

# BFR94A

NPN 5 GHz wideband transistor

Rev. 3 — 15 November 2010

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

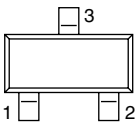
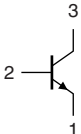
Table 1. Quick reference data

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	$T_{sp} \leq 95\text{ °C}$	-	-	300	mW
$C_{re}$	feedback capacitance	$I_C = i_C = 0\text{ mA}; V_{CE} = 10\text{ V};$ $f = 1\text{ MHz}$	-	0.35	-	pF
$f_T$	transition frequency	$I_C = 15\text{ mA}; V_{CE} = 10\text{ V};$ $f = 500\text{ MHz}$	-	5	-	GHz
$G_{UM}$	unilateral power gain	$I_C = 15\text{ mA}; V_{CE} = 10\text{ V};$ $T_{amb} = 25\text{ °C}$				
		$f = 1\text{ GHz}$	-	14	-	dB
		$f = 2\text{ GHz}$	-	8	-	dB
NF	noise figure	$I_C = 5\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ GHz};$ $\Gamma_S = \Gamma_{opt}; T_{amb} = 25\text{ °C}$	-	2.1	-	dB
$V_O$	output voltage	IMD = -60 dB; $I_C = 14\text{ mA};$ $V_{CE} = 10\text{ V}; R_L = 75\ \Omega;$ $f_p + f_q - f_r = 793.25\text{ MHz}$	-	150	-	mV



## 2. Pinning information

Table 2. Pinning

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

*sym026*

## 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	$T_{sp} \leq 95\text{ °C}$ ; see <a href="#">Figure 2</a>	[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	$T_{sp} \leq 95\text{ °C}$	[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	$I_E = 0\text{ A}; V_{CB} = 10\text{ V}$	-	-	50	nA
$h_{FE}$	DC current gain	$I_C = 15\text{ mA}; V_{CE} = 10\text{ V}$ ; see <a href="#">Figure 3</a>	65	90	135	
$C_c$	collector capacitance	$I_E = i_e = 0\text{ A}; V_{CB} = 10\text{ V}; f = 1\text{ MHz}$ ; see <a href="#">Figure 4</a>	-	0.6	-	pF
$C_e$	emitter capacitance	$I_C = i_c = 0\text{ A}; V_{EB} = 10\text{ V}; f = 1\text{ MHz}$	-	1.2	-	pF
$C_{re}$	feedback capacitance	$I_C = i_c = 0\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ MHz}$	-	0.35	-	pF
$f_T$	transition frequency	$I_C = 15\text{ mA}; V_{CE} = 10\text{ V}; f = 500\text{ MHz}$ ; see <a href="#">Figure 5</a>	-	5	-	GHz
$G_{UM}$	unilateral power gain	$I_C = 15\text{ mA}; V_{CE} = 10\text{ V}; T_{amb} = 25\text{ °C}$ [1]				
		$f = 1\text{ GHz}$	-	14	-	dB
		$f = 2\text{ GHz}$	-	8	-	dB
NF	noise figure	$I_C = 5\text{ mA}; V_{CE} = 10\text{ V}; \Gamma_S = \Gamma_{opt}$ ; $T_{amb} = 25\text{ °C}$ ; see <a href="#">Figure 12</a> and <a href="#">Figure 13</a>				
		$f = 1\text{ GHz}$	-	2.1	-	dB
		$f = 2\text{ GHz}$	-	3	-	dB
$V_O$	output voltage		[2][3] -	150	-	mV
IMD2	second-order intermodulation distortion	see <a href="#">Figure 15</a>	[2][4] -	-50	-	dB

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

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

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

[3]  $IMD = -60\text{ dB}$  (DIN 45004B);  $I_C = 14\text{ mA}; V_{CE} = 10\text{ V}; R_L = 75\ \Omega; VSWR < 2; T_{amb} = 25\text{ °C}$ ;

$V_p = V_O$  at  $IMD = -60\text{ dB}$ ;  $f_p = 795.25\text{ MHz}$ ;

$V_q = V_O - 6\text{ dB}$  at  $f_q = 803.25\text{ MHz}$ ;

$V_r = V_O - 6\text{ dB}$  at  $f_r = 805.25\text{ MHz}$ ;

