



# BFR93AR

NPN 6 GHz wideband transistor

Rev. 01 — 30 November 2006

Product data sheet

## 1. Product profile

### 1.1 General description

NPN wideband transistor in a plastic SOT23 package.  
PNP complement: BFT93.

### 1.2 Features

- Very high power gain
- Low noise figure
- Very low intermodulation distortion

### 1.3 Applications

- RF wideband amplifiers and oscillators

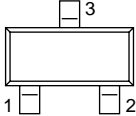
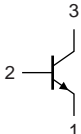
### 1.4 Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{CBO}$	collector-base voltage	open emitter	-	-	15	V
$V_{CEO}$	collector-emitter voltage	open base	-	-	12	V
$I_C$	collector current		-	-	35	mA
$P_{tot}$	total power dissipation	$T_{sp} \leq 95\text{ °C}$	-	-	300	mW
$C_{re}$	feedback capacitance	$I_C = 0\text{ mA}; V_{CE} = 5\text{ V}; f = 1\text{ MHz};$	-	0.6	-	pF
$f_T$	transition frequency	$I_C = 30\text{ mA}; V_{CE} = 5\text{ V};$ $f = 500\text{ MHz};$	-	6	-	GHz
$G_{UM}$	unilateral power gain	$I_C = 30\text{ mA}; V_{CE} = 8\text{ V};$ $T_{amb} = 25\text{ °C}$				
		$f = 1\text{ GHz}$	-	13	-	dB
		$f = 2\text{ GHz}$	-	7	-	dB
NF	noise figure	$I_C = 5\text{ mA}; V_{CE} = 8\text{ V}; f = 1\text{ GHz};$ $\Gamma_S = \Gamma_{opt}; T_{amb} = 25\text{ °C}$	-	1.9	-	dB
$V_O$	output voltage	IMD = -60 dB; $I_C = 30\text{ mA};$ $V_{CE} = 8\text{ V}; R_L = 75\ \Omega;$ $T_{amb} = 25\text{ °C};$ $f_p + f_q - f_r = 793.25\text{ MHz}$	-	425	-	mV

## 2. Pinning information

**Table 2. Pinning**

Pin	Description	Simplified outline	Symbol
1	emitter		
2	base		
3	collector		

*sym026*

## 3. Ordering information

**Table 3. Ordering information**

Type number	Package		
	Name	Description	Version
BFR93AR	-	plastic surface-mounted package; 3 leads	SOT23

## 4. Marking

**Table 4. Marking**

Type number	Marking code	Description
BFR93AR	*R5	* = 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).*

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
$I_C$	collector current		-	35	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		-	+175	°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	$I_E = 0\text{ A}; V_{CB} = 5\text{ V}$	-	-	50	nA
$h_{FE}$	DC current gain	$I_C = 30\text{ mA}; V_{CE} = 5\text{ V}$ ; see <a href="#">Figure 3</a>	40	90	-	
$C_c$	collector capacitance	$I_E = i_e = 0\text{ A}; V_{CB} = 5\text{ V}; f = 1\text{ MHz}$ ; see <a href="#">Figure 4</a>	-	0.7	-	pF
$C_e$	emitter capacitance	$I_C = i_c = 0\text{ A}; V_{EB} = 0.5\text{ V}; f = 1\text{ MHz}$	-	1.9	-	pF
$C_{re}$	feedback capacitance	$I_C = i_c = 0\text{ A}; V_{CE} = 5\text{ V}; f = 1\text{ MHz}$ ; $T_{amb} = 25\text{ °C}$	-	0.6	-	pF
$f_T$	transition frequency	$I_C = 30\text{ mA}; V_{CE} = 5\text{ V}; f = 500\text{ MHz}$ ; see <a href="#">Figure 5</a>	4.5	6	-	GHz
$G_{UM}$	unilateral power gain	$I_C = 30\text{ mA}; V_{CE} = 8\text{ V}; T_{amb} = 25\text{ °C}$ ; see <a href="#">Figure 6</a> to <a href="#">Figure 9</a>	[1]			
		$f = 1\text{ GHz}$	-	13	-	dB
		$f = 2\text{ GHz}$	-	7	-	dB
NF	noise figure	$I_C = 5\text{ mA}; V_{CE} = 8\text{ V}; \Gamma_S = \Gamma_{opt}$ ; $T_{amb} = 25\text{ °C}$ ; see <a href="#">Figure 12</a> and <a href="#">Figure 13</a>				
		$f = 1\text{ GHz}$	-	1.9	-	dB
		$f = 2\text{ GHz}$	-	3	-	dB
$V_O$	output voltage		[2][3]	-	425	mV
IMD2	second-order intermodulation distortion	see <a href="#">Figure 15</a>	[2][4]	-	-50	dB

