

# BFU590G

NPN wideband silicon RF transistor

Rev. 1 — 28 April 2014

Product data sheet

## 1. Product profile

### 1.1 General description

NPN silicon microwave transistor for high speed, medium power applications in a plastic, 4-pin SOT223 package.

The BFU590G is part of the BFU5 family of transistors, suitable for small signal to medium power applications up to 2 GHz.

### 1.2 Features and benefits

- Medium power, high linearity, high breakdown voltage RF transistor
- AEC-Q101 qualified
- Maximum stable gain 13 dB at 900 MHz
- $P_{L(1dB)}$  21.5 dBm at 900 MHz
- 8.5 GHz  $f_T$  silicon technology

### 1.3 Applications

- Automotive applications
- Broadband amplifiers
- Medium power amplifiers (500 mW at a frequency of 433 MHz or 866 MHz)
- Large signal amplifiers for ISM applications

### 1.4 Quick reference data

Table 1. Quick reference data

$T_{amb} = 25\text{ °C}$  unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{CB}$	collector-base voltage	open emitter	-	-	24	V
$V_{CE}$	collector-emitter voltage	open base	-	-	12	V
		shorted base	-	-	24	V
$V_{EB}$	emitter-base voltage	open collector	-	-	2	V
$I_C$	collector current		-	80	200	mA
$P_{tot}$	total power dissipation	$T_{sp} \leq 90\text{ °C}$ [1]	-	-	2000	mW
$h_{FE}$	DC current gain	$I_C = 80\text{ mA}$ ; $V_{CE} = 8\text{ V}$	60	95	130	
$C_c$	collector capacitance	$V_{CB} = 8\text{ V}$ ; $f = 1\text{ MHz}$	-	1.9	-	pF
$f_T$	transition frequency	$I_C = 80\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ; $f = 900\text{ MHz}$	-	8.5	-	GHz



**Table 1. Quick reference data ...continued**

$T_{amb} = 25\text{ }^{\circ}\text{C}$  unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$G_{p(max)}$	maximum power gain	$I_C = 80\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ; $f = 900\text{ MHz}$ [2]	-	13	-	dB
$P_{L(1dB)}$	output power at 1 dB gain compression	$I_C = 80\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ; $Z_S = Z_L = 50\text{ }\Omega$ ; $f = 900\text{ MHz}$	-	21.5	-	dBm

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

[2] If  $K > 1$  then  $G_{p(max)}$  is the maximum power gain. If  $K < 1$  then  $G_{p(max)} = MSG$ .

## 2. Pinning information

**Table 2. Discrete pinning**

Pin	Description	Simplified outline	Graphic symbol
1	emitter		<p>mbb159</p>
2	base		
3	emitter		
4	collector		

## 3. Ordering information

**Table 3. Ordering information**

Type number	Package		
	Name	Description	Version
BFU590G	-	plastic surface-mounted package with increased heatsink; 4 leads	SOT223
OM7966	-	Customer evaluation kit for BFU580G and BFU590G [1]	-

[1] The customer evaluation kit contains the following:

- Unpopulated RF amplifier Printed-Circuit Board (PCB)
- Unpopulated RF amplifier Printed-Circuit Board (PCB) with emitter degeneration
- Four SMA connectors for fitting unpopulated Printed-Circuit Board (PCB)
- BFU580G and BFU590G samples
- USB stick with data sheets, application notes, models, S-parameter and noise files

## 4. Marking

**Table 4. Marking**

Type number	Marking
BFU590G	BFU590

## 5. Design support

**Table 5. Available design support**

Download from the BFU590G product information page on <http://www.nxp.com>.

Support item	Available	Remarks
Device models for Agilent EEsof EDA ADS	yes	Based on Mextram device model.
SPICE model	yes	Based on Gummel-Poon device model.
S-parameters	yes	
Customer evaluation kit	yes	See <a href="#">Section 3</a> and <a href="#">Section 10</a> .
Solder pattern	yes	
Application notes	yes	See <a href="#">Section 10.1</a> and <a href="#">Section 10.2</a> .

