

# DATA SHEET

**BFG410W**  
NPN 22 GHz wideband transistor

Product specification  
Supersedes data of 1997 Oct 29

1998 Mar 11



**NPN 22 GHz wideband transistor****BFG410W****FEATURES**

- Very high power gain
- Low noise figure
- High transition frequency
- Emitter is thermal lead
- Low feedback capacitance.

**PINNING**

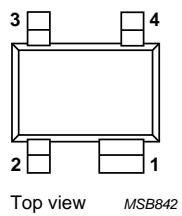
PIN	DESCRIPTION
1	emitter
2	base
3	emitter
4	collector

**APPLICATIONS**

- RF front end
- Wideband applications, e.g. analog and digital cellular telephones, cordless telephones (PHS, DECT, etc.)
- Radar detectors
- Pagers
- Satellite television tuners (SATV)
- High frequency oscillators.

**DESCRIPTION**

NPN double polysilicon wideband transistor with buried layer for low voltage applications in a plastic, 4-pin dual-emitter SOT343R package.



Marking code: P4.

Fig.1 Simplified outline SOT343R.

**QUICK REFERENCE DATA**

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{CBO}$	collector-base voltage	open emitter	–	–	10	V
$V_{CEO}$	collector-emitter voltage	open base	–	–	4.5	V
$I_C$	collector current (DC)		–	10	12	mA
$P_{tot}$	total power dissipation	$T_s \leq 110^\circ\text{C}$	–	–	54	mW
$h_{FE}$	DC current gain	$I_C = 10 \text{ mA}; V_{CE} = 2 \text{ V}; T_j = 25^\circ\text{C}$	50	80	120	
$C_{re}$	feedback capacitance	$I_C = 0; V_{CB} = 2 \text{ V}; f = 1 \text{ MHz}$	–	45	–	fF
$f_T$	transition frequency	$I_C = 10 \text{ mA}; V_{CE} = 2 \text{ V}; f = 2 \text{ GHz}; T_{amb} = 25^\circ\text{C}$	–	22	–	GHz
$G_{max}$	maximum power gain	$I_C = 10 \text{ mA}; V_{CE} = 2 \text{ V}; f = 2 \text{ GHz}; T_{amb} = 25^\circ\text{C}$	–	21	–	dB
$F$	noise figure	$I_C = 1 \text{ mA}; V_{CE} = 2 \text{ V}; f = 2 \text{ GHz}; \Gamma_S = \Gamma_{opt}$	–	1.2	–	dB

**CAUTION**

This product is supplied in anti-static packing to prevent damage caused by electrostatic discharge during transport and handling.

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**LIMITING VALUES**

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

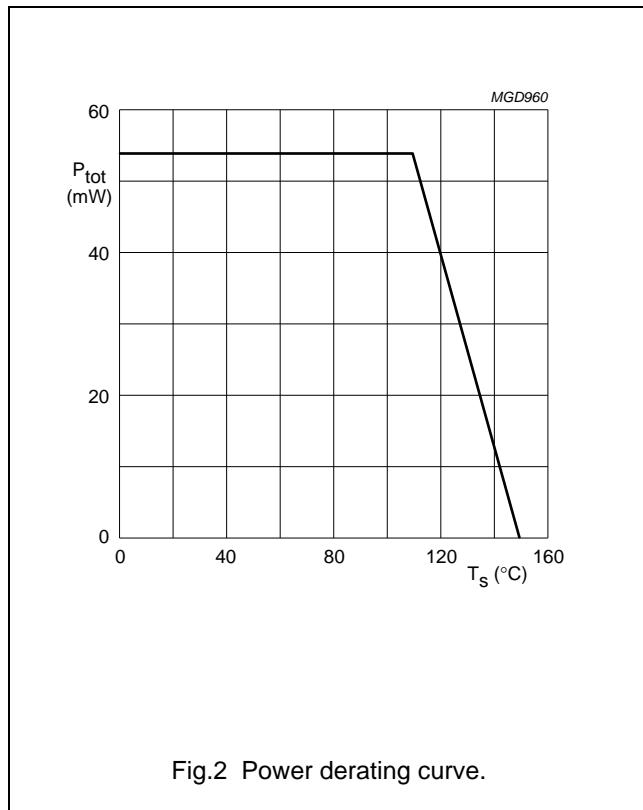
SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$V_{CBO}$	collector-base voltage	open emitter	–	10	V
$V_{CEO}$	collector-emitter voltage	open base	–	4.5	V
$V_{EBO}$	emitter-base voltage	open collector	–	1	V
$I_C$	collector current (DC)		–	12	mA
$P_{tot}$	total power dissipation	$T_s \leq 110^\circ\text{C}$ ; note 1; see Fig.2	–	54	mW
$T_{stg}$	storage temperature		–65	+150	°C
$T_j$	operating junction temperature		–	150	°C