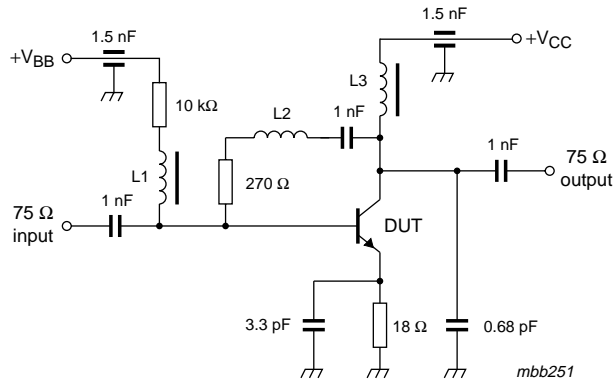
[1]  $G_{UM}$  is the maximum unilateral power gain, assuming  $S_{12}$  is zero and

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

[2] Measured on the same crystal in a SOT37 package (BFR91A).

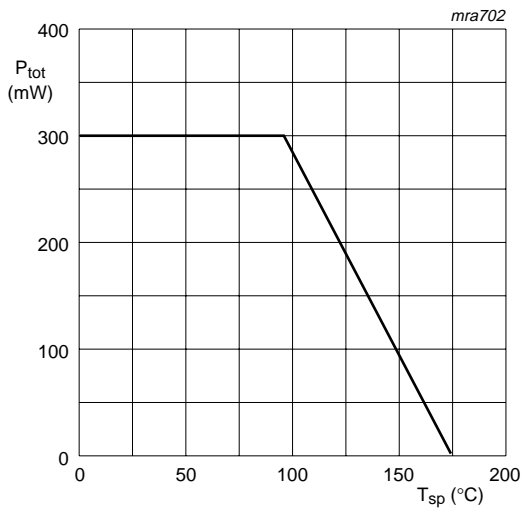
[3]  $IMD = -60\text{ dB}$  (DIN 45004B);  $I_C = 30\text{ mA}; V_{CE} = 8\text{ V}; R_L = 75\ \Omega; T_{amb} = 25\text{ °C}$ ;  
 $V_p = V_O$  at  $IMD = -60\text{ dB}$ ;  $f_p = 795.25\text{ MHz}$ ;  
 $V_q = V_O - 6\text{ dB}$  at  $f_q = 803.25\text{ MHz}$ ;  
 $V_r = V_O - 6\text{ dB}$  at  $f_r = 805.25\text{ MHz}$ ;  
 measured at  $f_p + f_q - f_r = 793.25\text{ MHz}$

[4]  $I_C = 30\text{ mA}; V_{CE} = 8\text{ V}; R_L = 75\ \Omega; T_{amb} = 25\text{ °C}$ ;  
 $V_p = 200\text{ mV}$  at  $f_p = 250\text{ MHz}$ ;  
 $V_q = 200\text{ mV}$  at  $f_p = 560\text{ MHz}$ ;  
 measured at  $f_p + f_q = 810\text{ MHz}$

