BFR94A

NPN 5 GHz wideband transistor

Rev. 4 — 2 October 2014 **Product data sheet**

1. Product profile

1.1 General description

NPN wideband transistor in a plastic SOT23 package. PNP complement; BFT92

1.2 Features and benefits

- High power gain
- Low noise figure
- Low intermodulation distortion
- AEC-Q101 qualified

1.3 Applications

- RF wideband amplifiers and oscillators

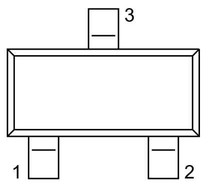
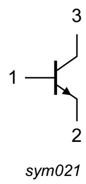
1.4 Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CBO}	collector-base voltage		-	-	20	V
V_{CEO}	collector-emitter voltage		-	-	15	V
I_C	collector current		-	-	25	mA
P_{tot}	total power dissipation	$T_{sp} \leq 95$ °C	-	-	300	mW
C_{re}	feedback capacitance	$I_C = i_C = 0$ mA; $V_{CE} = 10$ V; f = 1 MHz	-	0.35	-	pF
f_T	transition frequency	$I_C = 15$ mA; $V_{CE} = 10$ V; f = 500 MHz	-	5	-	GHz
G_{UM}	unilateral power gain	$I_C = 15$ mA; $V_{CE} = 10$ V; $T_{amb} = 25$ °C				
		f = 1 GHz	-	14	-	dB
		f = 2 GHz	-	8	-	dB
NF	noise figure	$I_C = 5$ mA; $V_{CE} = 10$ V; f = 1 GHz; $\Gamma_S = \Gamma_{opt}$; $T_{amb} = 25$ °C	-	2.1	-	dB
V_O	output voltage	IMD = –60 dB; $I_C = 14$ mA; $V_{CE} = 10$ V; $R_L = 75$ Ω; $f_p + f_q - f_r = 793.25$ MHz	-	150	-	mV

2. Pinning information

Table 2. Pinning

Pin	Description	Simplified outline	Graphic symbol
1	base		
2	emitter		
3	collector		

3. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
BFR94A	-	plastic surface-mounted package; 3 leads	SOT23

4. Marking

Table 4. Marking

Type number	Marking code	Description
BFR94A	NL*	* = p : made in Hong Kong
		* = w : made in China

5. Limiting values

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

	Parameter	Conditions	Min	Max	Unit
V_{CBO}	collector-base voltage	open emitter	-	20	V
V_{CEO}	collector-emitter voltage	open base	-	15	V
V_{EBO}	emitter-base voltage	open collector	-	2	V
I_C	collector current		-	25	mA
P_{tot}	total power dissipation	$T_{sp} \leq 95$ °C; see Figure 2 [1]	-	300	mW
T_{stg}	storage temperature		–65	+150	°C
T_j	junction temperature		-	+150	°C

[1] T_{sp} is the temperature at the solder point of the collector pin.

6. Thermal characteristics

Table 6. Thermal characteristics

Symbol	Parameter	Conditions		Typ	Unit
$R_{th(j-sp)}$	thermal resistance from junction to solder point	$T_{sp} \leq 95$ °C	[1]	260	K/W

[1] T_{sp} is the temperature at the solder point of the collector pin.