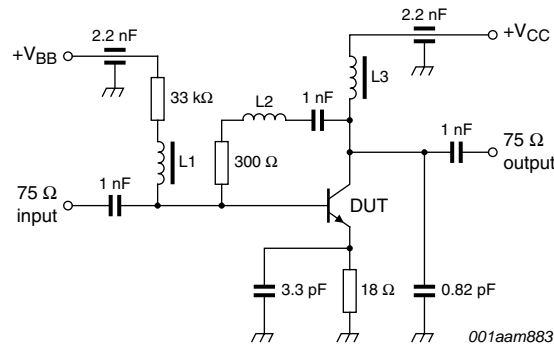
measured at  $f_p + f_q - f_r = 793.25\text{ MHz}$

[4]  $I_C = 14\text{ mA}; V_{CE} = 10\text{ V}; R_L = 75\ \Omega; VSWR < 2; T_{amb} = 25\text{ °C}$ ;

$V_p = 60\text{ mV}$  at  $f_p = 250\text{ MHz}$ ;

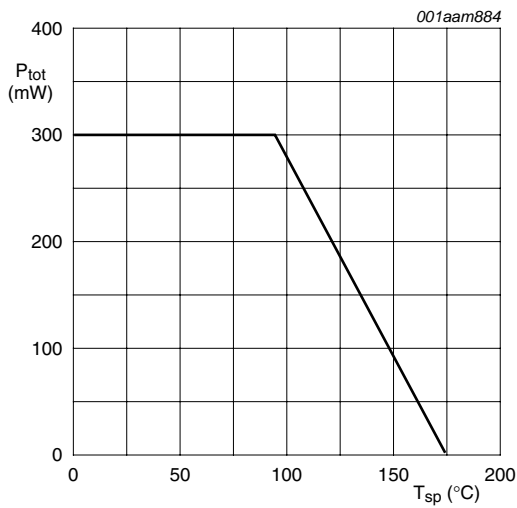
$V_q = 60\text{ mV}$  at  $f_p = 560\text{ MHz}$ ;

measured at  $f_p + f_q = 810\text{ MHz}$

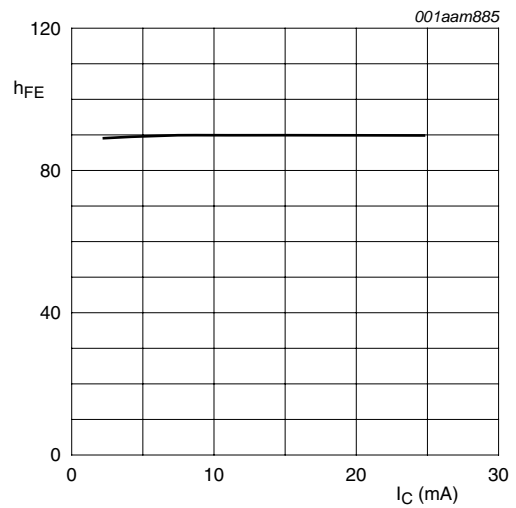


L1 = L2 = 5  $\mu$ H choke.  
 L2 = 3 turns 0.4 mm copper wire, internal diameter 3 mm, winding pitch 1 mm.

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

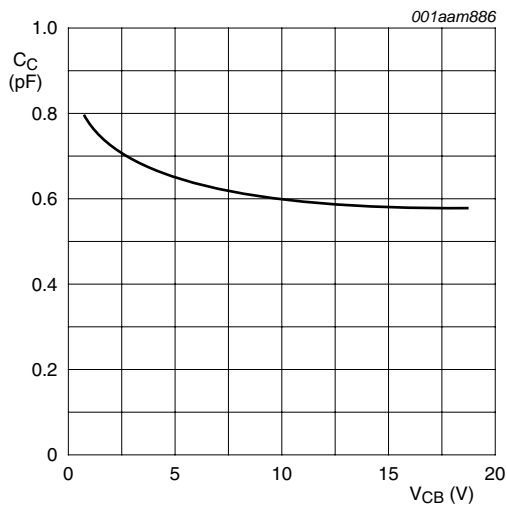


**Fig 2. Power derating curve**



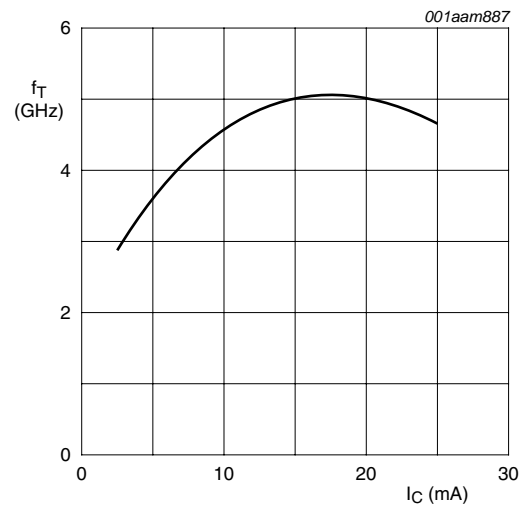
$V_{CE} = 10$  V;  $T_j = 25$  °C.