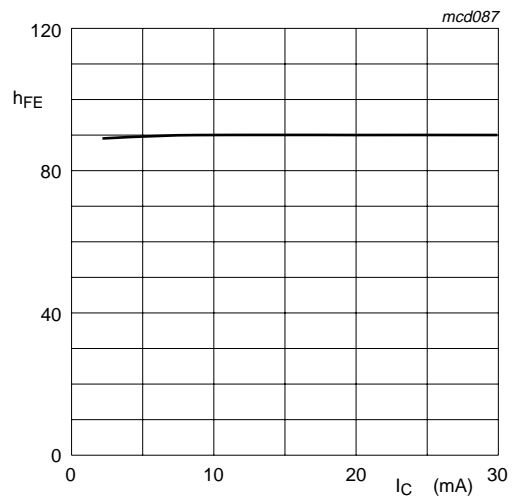


L1 = L3 = 5  $\mu$ H choke.  
 L2 = 3 turns 0.4 mm copper wire; winding pitch 1 mm; internal diameter 3 mm.

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

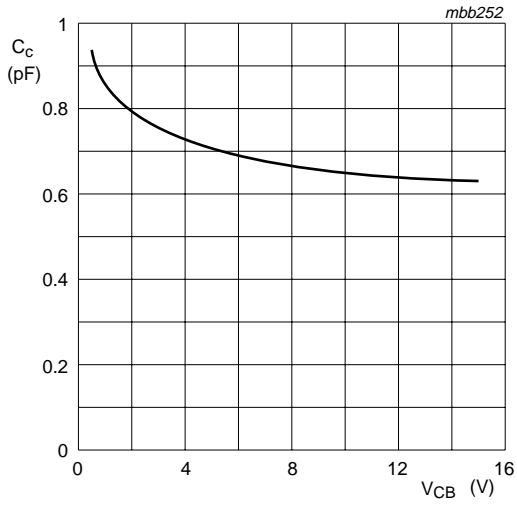


**Fig 2. Power derating curve**



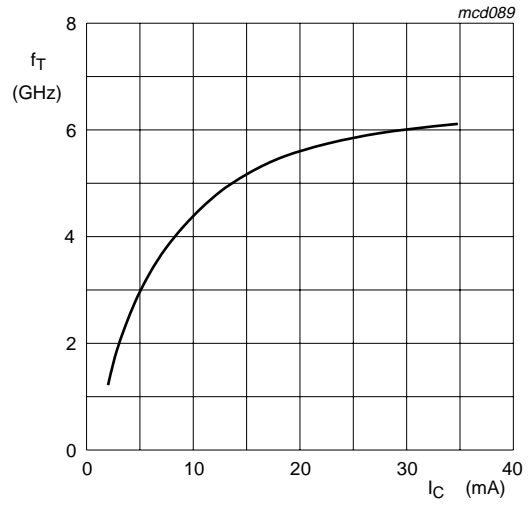
V<sub>CE</sub> = 5 V; T<sub>j</sub> = 25 °C.

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



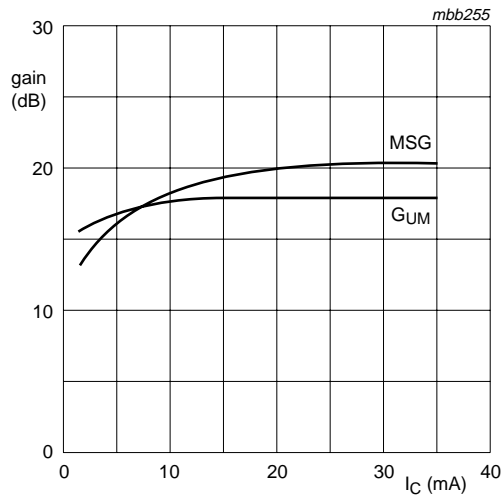
$I_E = I_e = 0 \text{ mA}$ ;  $f = 1 \text{ MHz}$ ;  $T_j = 25 \text{ }^\circ\text{C}$ .