7. Characteristics

Table 7. Characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
I_{CBO}	collector-base cut-off current	I_E = 0 A; V_{CB} = 10 V		-	-	50	nA
h_{FE}	DC current gain	I_C = 15 mA; V_{CE} = 10 V; see Figure 3		65	90	135	
C_c	collector capacitance	$I_E = i_e$ = 0 A; V_{CB} = 10 V; f = 1 MHz: see Figure 4		-	0.6	-	pF
C_e	emitter capacitance	$I_C = i_c$ = 0 A; V_{EB} = 10 V; f = 1 MHz		-	1.2	-	pF
C_{re}	feedback capacitance	$I_C = i_c$ = 0 mA; V_{CE} = 10 V; f = 1 MHz		-	0.35	-	pF
f_T	transition frequency	I_C = 15 mA; V_{CE} = 10 V; f = 500 MHz; see Figure 5		-	5	-	GHz
G_{UM}	unilateral power gain	I_C = 15 mA; V_{CE} = 10 V; T_{amb} = 25 °C	[1]				
		f = 1 GHz		-	14	-	dB
		f = 2 GHz		-	8	-	dB
NF	noise figure	I_C = 5 mA; V_{CE} = 10 V; $\Gamma_S = \Gamma_{opt}$; T_{amb} = 25 °C; see Figure 12 and Figure 13					
		f = 1 GHz		-	2.1	-	dB
		f = 2 GHz		-	3	-	dB
V_O	output voltage		[2][3]	-	150	-	mV
IMD2	second-order intermodulation distortion	see Figure 15	[2][4]	-	–50	-	dB

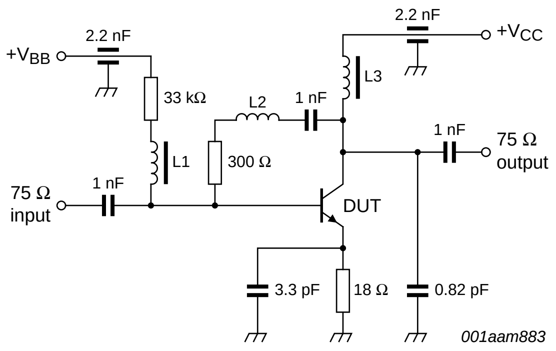
[1] G_{UM} is the maximum unilateral power gain, assuming S_{12} is zero and

$$G_{UM} = 10 \log \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)} dB.$$

[2] Measured on the same crystal in a SOT37 package (BFR90A).

[3] IMD = –60 dB (DIN 45004B); I_C = 14 mA; V_{CE} = 10 V; R_L = 75 Ω; VSWR < 2; T_{amb} = 25 °C;
$V_p = V_O$ at IMD = –60 dB; f_p = 795.25 MHz;
$V_q = V_O$ –6 dB at f_q = 803.25 MHz;
$V_r = V_O$ –6 dB at f_r = 805.25 MHz;
measured at $f_p + f_q - f_r$ = 793.25 MHz

[4] I_C = 14 mA; V_{CE} = 10 V; R_L = 75 Ω; VSWR < 2; T_{amb} = 25 °C;
V_p = 60 mV at f_p = 250 MHz;
V_q = 60 mV at f_p = 560 MHz;
measured at $f_p + f_q$ = 810 MHz



L1 = L2 = 5 μH choke.

L2 = 3 turns 0.4 mm copper wire, internal diameter 3 mm, winding pitch 1 mm.

Fig 1. Intermodulation distortion and second harmonic distortion MATV test circuit