**Note**

1.  $T_s$  is the temperature at the soldering point of the emitter pins.

**THERMAL CHARACTERISTICS**

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\ j-s}$	thermal resistance from junction to soldering point	750	K/W



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## CHARACTERISTICS

 $T_j = 25^\circ\text{C}$  unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{(\text{BR})\text{CBO}}$	collector-base breakdown voltage	$I_C = 2.5 \mu\text{A}; I_E = 0$	10	—	—	V
$V_{(\text{BR})\text{CEO}}$	collector-emitter breakdown voltage	$I_C = 1 \text{ mA}; I_B = 0$	4.5	—	—	V
$V_{(\text{BR})\text{EBO}}$	emitter-base breakdown voltage	$I_E = 2.5 \mu\text{A}; I_C = 0$	1	—	—	V
$I_{\text{CBO}}$	collector-base leakage current	$I_E = 0; V_{\text{CB}} = 4.5 \text{ V}$	—	—	15	nA
$h_{\text{FE}}$	DC current gain	$I_C = 10 \text{ mA}; V_{\text{CE}} = 2 \text{ V}; \text{see Fig.3}$	50	80	120	
$C_c$	collector capacitance	$I_E = i_e = 0; V_{\text{CB}} = 2 \text{ V}; f = 1 \text{ MHz}$	—	220	—	fF
$C_e$	emitter capacitance	$I_C = i_c = 0; V_{\text{EB}} = 0.5 \text{ V}; f = 1 \text{ MHz}$	—	400	—	fF
$C_{\text{re}}$	feedback capacitance	$I_C = 0; V_{\text{CB}} = 2 \text{ V}; f = 1 \text{ MHz}; \text{see Fig.4}$	—	45	—	fF
$f_T$	transition frequency	$I_C = 10 \text{ mA}; V_{\text{CE}} = 2 \text{ V}; f = 2 \text{ GHz}; T_{\text{amb}} = 25^\circ\text{C}; \text{see Fig.5}$	—	22	—	GHz
$G_{\text{max}}$	maximum power gain; note 1	$I_C = 10 \text{ mA}; V_{\text{CE}} = 2 \text{ V}; f = 2 \text{ GHz}; T_{\text{amb}} = 25^\circ\text{C}; \text{see Figs 7 and 8}$	—	21	—	dB
$ S_{21} ^2$	insertion power gain	$I_C = 10 \text{ mA}; V_{\text{CE}} = 2 \text{ V}; f = 2 \text{ GHz}; T_{\text{amb}} = 25^\circ\text{C}; \text{see Fig.8}$	—	18	—	dB
$F$	noise figure	$I_C = 1 \text{ mA}; V_{\text{CE}} = 2 \text{ V}; f = 900 \text{ MHz}; \Gamma_S = \Gamma_{\text{opt}}; \text{see Fig.13}$	—	0.9	—	dB
		$I_C = 1 \text{ mA}; V_{\text{CE}} = 2 \text{ V}; f = 2 \text{ GHz}; \Gamma_S = \Gamma_{\text{opt}}; \text{see Fig.13}$	—	1.2	—	dB
$P_{\text{L1}}$	output power at 1 dB gain compression	$I_C = 10 \text{ mA}; V_{\text{CE}} = 2 \text{ V}; f = 2 \text{ GHz}; Z_S = Z_{\text{S opt}}; Z_L = Z_{\text{L opt}}; \text{note 2}$	—	5	—	dBm
ITO	third order intercept point	$I_C = 10 \text{ mA}; V_{\text{CE}} = 2 \text{ V}; f = 2 \text{ GHz}; Z_S = Z_{\text{S opt}}; Z_L = Z_{\text{L opt}}; \text{note 2}$	—	15	—	dBm