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



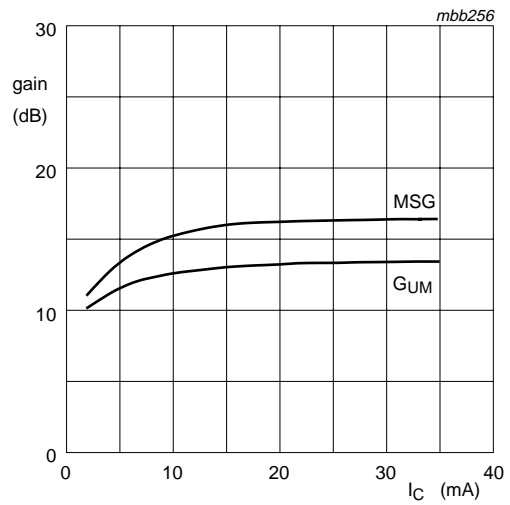
$V_{CE} = 2 \text{ V}$ ;  $f = 500 \text{ MHz}$ ;  $T_j = 25 \text{ }^\circ\text{C}$ .

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



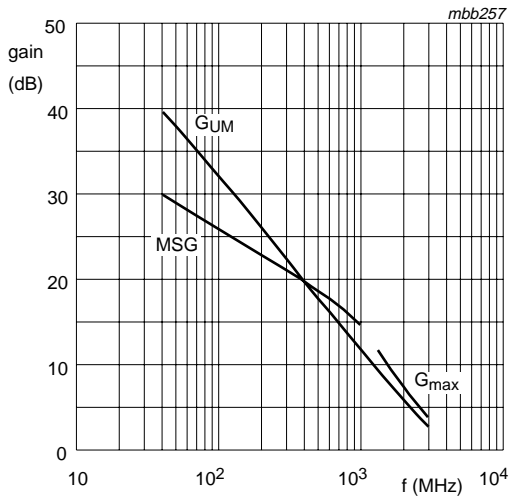
$V_{CE} = 8 \text{ V}$ ;  $f = 500 \text{ MHz}$ .

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



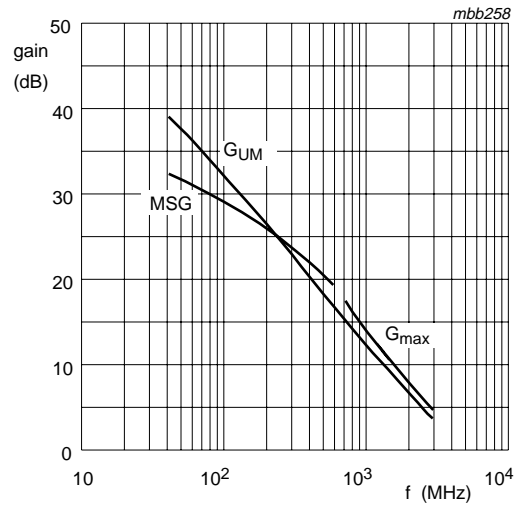
$V_{CE} = 8 \text{ V}$ ;  $f = 1 \text{ GHz}$ .

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



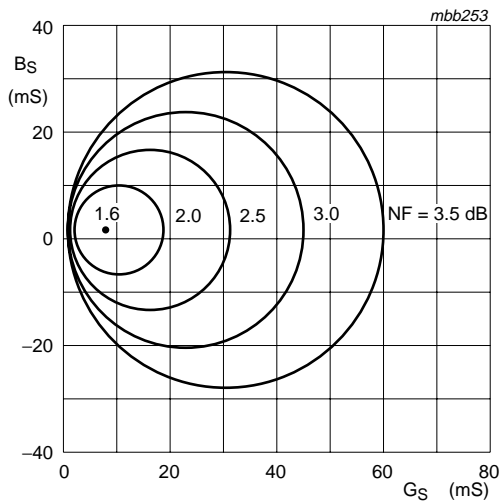
$I_C = 10 \text{ mA}; V_{CE} = 8 \text{ V}.$