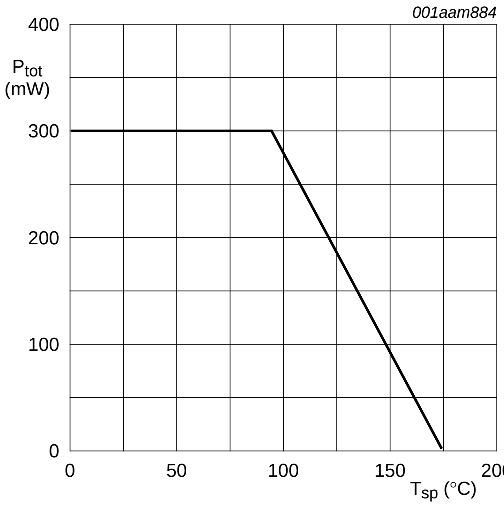
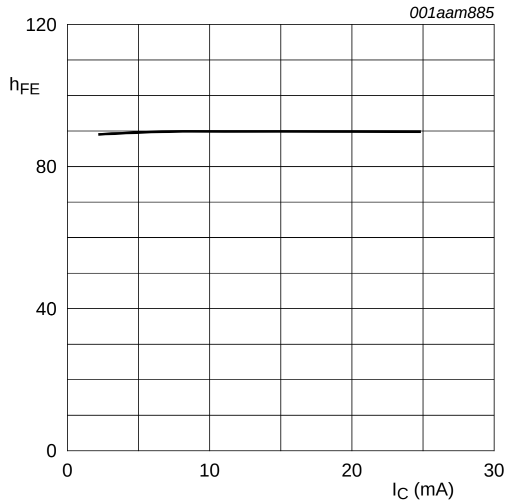
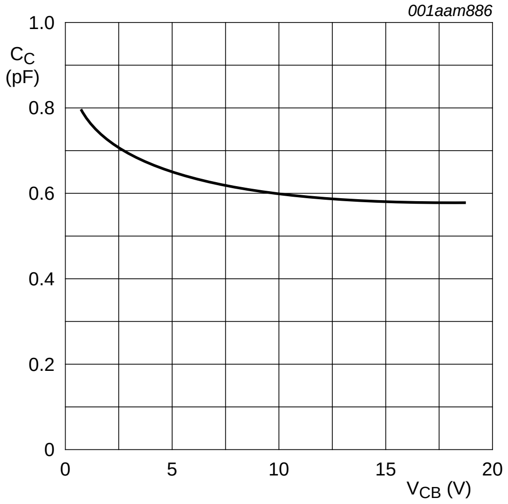


Fig 2. Power derating curve



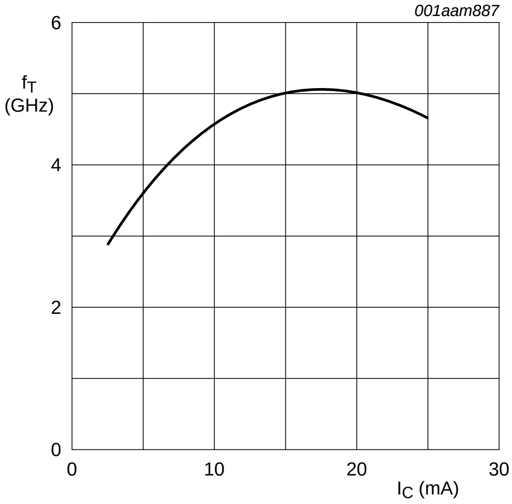
V_{CE} = 10 V; T_j = 25 °C.

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



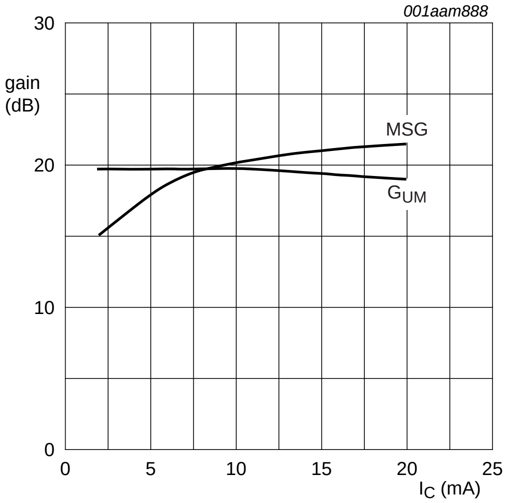
$I_C = i_C = 0$ mA; f = 1 MHz; $T_j = 25$ °C.