## Notes

- $G_{\text{max}}$  is the maximum power gain, if  $K > 1$ . If  $K < 1$  then  $G_{\text{max}} = \text{MSG}$ ; see Figs 6, 7 and 8.
- $Z_S$  is optimized for noise;  $Z_L$  is optimized for gain.

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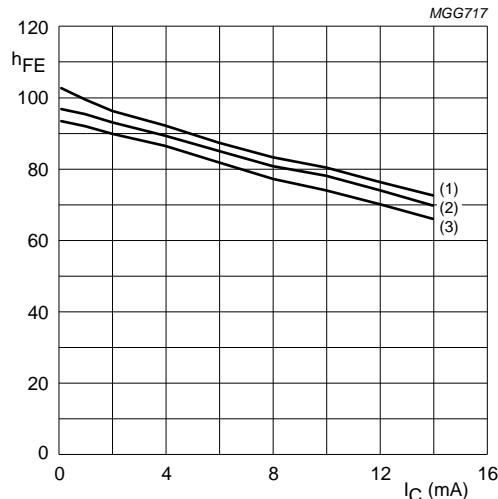


Fig.3 DC current gain as a function of collector current; typical values.

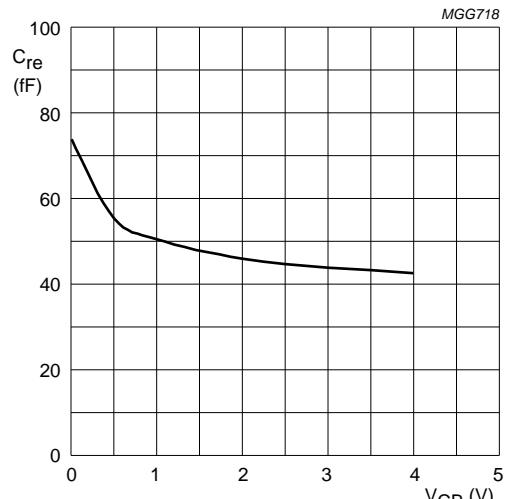
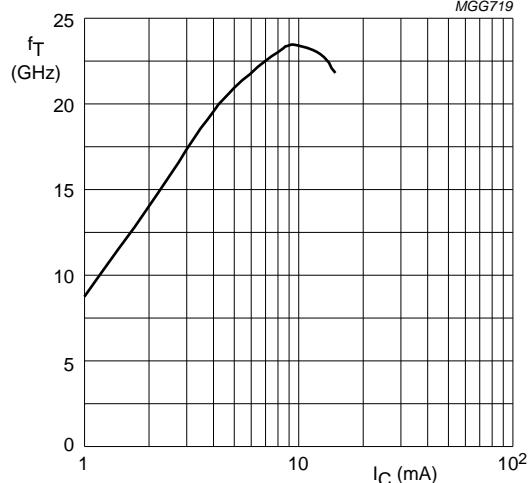
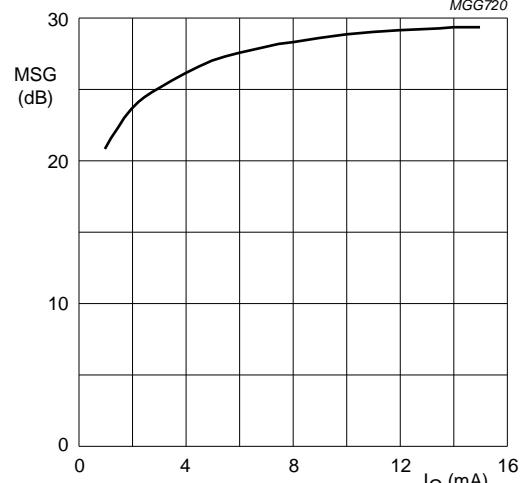


Fig.4 Feedback capacitance as a function of collector-base voltage; typical values.