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



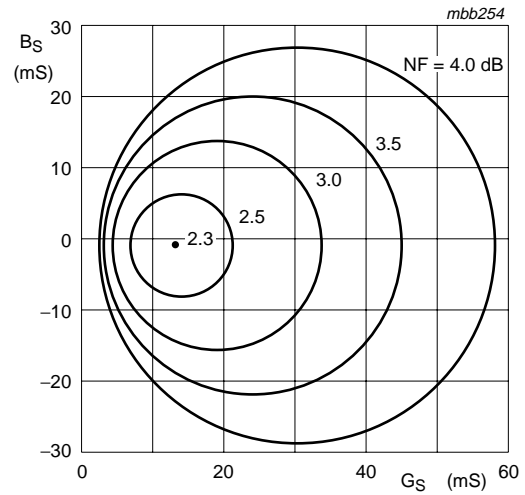
$I_C = 30 \text{ mA}; V_{CE} = 8 \text{ V}.$

**Fig 9. Gain as a function of frequency; typical values**



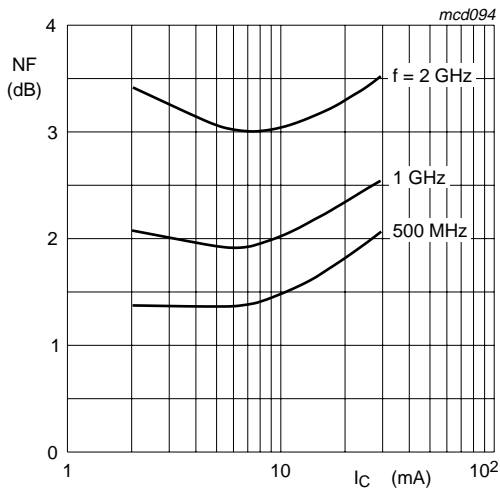
$I_C = 4 \text{ mA}; V_{CE} = 8 \text{ V}; f = 800 \text{ MHz}; T_{amb} = 25 \text{ }^\circ\text{C}.$

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



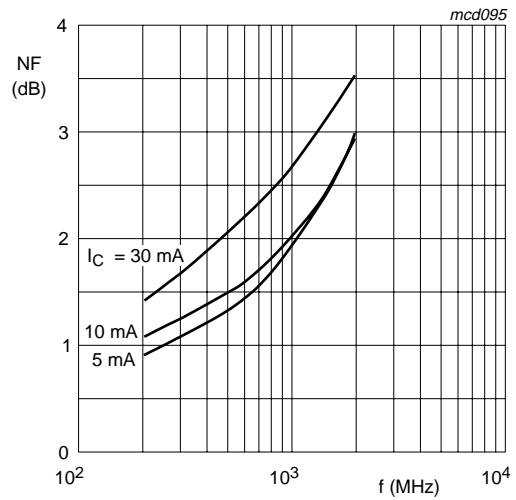
$I_C = 4 \text{ mA}; V_{CE} = 8 \text{ V}; f = 800 \text{ MHz}; T_{amb} = 25 \text{ }^\circ\text{C}.$

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



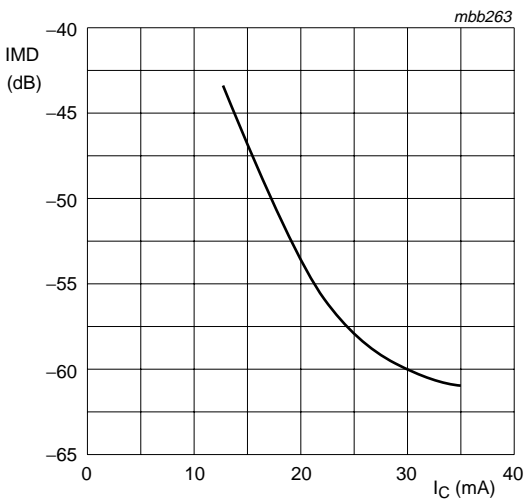
$V_{CE} = 8\text{ V}$ .

