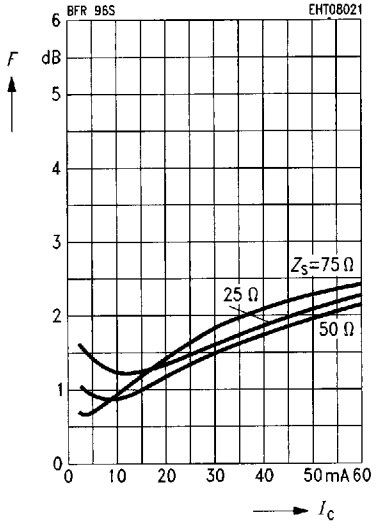
Collector-base capacitance $C_{cb} = f(V_{CB})$
$V_{BE} = v_{be} = 0$, f = 1 MHz



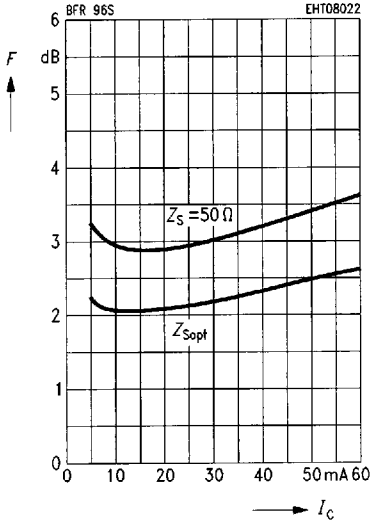
Common Emitter Noise Parameters

f	F_{min}	G_p (F_{min})	Γ_{opt}		R_N	N	$F_{50\Omega}$	G_p ($F_{50\Omega}$)
GHz	dB	dB	MAG	ANG	Ω	–	dB	dB
I_C = 10 mA, V_{CE} = 10 V, Z_0 = 50 Ω								
0.01	–	–	–	–	–	–	1.05	–
0.8	2.2	–	0.41	– 170.3	6.6	0.31	2.8	–
I_C = 70 mA, V_{CE} = 10 V, Z_0 = 50 Ω								
0.01	–	–	–	–	–	–	2.3	–
0.8	2.9	–	0.43	– 163	10	0.45	2.9	–

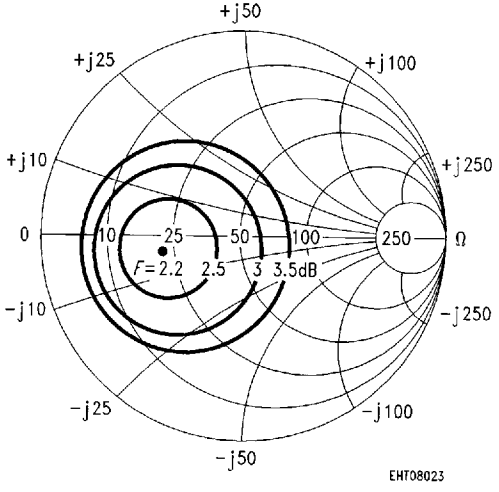
Noise figure $F = f(I_C)$
V_{CE} = 10 V, f = 10 MHz



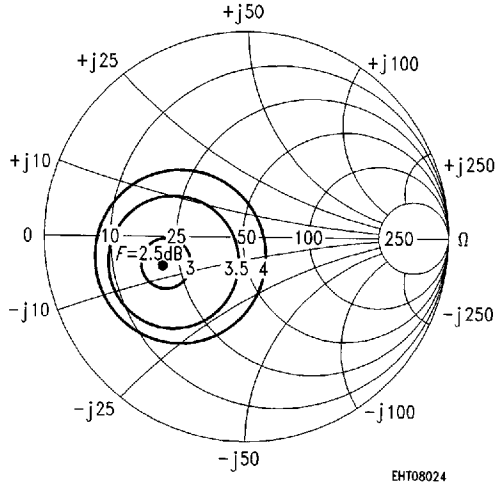
Noise figure $F = f(I_C)$
V_{CE} = 10 V, f = 800 MHz



Circles of constant noise figure $F = f(Z_S)$
I_C = 10 mA, V_{CE} = 10 V, f = 800 MHz,
R_N = 6.6 Ω, N = 0.31, Γ_{opt} = 0.41 < − 170°