$V_{CE} = 2\text{ V}$ ;  $f = 2\text{ GHz}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

Fig.5 Transition frequency as a function of collector current; typical values.



$V_{CE} = 2\text{ V}$ ;  $f = 900\text{ MHz}$ .

Fig.6 Maximum stable gain as a function of collector current; typical values.

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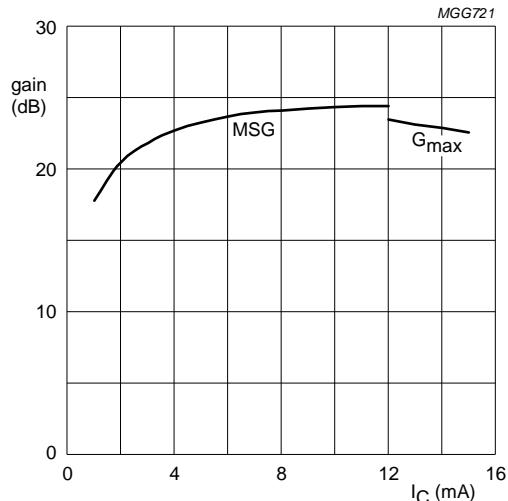
 $V_{CE} = 2$  V;  $f = 2$  GHz.

Fig.7 Gain as a function of collector current; typical values.