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



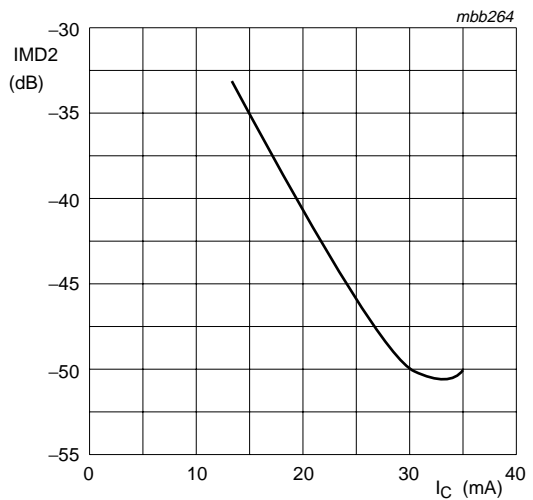
$V_{CE} = 8\text{ V}$ .

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



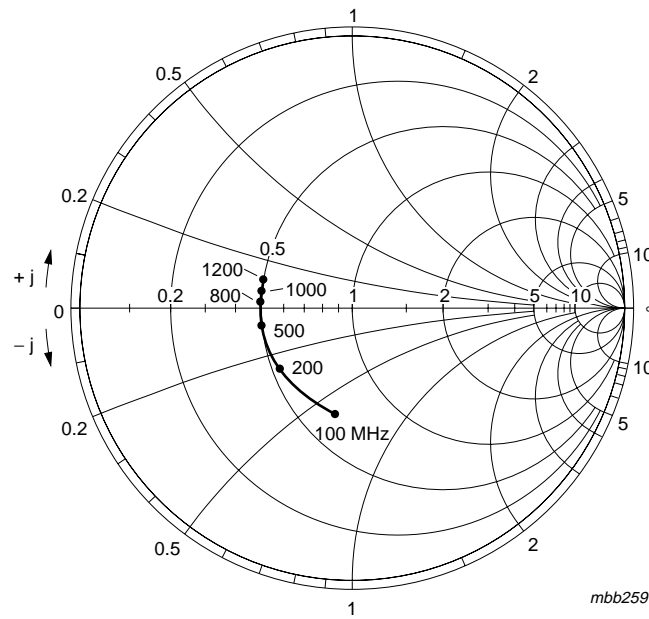
$V_{CE} = 8\text{ V}$ ;  $V_O = 425\text{ mV}$  (52.6 dBmV);  
 $f_p + f_q - f_r = 793.25\text{ MHz}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ .  
 Measured in MATV test circuit; see [Figure 1](#).

**Fig 14. Intermodulation distortion; typical values**



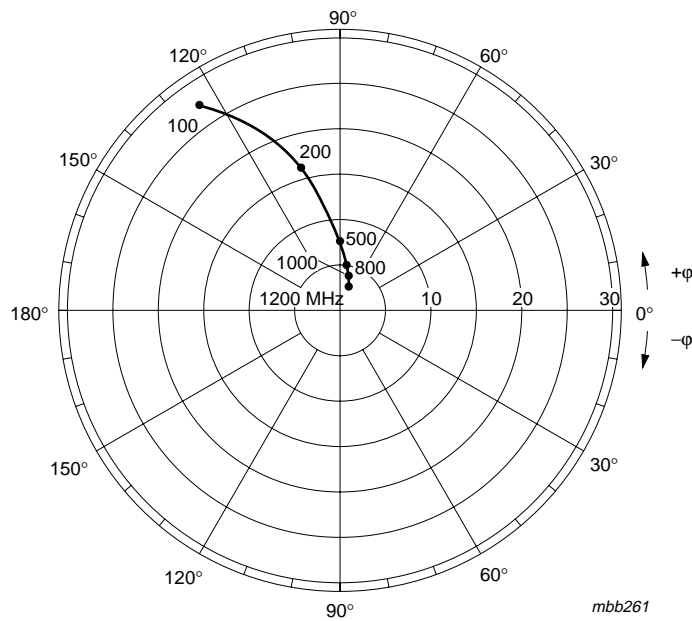
$V_{CE} = 8\text{ V}$ ;  $V_O = 200\text{ mV}$  (46 dBmV);  
 $f_p + f_q - f_r = 810\text{ MHz}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ .  
 Measured in MATV test circuit; see [Figure 1](#).