Circles of constant noise figure $F = f(Z_S)$
I_C = 70 mA, V_{CE} = 10 V, f = 800 MHz,
R_N = 10 Ω, F_{min} = 2.9 dB, Γ_{opt} = 0.43 < − 163°



Common Emitter S Parameters

f	S_{11}		S_{21}		S_{12}		S_{22}	
GHz	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG
I_C = 50 mA, V_{CE} = 5 V, Z_0 = 50 Ω								
0.1	0.42	– 143.2	26.24	104.5	0.022	64.4	0.31	– 63.9
0.2	0.40	– 167.1	13.22	91.6	0.040	69.7	0.17	– 67.8
0.3	0.41	– 178.2	8.81	84.0	0.058	71.1	0.12	– 68.9
0.4	0.41	173.9	6.60	78.5	0.076	70.5	0.10	– 70.4
0.5	0.42	167.2	5.30	73.4	0.094	69.0	0.09	– 72.9
0.6	0.43	161.5	4.44	68.6	0.112	67.1	0.08	– 77.8
0.7	0.44	155.8	3.82	64.0	0.129	65.2	0.07	– 82.7
0.8	0.44	151.1	3.34	59.8	0.147	63.7	0.07	– 84.6
0.9	0.44	147.0	2.99	55.6	0.166	61.0	0.07	– 93.6
1.0	0.45	142.2	2.71	51.5	0.182	58.5	0.06	– 104.2
1.1	0.46	138.1	2.49	47.5	0.199	56.0	0.06	– 115.7
1.2	0.47	133.9	2.29	43.6	0.215	53.6	0.06	– 127.8
1.3	0.49	129.6	2.14	39.7	0.231	51.2	0.06	– 140.0
1.4	0.49	125.5	2.00	35.9	0.246	48.7	0.07	– 151.7
1.5	0.51	121.6	1.89	32.1	0.262	46.2	0.07	– 160.1
1.6	0.51	118.0	1.79	28.3	0.276	43.6	0.08	– 167.6
1.7	0.53	114.6	1.69	24.7	0.290	40.9	0.09	– 175.5
1.8	0.54	111.4	1.61	21.3	0.303	38.4	0.10	176.9
1.9	0.55	108.6	1.54	17.9	0.316	36.0	0.11	170.1
2.0	0.57	105.4	1.47	14.6	0.328	33.6	0.12	163.6
I_C = 10 mA, V_{CE} = 10 V, Z_0 = 50 Ω								
0.1	0.63	– 89.9	18.56	124.5	0.033	54.7	0.66	– 33.9
0.2	0.51	– 131.0	10.78	102.9	0.046	50.1	0.45	– 38.3
0.3	0.48	– 153.7	7.43	91.4	0.056	52.9	0.38	– 37.4
0.4	0.47	– 166.9	5.64	83.6	0.066	55.4	0.34	– 36.8
0.5	0.47	– 177.9	4.55	77.1	0.078	57.1	0.32	– 37.3
0.6	0.48	173.4	3.82	71.2	0.090	58.1	0.31	– 38.8
0.7	0.48	165.9	3.29	65.9	0.101	58.7	0.30	– 40.7
0.8	0.48	159.6	2.89	61.0	0.114	59.4	0.30	– 42.6
0.9	0.49	154.1	2.59	56.3	0.128	58.9	0.29	– 45.9
1.0	0.50	148.3	2.35	51.7	0.141	58.0	0.28	– 49.4
1.1	0.51	143.2	2.16	47.4	0.155	57.0	0.28	– 53.1
1.2	0.52	138.3	1.99	43.2	0.168	56.0	0.27	– 56.9
1.3	0.53	133.2	1.86	38.9	0.182	54.8	0.26	– 61.0
1.4	0.54	128.8	1.74	34.8	0.196	53.5	0.25	– 65.4
1.5	0.55	124.6	1.64	30.9	0.210	52.0	0.25	– 70.2
1.6	0.56	120.4	1.55	26.9	0.224	50.3	0.25	– 75.7
1.7	0.57	116.7	1.47	23.1	0.238	48.5	0.24	– 81.8
1.8	0.58	113.1	1.40	19.6	0.252	46.8	0.24	– 87.5
1.9	0.59	109.7	1.33	16.2	0.266	45.0	0.23	– 94.1
2.0	0.61	106.2	1.28	12.7	0.280	43.2	0.23	– 101.3