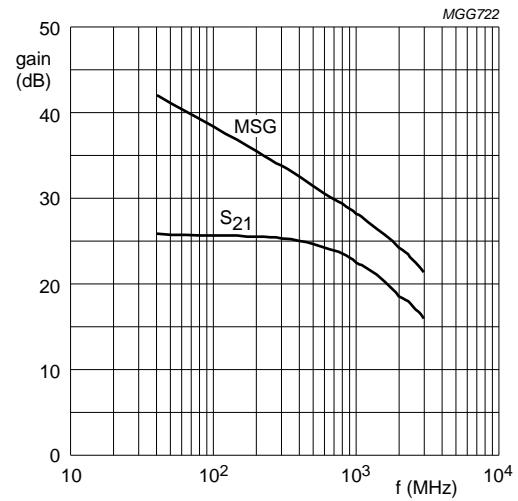
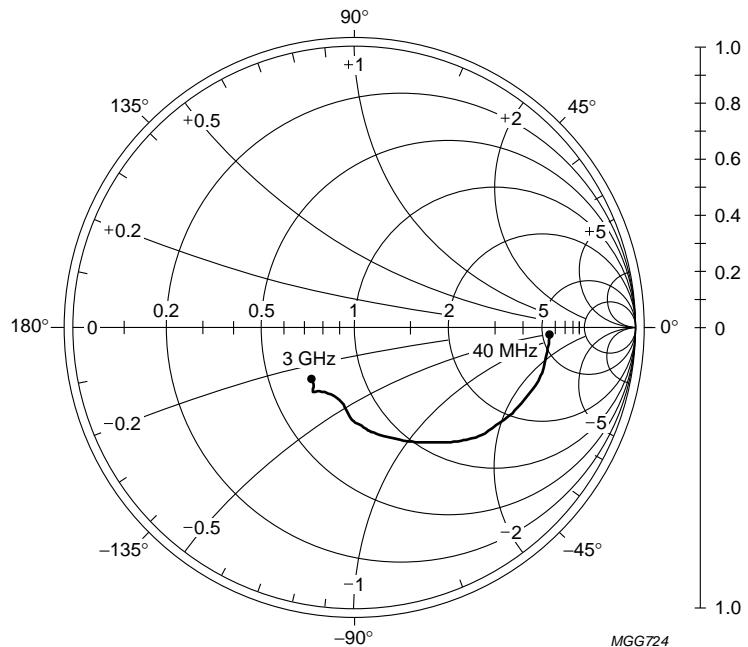
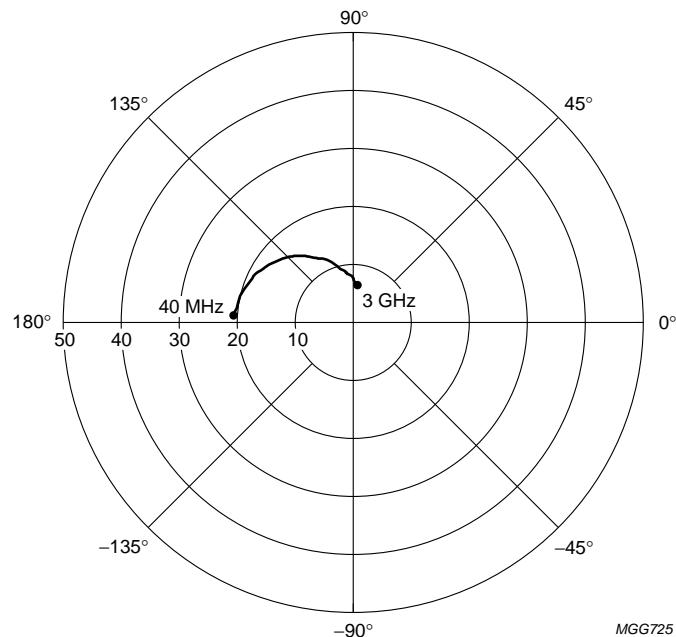
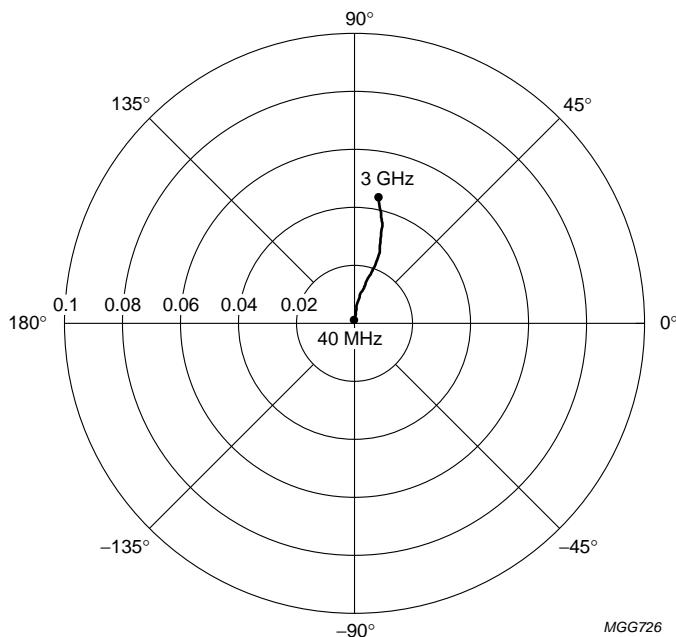
 $I_C = 10$  mA;  $V_{CE} = 2$  V.

Fig.8 Gain as a function of frequency; typical values.

 $I_C = 10$  mA;  $V_{CE} = 2$  V;  $Z_o = 50 \Omega$ .Fig.9 Common emitter input reflection coefficient ( $S_{11}$ ); typical values.