**Fig 15. Second order intermodulation distortion; typical values**



$I_C = 30 \text{ mA}; V_{CE} = 8 \text{ V}; Z_O = 50 \Omega; T_{amb} = 25 \text{ }^\circ\text{C}.$

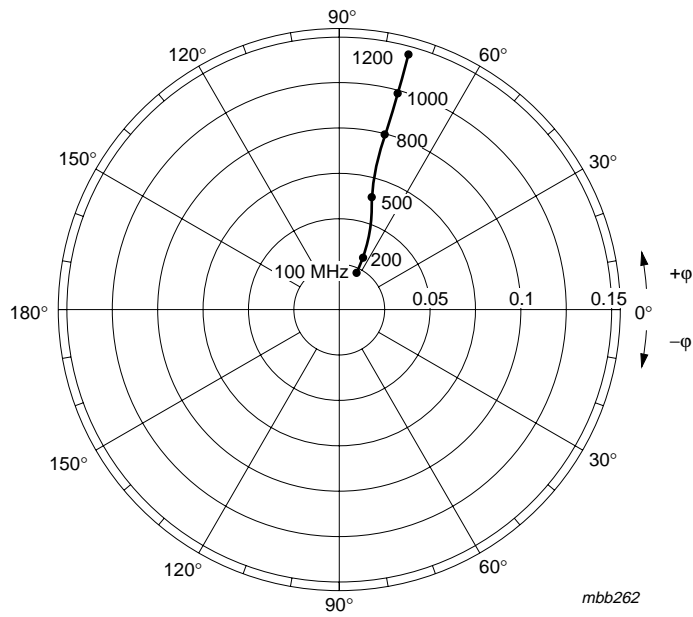
**Fig 16. Common emitter input reflection coefficient ( $S_{11}$ )**



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

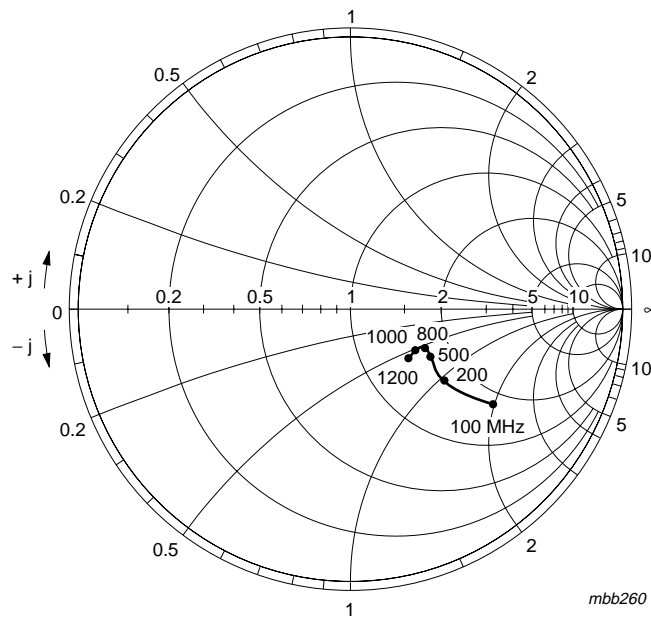
**Fig 17. Common emitter forward transmission coefficient ( $S_{21}$ )**





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

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



$I_C = 30 \text{ mA}$ ;  $V_{CE} = 8 \text{ V}$ ;  $Z_O = 50 \text{ } \Omega$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ .