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



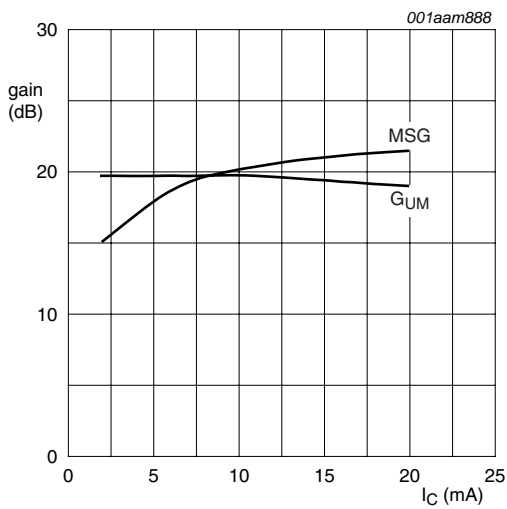
$I_C = i_C = 0$  mA;  $f = 1$  MHz;  $T_j = 25$  °C.

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



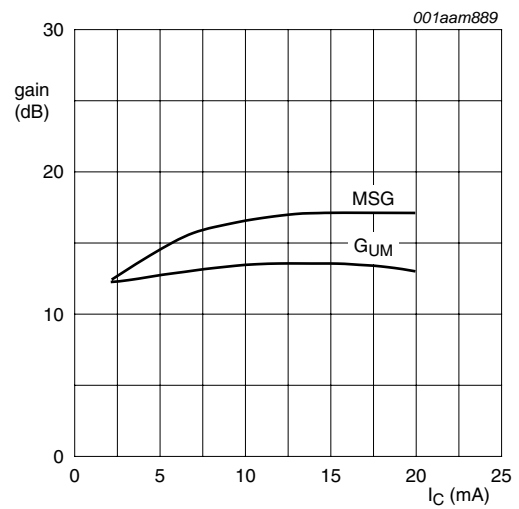
$V_{CE} = 10$  V;  $f = 500$  MHz;  $T_{amb} = 25$  °C.

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



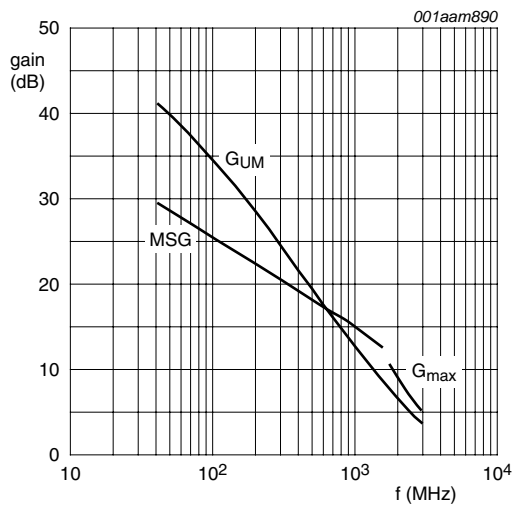
$V_{CE} = 10$  V;  $f = 500$  MHz.  
MSG = maximum stable gain.

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



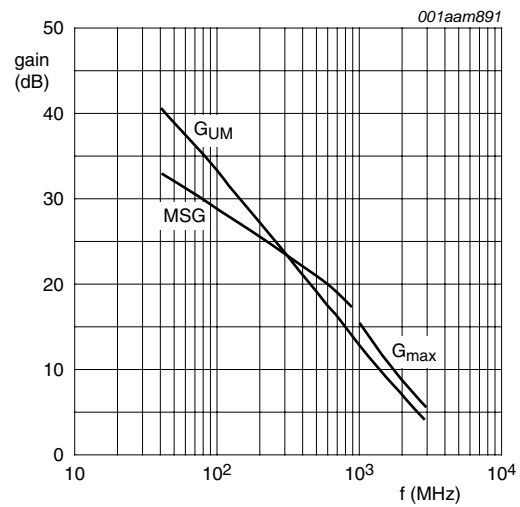
$V_{CE} = 10$  V;  $f = 500$  MHz.  
MSG = maximum stable gain.