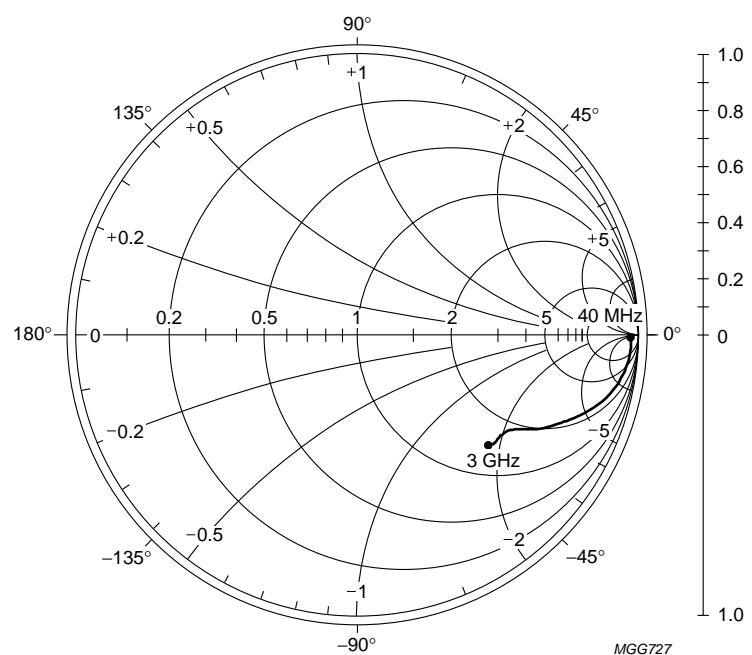
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 $I_C = 10 \text{ mA}$ ;  $V_{CE} = 2 \text{ V}$ .Fig.10 Common emitter forward transmission coefficient ( $S_{21}$ ); typical values. $I_C = 10 \text{ mA}$ ;  $V_{CE} = 2 \text{ V}$ .Fig.11 Common emitter reverse transmission coefficient ( $S_{12}$ ); typical values.

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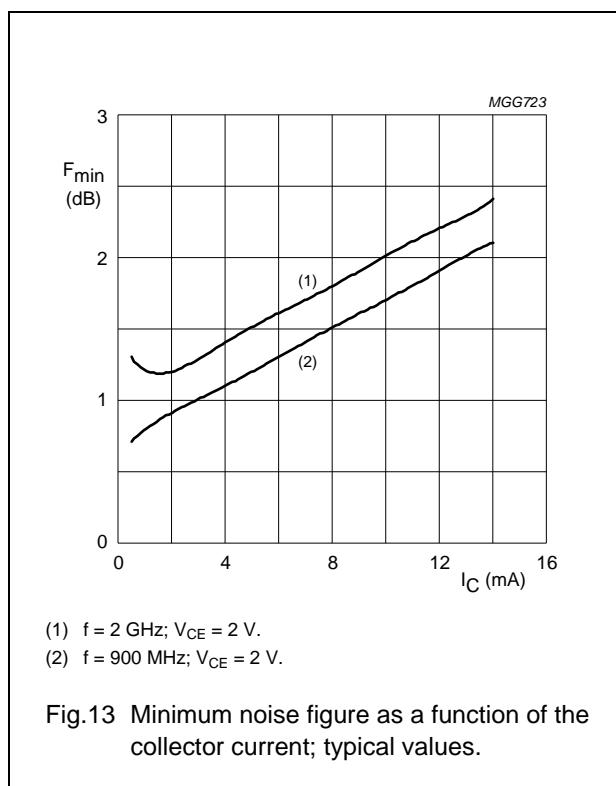
$I_C = 10 \text{ mA}$ ;  $V_{CE} = 2 \text{ V}$ ;  $Z_o = 50 \Omega$ .

Fig.12 Common emitter output reflection coefficient ( $S_{22}$ ); typical values.

## Noise data

$V_{CE} = 2 \text{ V}$ ; typical values.

$f$ (MHz)	$I_C$ (mA)	$F_{\min}$ (dB)	$\Gamma_{\text{mag}}$	$\Gamma_{\text{angle}}$	$r_n$ ( $\Omega$ )
900	1	0.8	0.73	11.2	0.56
	2	0.9	0.58	10.1	0.43
	4	1.1	0.40	10.1	0.33
	6	1.3	0.28	11.0	0.30
	8	1.5	0.20	8.0	0.30
	10	1.7	0.14	10.5	0.27
	12	1.9	0.06	10.1	0.25
	14	2.1	0.05	14.2	0.26
2000	1	1.2	0.64	35.7	0.57
	2	1.2	0.50	35.8	0.44
	4	1.4	0.34	34.4	0.37
	6	1.6	0.25	33.7	0.34
	8	1.8	0.17	34.5	0.35
	10	2.0	0.12	35.8	0.34
	12	2.2	0.05	38.0	0.35
	14	2.4	0.03	44.8	0.34