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



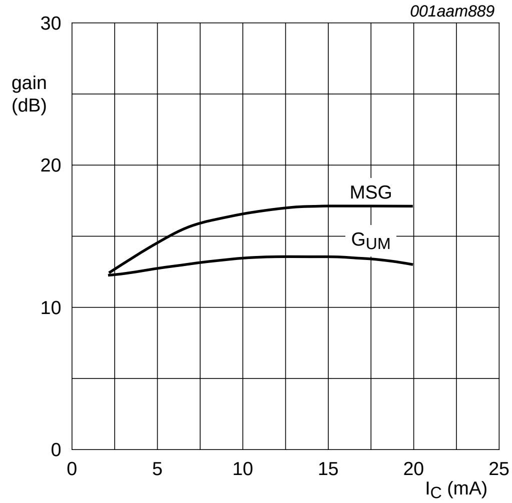
$V_{CE} = 10$ V; f = 500 MHz; $T_{amb} = 25$ °C.

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



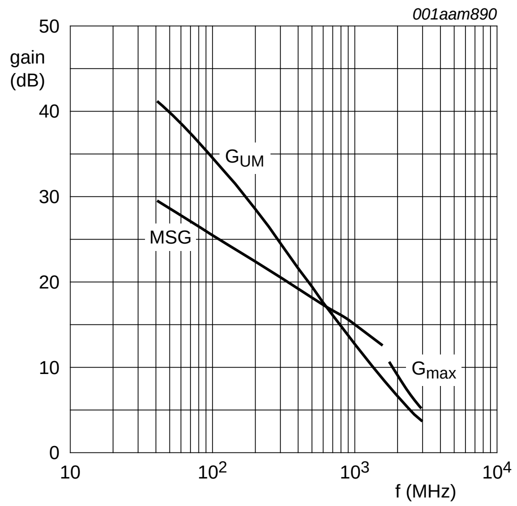
$V_{CE} = 10$ V; f = 500 MHz.
MSG = maximum stable gain.

Fig 6. Gain as a function of collector current; typical values



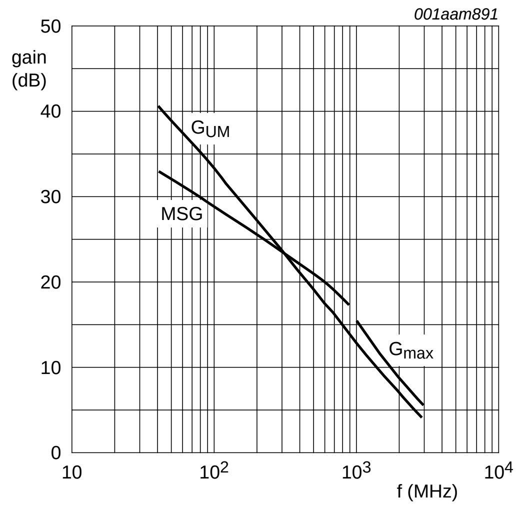
$V_{CE} = 10$ V; f = 500 MHz.
MSG = maximum stable gain.

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



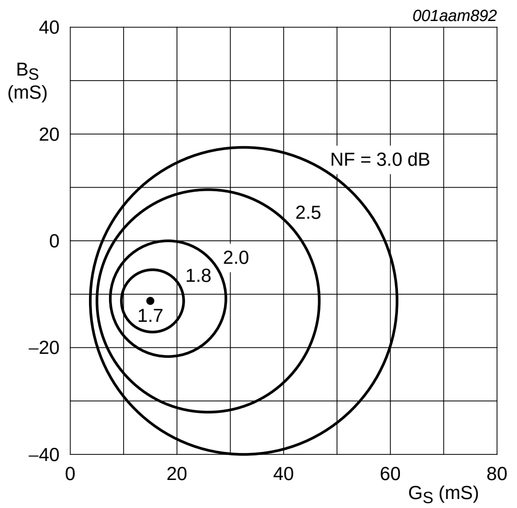
I_C = 5 mA; V_{CE} = 10 V.
MSG = maximum stable gain.
G_{max} = maximum available gain.