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



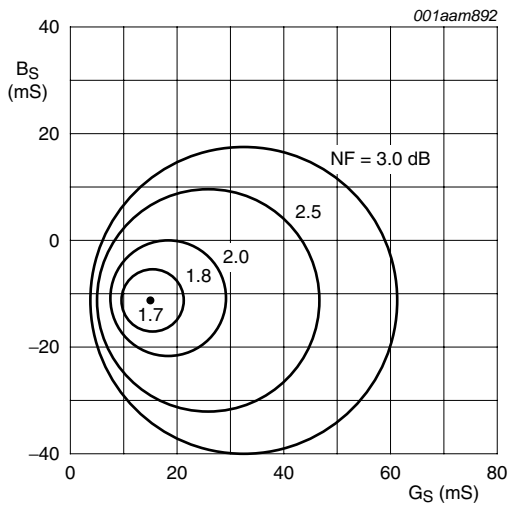
$I_C = 5 \text{ mA}$ ;  $V_{CE} = 10 \text{ V}$ .  
 MSG = maximum stable gain.  
 $G_{max}$  = maximum available gain.

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



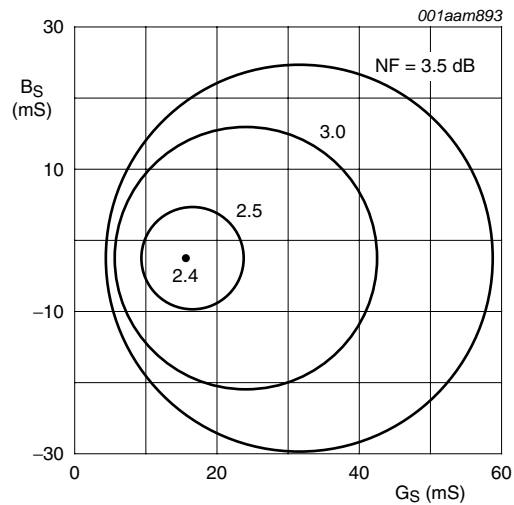
$I_C = 5 \text{ mA}$ ;  $V_{CE} = 10 \text{ V}$ .  
 MSG = maximum stable gain.  
 $G_{max}$  = maximum available gain.

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



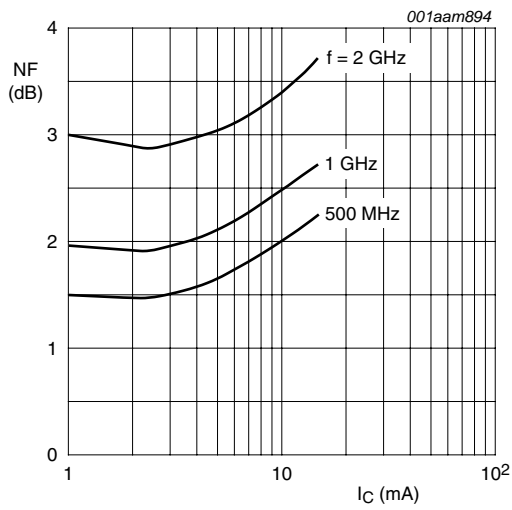
$I_C = 4 \text{ mA}$ ;  $V_{CE} = 10 \text{ V}$ ;  $f = 800 \text{ MHz}$ .

**Fig 10. Circles of constant noise figure; typical values**



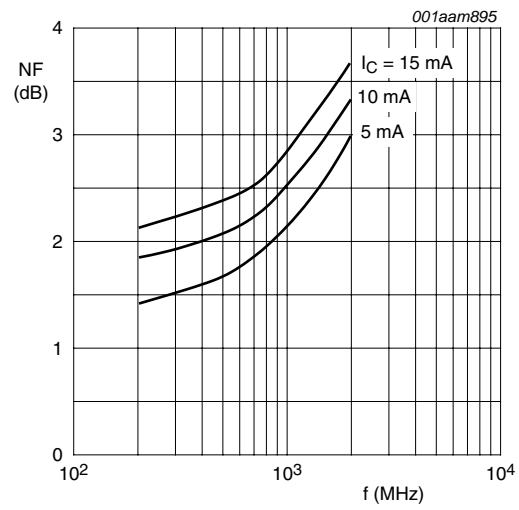
$I_C = 14 \text{ mA}$ ;  $V_{CE} = 10 \text{ V}$ ;  $f = 800 \text{ MHz}$ .