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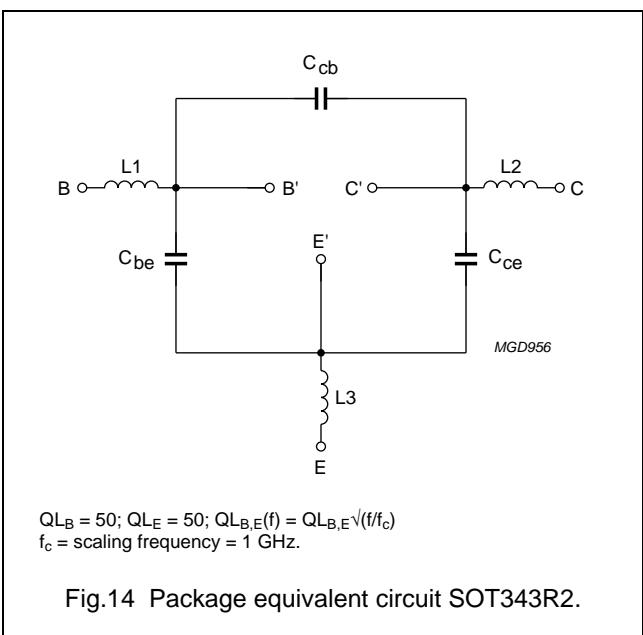
## SPICE parameters for the BFG410W die

SEQUENCE No.	PARAMETER	VALUE	UNIT
1	IS	19.42	aA
2	BF	145.0	–
3	NF	0.993	–
4	VAF	31.12	V
5	IKF	125.0	mA
6	ISE	123.6	fA
7	NE	3.000	–
8	BR	11.37	–
9	NR	0.985	–
10	VAR	1.874	V
11	IKR	50.00	mA
12	ISC	199.6	aA
13	NC	1.546	–
14	RB	35.00	Ω
15	IRB	0.000	A
16	RBM	15.00	Ω
17	RE	432.0	mΩ
18	RC	4.324	Ω
19 <sup>(1)</sup>	XTB	1.500	–
20 <sup>(1)</sup>	EG	1.110	eV
21 <sup>(1)</sup>	XTI	3.000	–
22	CJE	128.0	fF
23	VJE	900.0	mV
24	MJE	0.346	–
25	TF	4.122	ps
26	XTF	68.20	–
27	VTF	2.004	V
28	ITF	0.627	A
29	PTF	0.000	deg
30	CJC	56.68	fF
31	VJC	556.9	mV
32	MJC	0.207	–
33	XCJC	0.500	–
34 <sup>(1)</sup>	TR	0.000	ns
35 <sup>(1)</sup>	CJS	274.8	fF
36 <sup>(1)</sup>	VJS	418.3	mV
37 <sup>(1)</sup>	MJS	0.239	–
38	FC	0.550	–

SEQUENCE No.	PARAMETER	VALUE	UNIT
39 (2)(3)	$C_{bp}$	145	fF
40 (2)	$R_{sb1}$	25	$\Omega$
41 (3)	$R_{sb2}$	19	$\Omega$

## Notes

1. These parameters have not been extracted, the default values are shown.
2. Bonding pad capacity  $C_{bp}$  in series with substrate resistance  $R_{sb1}$  between B' and E'.
3. Bonding pad capacity  $C_{bp}$  in series with substrate resistance  $R_{sb2}$  between C' and E'.



### **List of components (see Fig.14)**

DESIGNATION	VALUE	UNIT
$C_{be}$	80	fF
$C_{cb}$	2	fF
$C_{ce}$	80	fF
L1	1.1	nH
L2	1.1	nH
L3 (note 1)	0.25	nH