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



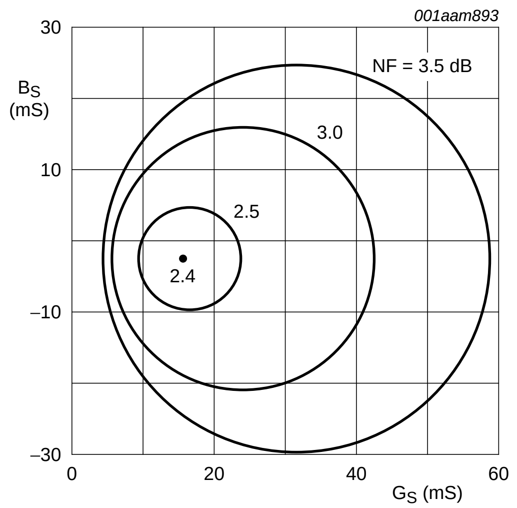
I_C = 5 mA; V_{CE} = 10 V.
MSG = maximum stable gain.
G_{max} = maximum available gain.

Fig 9. Minimum noise figure as a function of frequency; typical values



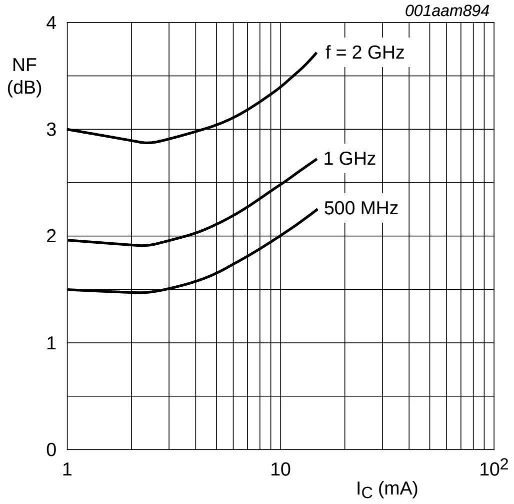
I_C = 4 mA; V_{CE} = 10 V; f = 800 MHz.

Fig 10. Circles of constant noise figure; typical values



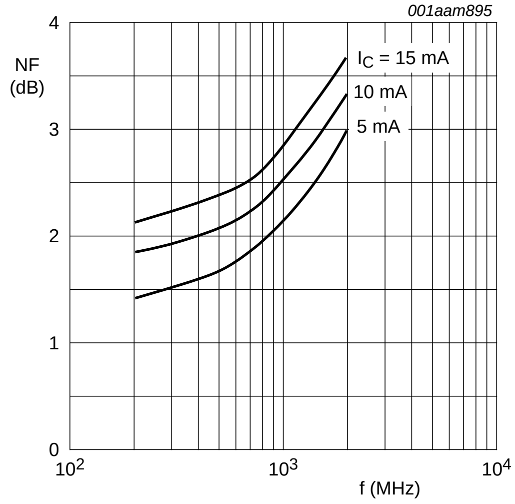
I_C = 14 mA; V_{CE} = 10 V; f = 800 MHz.

Fig 11. Circles of constant noise figure; typical values



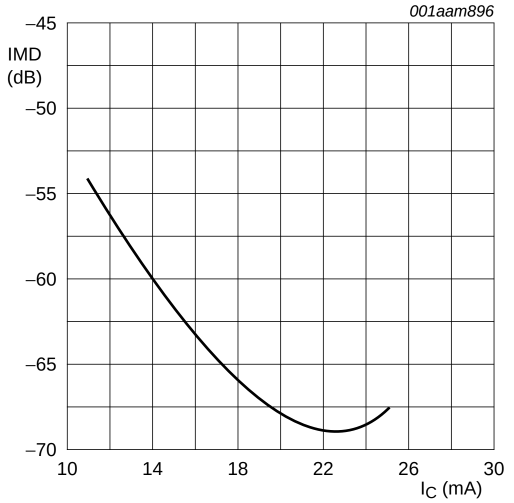
V_{CE} = 10 V.