**Fig 11. Circles of constant noise figure; typical values**



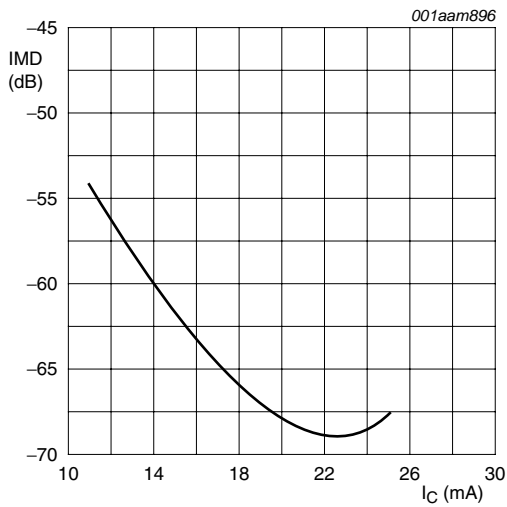
$V_{CE} = 10$  V.

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



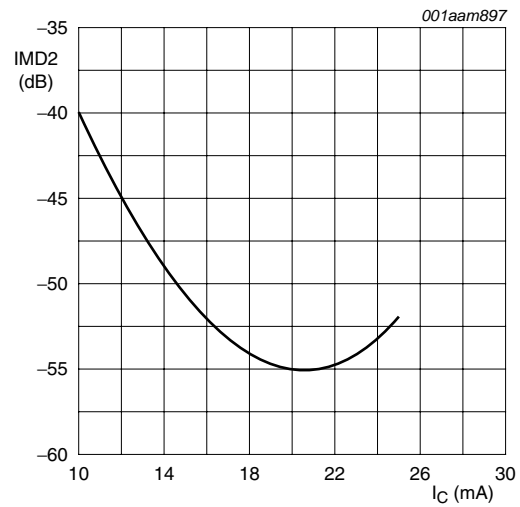
$V_{CE} = 10$  V.

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



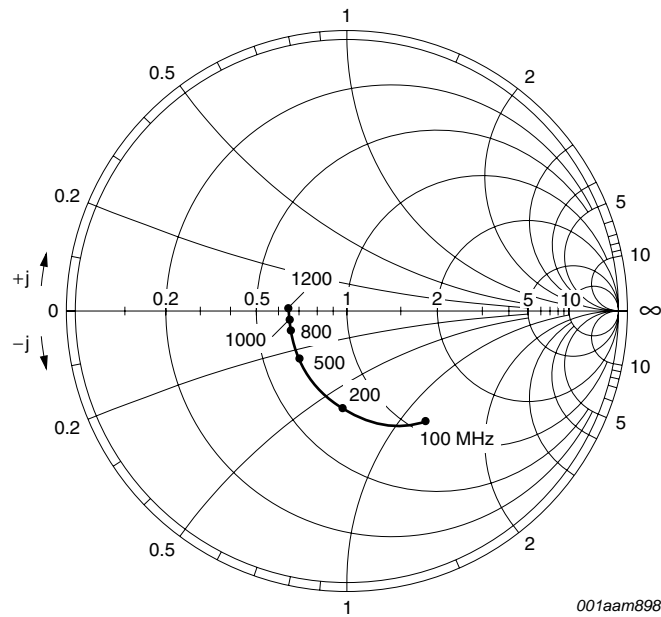
$V_{CE} = 10$  V.