### Note

1. External emitter inductance to be added separately due to the influence of the printed-circuit board.

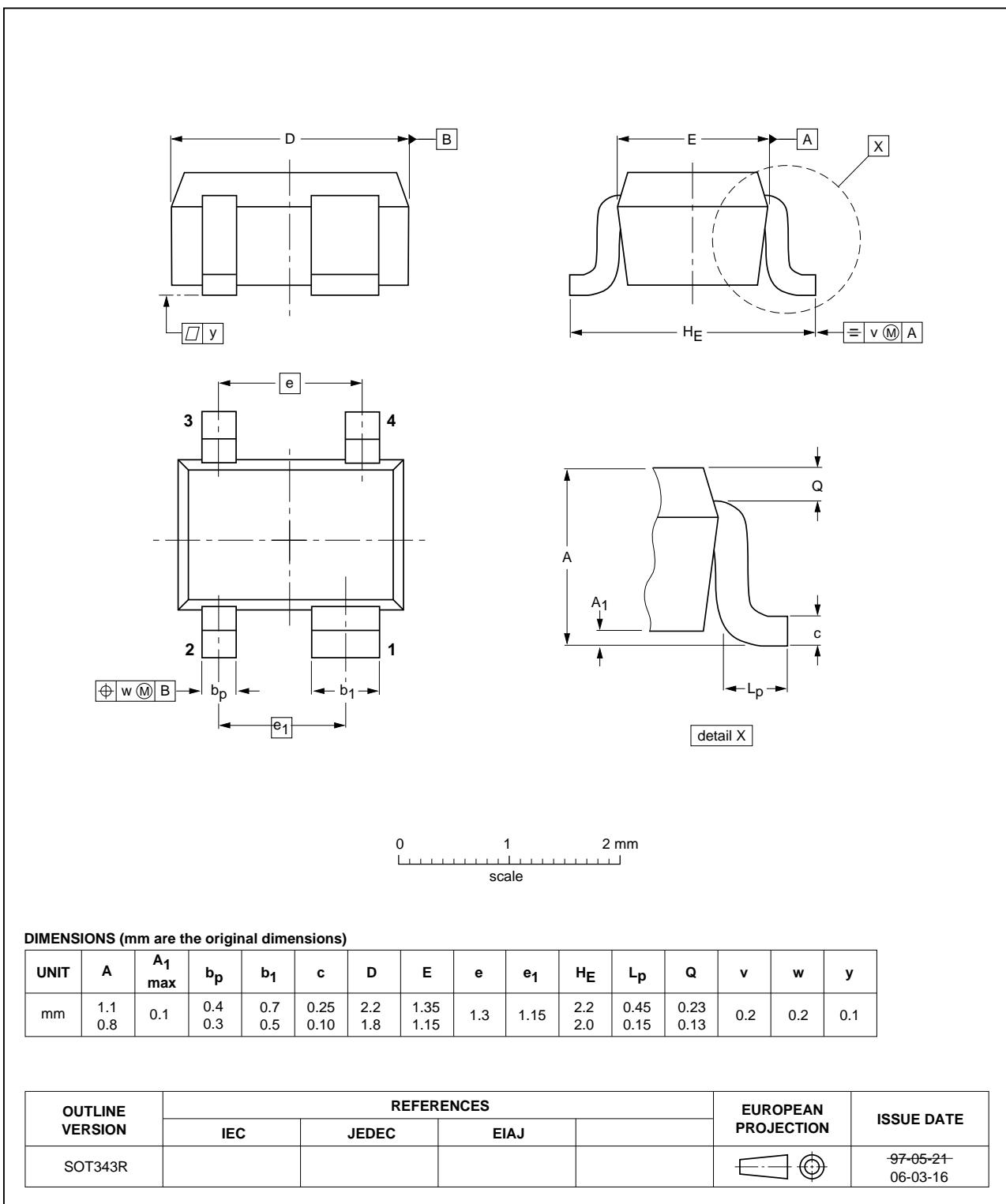
## NPN 22 GHz wideband transistor

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## PACKAGE OUTLINE

Plastic surface-mounted package; reverse pinning; 4 leads

SOT343R



## NPN 22 GHz wideband transistor

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## DATA SHEET STATUS

DOCUMENT STATUS <sup>(1)</sup>	PRODUCT STATUS <sup>(2)</sup>	DEFINITION
Objective data sheet	Development	This document contains data from the objective specification for product development.
Preliminary data sheet	Qualification	This document contains data from the preliminary specification.
Product data sheet	Production	This document contains the product specification.

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