Fig 12. Minimum noise figure as a function of collector current; typical values



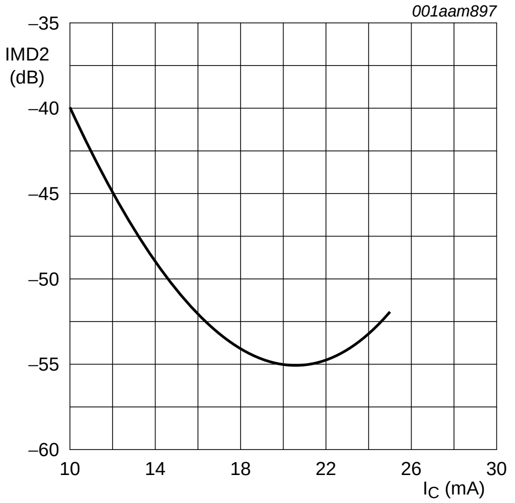
V_{CE} = 10 V.

Fig 13. Minimum noise figure as a function of frequency; typical values



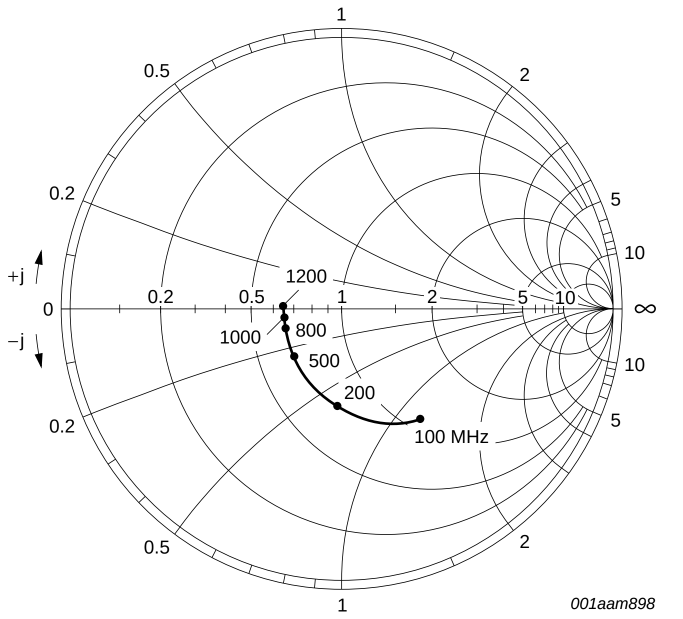
V_{CE} = 10 V.

Fig 14. Intermodulation distortion as a function of collector current; typical values



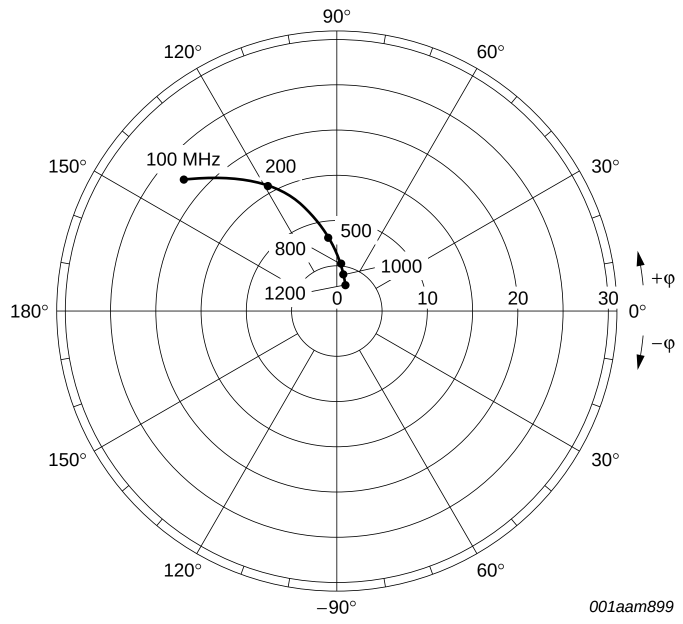
V_{CE} = 10 V.