## 6. Limiting values

**Table 6. Limiting values**

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

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{CB}$	collector-base voltage	open emitter	-	30	V
$V_{CE}$	collector-emitter voltage	open base	-	16	V
		shorted base	-	30	V
$V_{EB}$	emitter-base voltage	open collector	-	3	V
$I_C$	collector current		-	300	mA
$T_{stg}$	storage temperature		-65	+150	°C
$V_{ESD}$	electrostatic discharge voltage	Human Body Model (HBM) According to JEDEC standard 22-A114E	-	±250	V
		Charged Device Model (CDM) According to JEDEC standard 22-C101B	-	±2	kV

## 7. Recommended operating conditions

**Table 7. Characteristics**

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{CB}$	collector-base voltage	open emitter	-	-	24	V
$V_{CE}$	collector-emitter voltage	open base	-	-	12	V
		shorted base	-	-	24	V
$V_{EB}$	emitter-base voltage	open collector	-	-	2	V
$I_C$	collector current		-	-	200	mA
$P_i$	input power	$Z_S = 50 \Omega$	-	-	20	dBm
$T_j$	junction temperature		-40	-	+150	°C
$P_{tot}$	total power dissipation	$T_{sp} \leq 90 \text{ °C}$ <a href="#">[1]</a>	-	-	2000	mW

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

## 8. Thermal characteristics

**Table 8. Thermal characteristics**

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-sp)}$	thermal resistance from junction to solder point		[1] 30	K/W

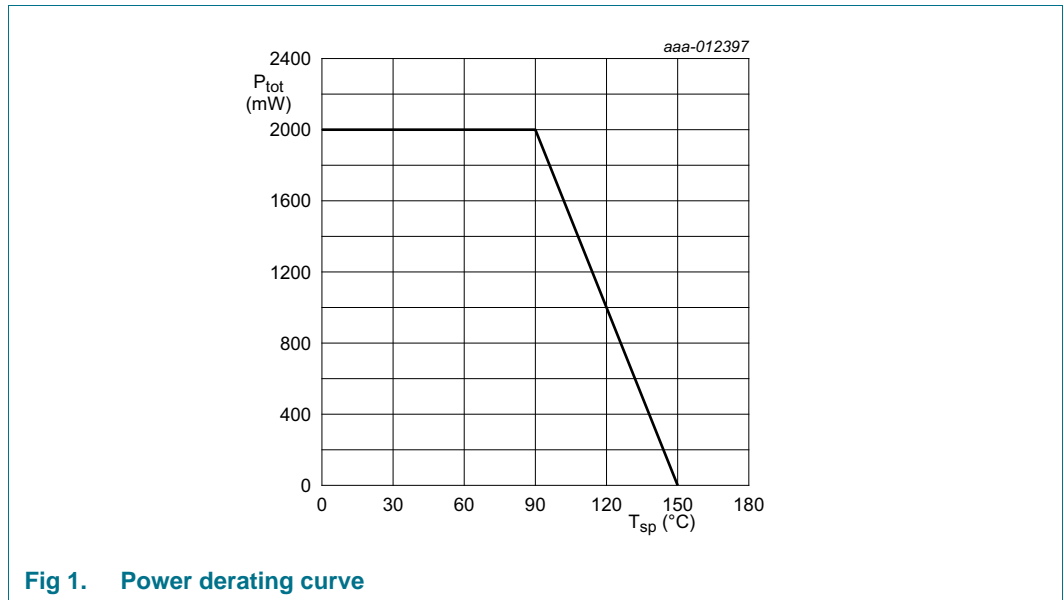
[1]  $T_{sp}$  is the temperature at the solder point of the collector lead.

$T_{sp}$  has the following relation to the ambient temperature  $T_{amb}$ :

$$T_{sp} = T_{amb} + P \times R_{th(sp-a)}$$

With P being the power dissipation and  $R_{th(sp-a)}$  being the thermal resistance between the solder point and ambient.  $R_{th(sp-a)}$  is determined by the heat transfer properties in the application.

The heat transfer properties are set by the application board materials, the board layout and the environment e.g. housing.



**Fig 1. Power derating curve**

## 9. Characteristics

**Table 9. Characteristics**

$T_{amb} = 25\text{ °C}$  unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{(BR)CBO}$	collector-base breakdown voltage	$I_C = 100\text{ nA}; I_E = 0\text{ mA}$	24	-	-	V
$V_{(BR)CEO}$	collector-emitter breakdown voltage	$I_C = 150\text{ nA}; I_B = 0\text{ mA}$	12	-	-	V
$I_C$	collector current		-	80	200	mA
$I_{CBO}$	collector-base cut-off current	$I_E = 0\text{ mA}; V_{CB} = 8\text{ V}$	-	<1	-	nA
$h_{FE}$	DC current gain	$I_C = 80\text{ mA}; V_{CE} = 8\text{ V}$	60	95	130	
$C_e$	emitter capacitance	$V_{EB} = 0.5\text{ V}; f = 1\text{ MHz}$	-	3.9	-	pF
$C_{re}$	feedback capacitance	$V_{CE} = 8\text{ V}; f = 1\text{ MHz}$	-	1.1	-	pF
$C_c$	collector capacitance	$V_{CB} = 8\text{ V}; f = 1\text{ MHz}$	-	1.9	-	pF
$f_T$	transition frequency	$I_C = 50\text{ mA}; V_{CE} = 8\text{ V}; f = 900\text{ MHz}$	-	8.5	-	GHz