Common Emitter S Parameters (continued)

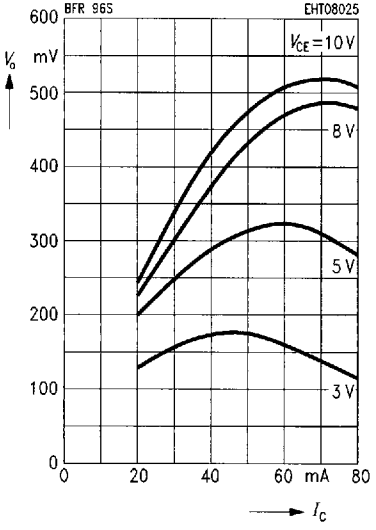
f	S_{11}		S_{21}		S_{12}		S_{22}	
GHz	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG
I_C = 30 mA, V_{CE} = 10 V, Z_0 = 50 Ω								
0.1	0.44	– 120.4	25.96	110.4	0.024	58.3	0.43	– 48.5
0.2	0.40	– 154.1	13.48	94.9	0.039	64.6	0.27	– 48.0
0.3	0.39	– 169.6	9.04	86.3	0.054	67.4	0.21	– 45.3
0.4	0.39	– 179.2	6.79	80.3	0.070	67.6	0.19	– 43.8
0.5	0.39	172.5	5.45	74.9	0.086	67.1	0.17	– 43.7
0.6	0.40	165.9	4.57	69.9	0.101	65.8	0.16	– 45.3
0.7	0.41	159.7	3.93	65.2	0.117	64.6	0.15	– 46.9
0.8	0.41	154.4	3.44	60.9	0.133	63.5	0.15	– 48.1
0.9	0.42	150.3	3.08	56.7	0.150	61.4	0.15	– 52.2
1.0	0.43	144.7	2.79	52.5	0.165	59.3	0.14	– 56.7
1.1	0.44	140.3	2.56	48.5	0.180	57.2	0.13	– 61.0
1.2	0.45	136.1	2.36	44.6	0.195	55.1	0.12	– 66.0
1.3	0.46	131.3	2.20	40.6	0.209	53.0	0.11	– 71.1
1.4	0.47	127.3	2.06	36.7	0.224	50.8	0.10	– 77.2
1.5	0.48	123.6	1.94	33.0	0.238	48.6	0.10	– 84.1
1.6	0.49	120.0	1.84	29.1	0.253	46.3	0.10	– 92.9
1.7	0.51	116.5	1.74	25.5	0.266	43.9	0.09	– 103.1
1.8	0.52	113.1	1.66	22.0	0.279	41.6	0.09	– 112.9
1.9	0.53	110.2	1.58	18.7	0.291	39.4	0.09	– 124.1
2.0	0.55	106.9	1.51	15.3	0.304	37.2	0.09	– 136.5
I_C = 50 mA, V_{CE} = 10 V, Z_0 = 50 Ω								
0.1	0.42	– 130.9	27.43	106.3	0.022	62.0	0.35	– 52.7
0.2	0.37	– 161.1	13.90	92.6	0.038	68.5	0.21	– 50.4
0.3	0.37	– 173.9	9.28	84.8	0.055	70.4	0.17	– 47.3
0.4	0.37	178.1	6.95	79.2	0.072	70.1	0.15	– 45.8
0.5	0.38	170.2	5.58	74.1	0.089	68.8	0.14	– 46.0
0.6	0.39	164.4	4.67	69.3	0.105	67.1	0.13	– 48.0
0.7	0.40	158.5	4.02	64.8	0.121	65.5	0.12	– 49.6
0.8	0.40	153.4	3.52	60.6	0.138	64.0	0.12	– 50.7
0.9	0.40	149.3	3.15	56.4	0.156	61.6	0.11	– 55.8
1.0	0.42	144.4	2.86	52.3	0.171	59.3	0.11	– 61.0
1.1	0.43	140.1	2.61	48.3	0.186	56.9	0.10	– 66.2
1.2	0.44	135.7	2.41	44.5	0.202	54.7	0.09	– 72.4
1.3	0.45	131.2	2.25	40.6	0.216	52.4	0.08	– 79.1
1.4	0.46	127.2	2.11	36.7	0.231	50.0	0.07	– 87.3
1.5	0.47	123.3	1.98	33.0	0.246	47.7	0.07	– 96.1
1.6	0.48	119.7	1.87	29.2	0.260	45.2	0.07	– 107.4
1.7	0.50	116.2	1.78	25.6	0.274	42.8	0.07	– 120.3
1.8	0.51	113.1	1.69	22.2	0.286	40.4	0.07	– 132.8
1.9	0.52	110.0	1.61	18.8	0.299	38.1	0.07	– 145.6
2.0	0.54	106.9	1.54	15.4	0.311	35.9	0.08	– 158.7