Fig 15. Second-order intermodulation distortion as a function of collector current; typical values



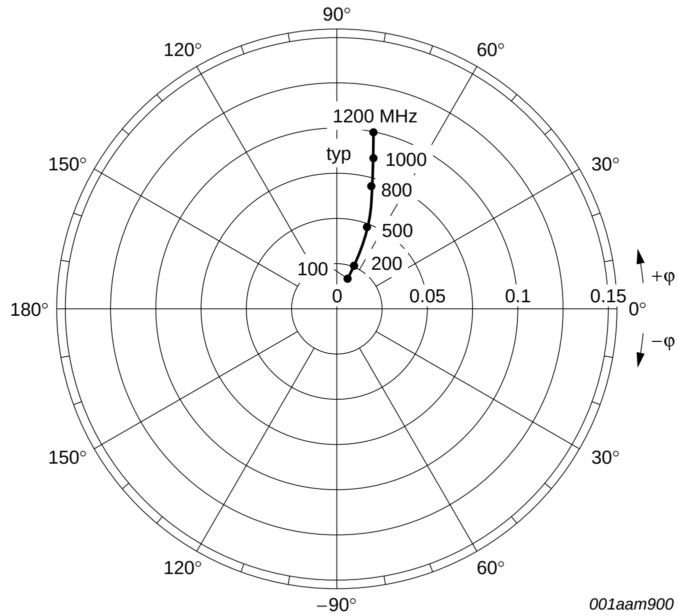
V_{CE} = 10 V; I_C = 14 mA; Z_O = 50 Ω; T_{amb} = 25 °C.

Fig 16. Common emitter input reflection coefficient (S_{11}); typical values



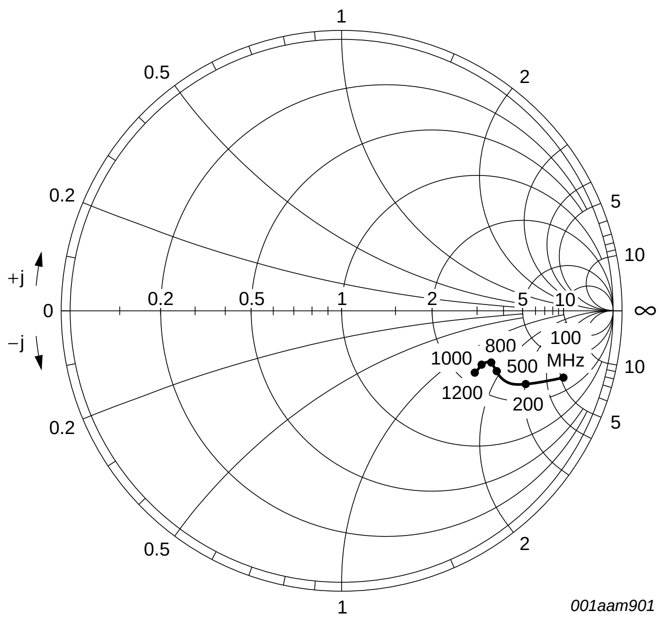
V_{CE} = 10 V; I_C = 14 mA; T_{amb} = 25 °C.

Fig 17. Common emitter forward transmission coefficient (S_{21}); typical values



V_{CE} = 10 V; I_C = 14 mA; T_{amb} = 25 °C.