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



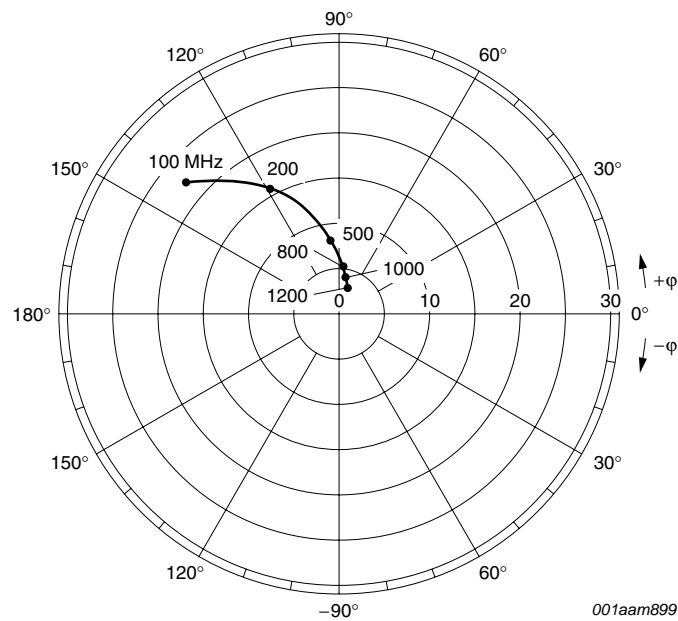
$V_{CE} = 10$  V.

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



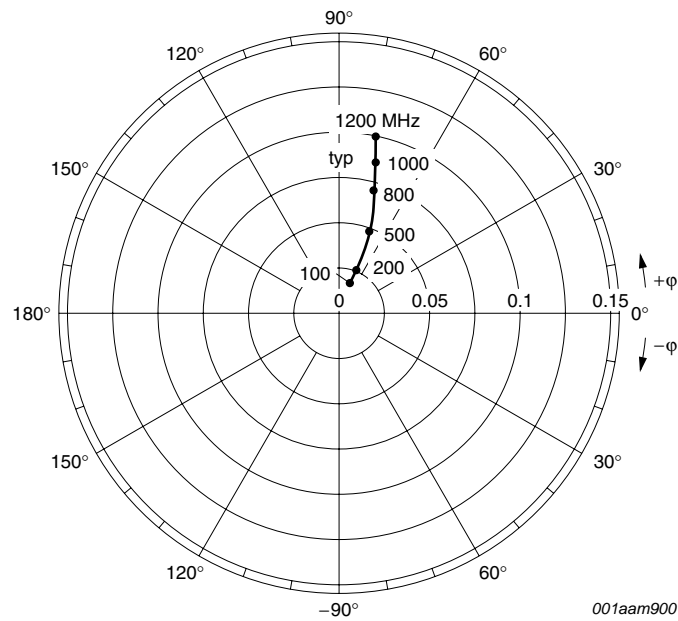
$V_{CE} = 10\text{ V}$ ;  $I_C = 14\text{ mA}$ ;  $Z_O = 50\ \Omega$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ .

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



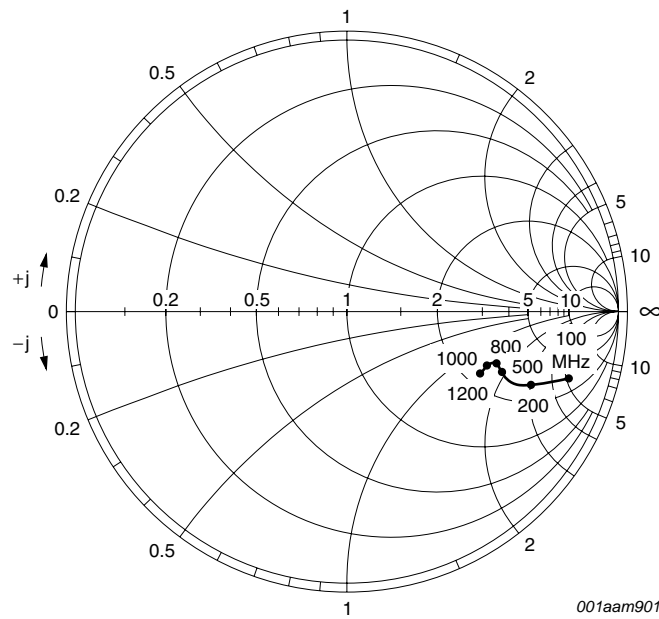
$V_{CE} = 10\text{ V}$ ;  $I_C = 14\text{ mA}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ .

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



$V_{CE} = 10\text{ V}$ ;  $I_C = 14\text{ mA}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ .

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



$V_{CE} = 10\text{ V}$ ;  $I_C = 14\text{ mA}$ ;  $Z_O = 50\text{ }\Omega$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ .

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

**8. Package outline**

Plastic surface-mounted package; 3 leads

SOT23

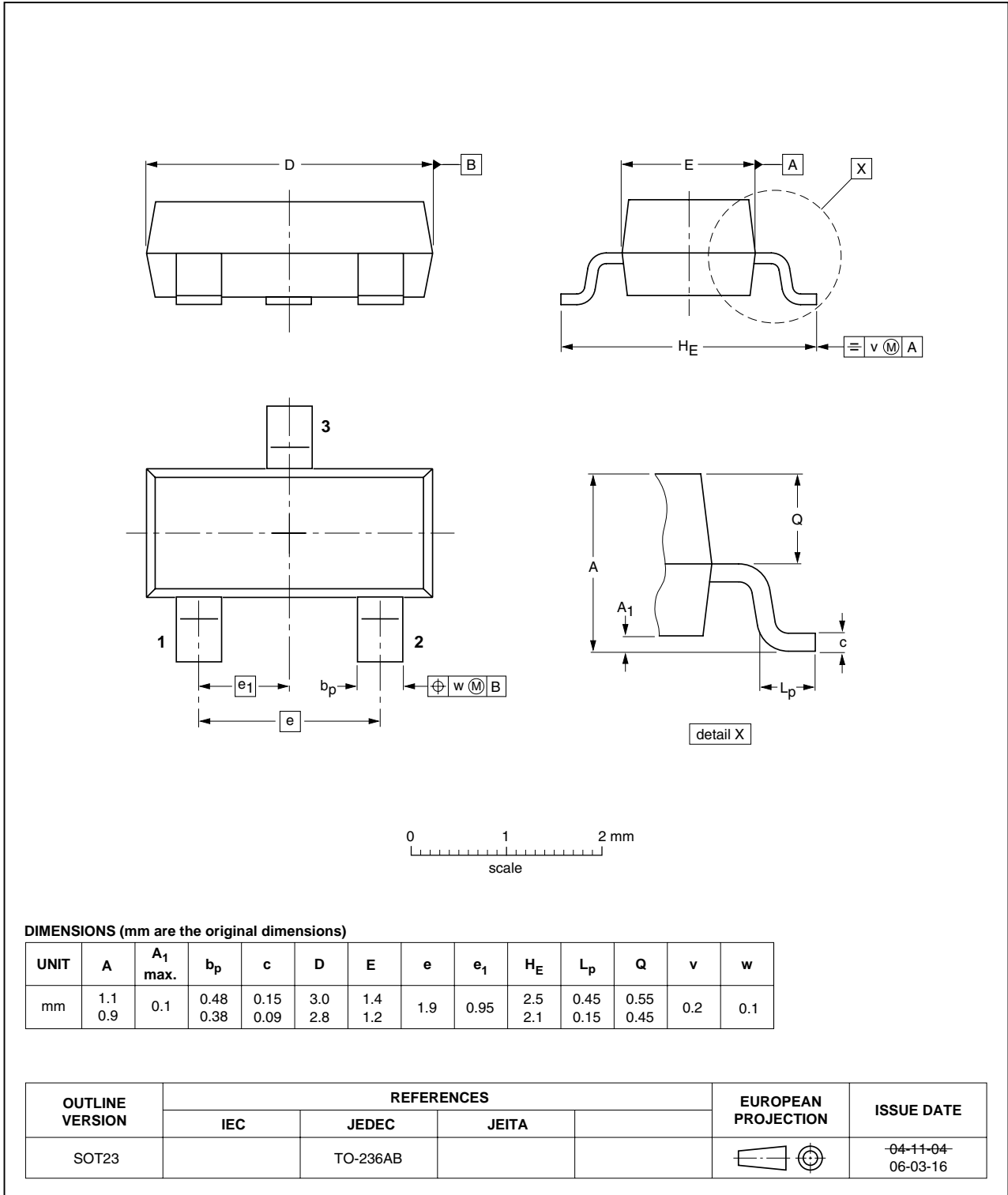


Fig 20. Package outline SOT23

## 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.3	20101115	Product data sheet	-	BFR94A v.2
Modifications:	<ul style="list-style-type: none"><li>• The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors.</li><li>• Legal texts have been adapted to the new company name where appropriate.</li><li>• Replaces previous data sheet and documentation of BFR94A.</li></ul>			
BFR94A v.2	19971204	Product data sheet	-	-

## 11. Legal information

### 11.1 Data sheet status

Document status <sup>[1][2]</sup>	Product status <sup>[3]</sup>	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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