Common Emitter S Parameters (continued)

f	S_{11}		S_{21}		S_{12}		S_{22}	
GHz	**MAG**	**ANG**	**MAG**	**ANG**	**MAG**	**ANG**	**MAG**	**ANG**
I_C = 70 mA, V_{CE} = 10 V, Z_0 = 50 Ω								
0.1	0.40	– 138.5	27.66	103.9	0.021	63.4	0.32	– 53.6
0.2	0.37	– 164.1	13.87	91.3	0.038	70.6	0.19	– 50.1
0.3	0.36	– 176.2	9.22	83.9	0.055	71.5	0.15	– 46.9
0.4	0.37	176.1	6.91	78.6	0.073	70.9	0.13	– 45.6
0.5	0.38	169.2	5.54	73.5	0.089	69.5	0.12	– 45.8
0.6	0.39	163.2	4.64	68.8	0.107	67.7	0.11	– 48.0
0.7	0.40	157.6	3.99	64.3	0.122	65.8	0.11	– 50.0
0.8	0.40	152.9	3.49	60.2	0.140	64.3	0.10	– 51.2
0.9	0.41	149.0	3.12	56.0	0.157	61.8	0.10	– 56.8
1.0	0.42	144.0	2.83	51.9	0.173	59.4	0.09	– 62.5
1.1	0.43	139.8	2.59	48.1	0.188	57.0	0.08	– 68.5
1.2	0.44	135.7	2.39	44.2	0.203	54.7	0.08	– 75.7
1.3	0.45	130.9	2.23	40.3	0.218	52.4	0.07	– 83.7
1.4	0.46	126.9	2.09	36.5	0.233	50.1	0.06	– 93.4
1.5	0.48	123.4	1.96	32.7	0.248	47.7	0.06	– 103.5
1.6	0.49	119.8	1.86	29.0	0.262	45.2	0.06	– 116.6
1.7	0.50	116.3	1.76	25.4	0.275	42.7	0.06	– 130.7
1.8	0.51	113.0	1.67	22.0	0.288	40.3	0.07	– 144.0
1.9	0.53	110.1	1.60	18.6	0.300	38.0	0.07	– 157.3
2.0	0.55	107.0	1.53	15.3	0.312	35.8	0.08	– 169.5

Common Emitter Large Signal Parameters

Linear output voltage $V_o = f(I_C)$
d_{IM} = 60 dB, f_1 = 806 MHz,
f_2 = 810 MHz, $Z_S = Z_L$ = 50 Ω



Note:

The transistor is driven by 2 adjacent signals f_1, f_2 with equal output power levels P_o for each carrier.

The distance d_{IM} between P_o and the third order intermodulation products P_{IM} ($2f_1 - f_2$ or $2f_2 - f_1$) is:

$d_{IM} = P_o - P_{IM}$
where P_o = 10 log (V_o^2/(50 Ω · 1 mW)) (dBm)
and V_o = linear output voltage of each carrier.

The 3rd order intercept point IP_3 will be found by extrapolation to the point where P_{IM} would be identical to P_o:

IP_3 (output) = $P_o + d_{IM}/2$.

Linear output voltages for other d_{IM} (e.g. 50 dB) can be calculated thereby.