Fig 18. Common emitter reverse transmission coefficient (S_{12}); typical values

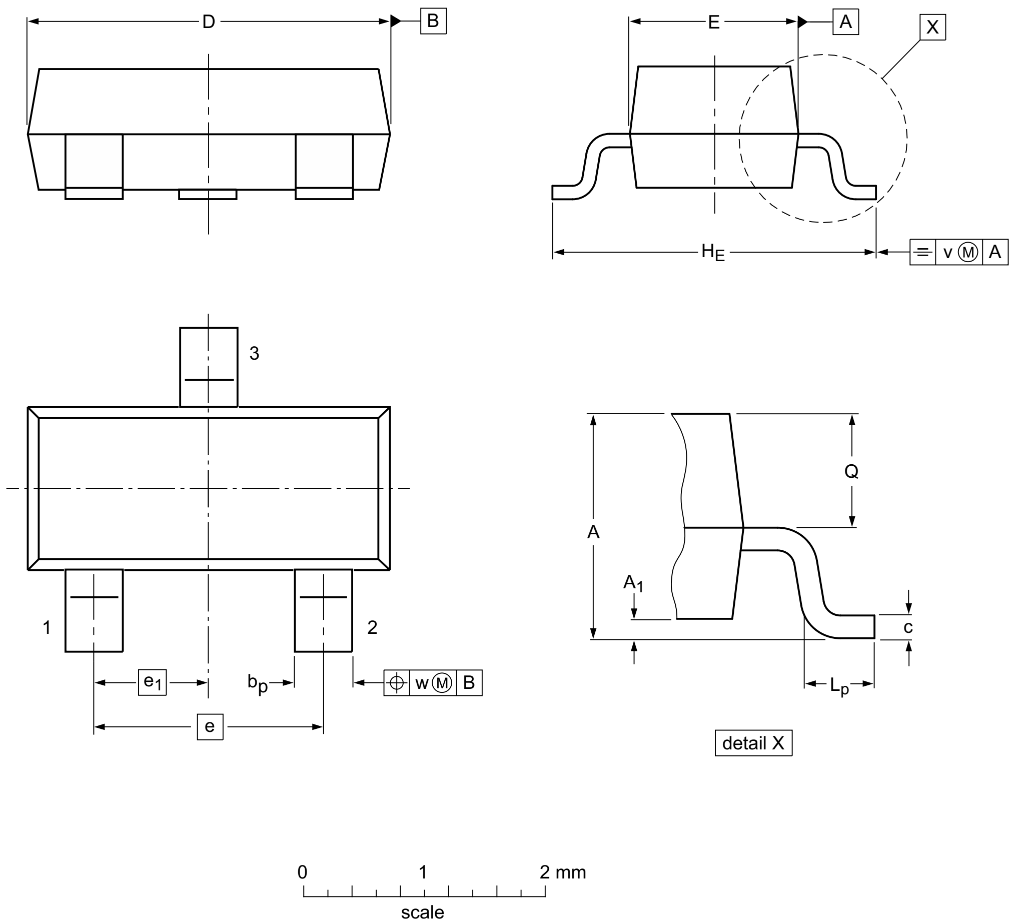


V_{CE} = 10 V; I_C = 14 mA; Z_O = 50 Ω; T_{amb} = 25 °C.

Fig 19. Common emitter output reflection coefficient (S_{22}); typical values

8. Package outline

Plastic surface-mounted package; 3 leads **SOT23**



Dimensions (mm are the original dimensions)

Unit		A	A_1	b_p	c	D	E	e	e_1	H_E	L_p	Q	v	w
mm	max	1.1	0.1	0.48	0.15	3.0	1.4			2.5	0.45	0.55		
	nom							1.9	0.95				0.2	0.1
	min	0.9		0.38	0.09	2.8	1.2			2.1	0.15	0.45		

sot023_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT23		TO-236AB				~~14-06-19~~ 14-09-22

Fig 20. Package outline SOT23

9. Abbreviations

Table 8. Abbreviations

Acronym	Description
NPN	Negative Positive Negative
PNP	Positive Negative Positive
RF	Radio Frequency
MATV	Master Antenna Television
VSWR	Voltage Standing Wave Ratio

10. Revision history

Table 9. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
BFR94A v.4	20141002	Product data sheet	-	BFR94A v.3
Modifications:	• Table 2 on page 2: changed graphic symbol • Figure 20 on page 10: updated			
BFR94A v.3	20101115	Product data sheet	-	BFR94A v.2
BFR94A v.2	19971204	Product data sheet	-	-

11. Legal information

11.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

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13. Contents

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