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

**8. Package outline**

Plastic surface-mounted package; 3 leads

SOT23

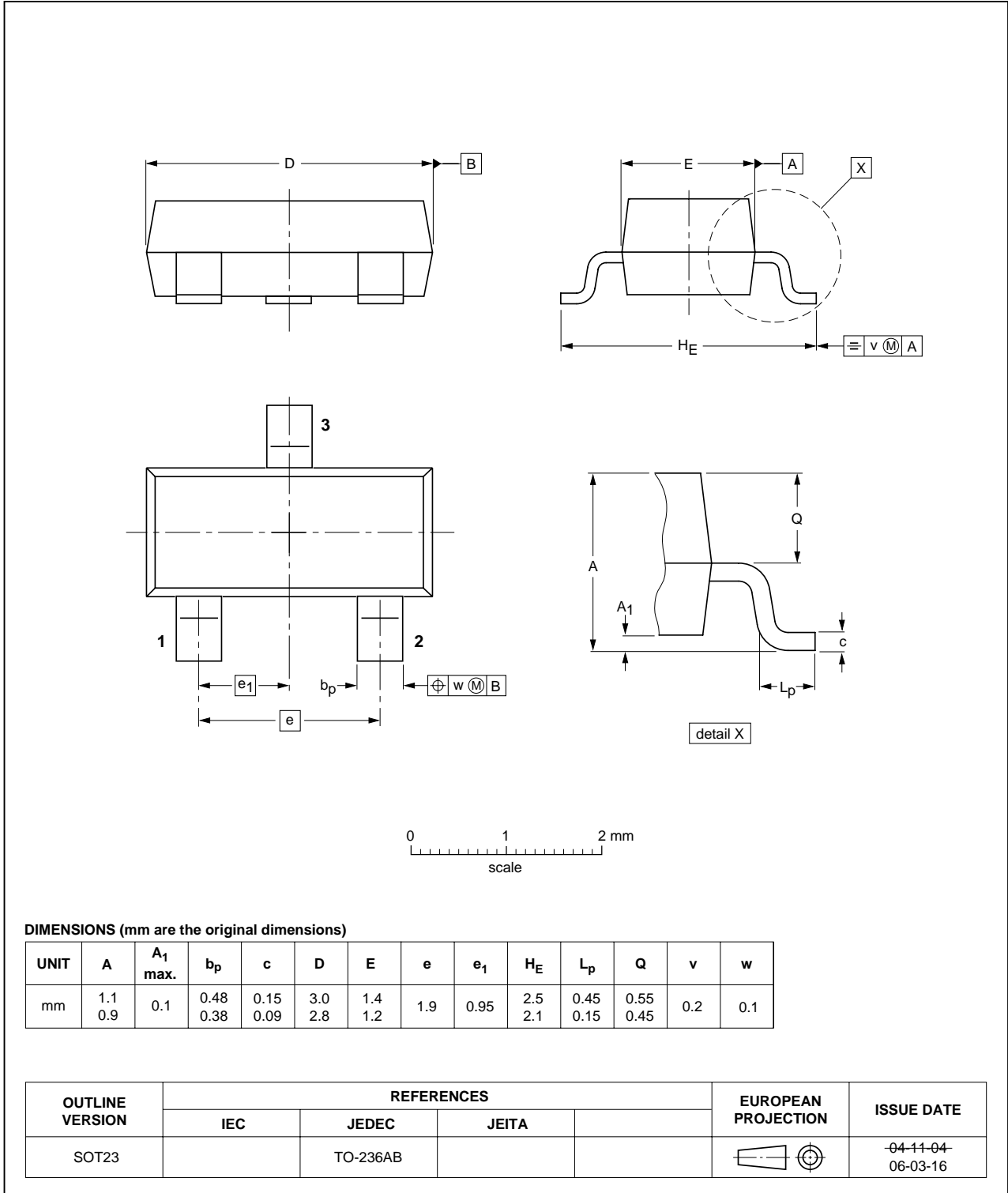


Fig 20. Package outline SOT23

## 9. Abbreviations

Table 8. Abbreviations

Acronym	Description
NPN	Negative Positive Negative
PNP	Positive Negative Positive
RF	Radio Frequency
MATV	Master Antenna Television

## 10. Revision history

Table 9. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
BFR93AR_1	20061130	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.
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Product [short] data sheet	Production	This document contains the product specification.

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

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