**Table 9. Characteristics ...continued**  
*T<sub>amb</sub> = 25 °C unless otherwise specified*

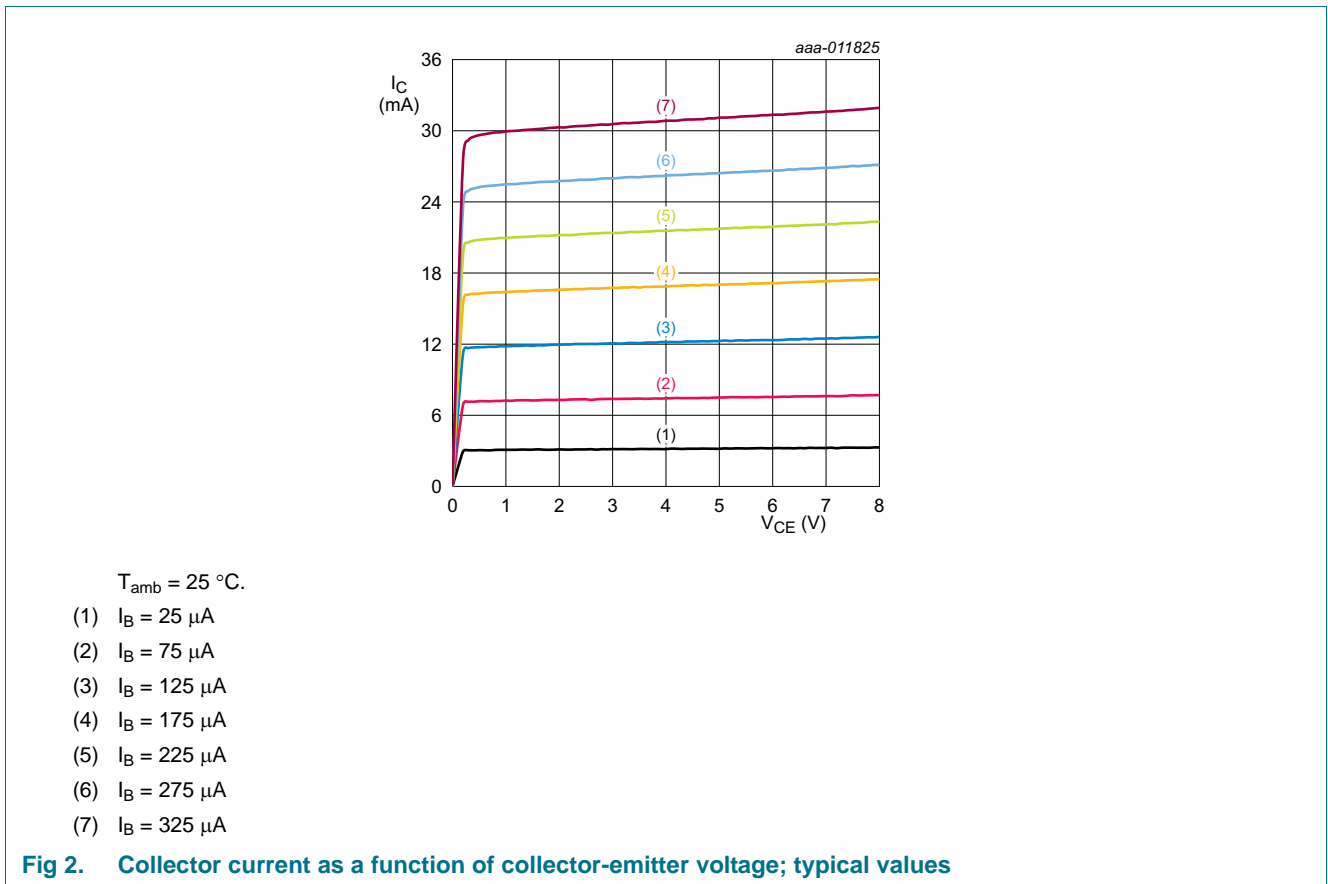
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
G <sub>p(max)</sub>	maximum power gain	f = 433 MHz; V <sub>CE</sub> = 8 V [1]				
		I <sub>C</sub> = 10 mA	-	18.5	-	dB
		I <sub>C</sub> = 50 mA	-	19.5	-	dB
		I <sub>C</sub> = 80 mA	-	19.5	-	dB
		f = 900 MHz; V <sub>CE</sub> = 8 V [1]				
		I <sub>C</sub> = 10 mA	-	13.5	-	dB
		I <sub>C</sub> = 50 mA	-	13	-	dB
		I <sub>C</sub> = 80 mA	-	13	-	dB
		f = 1800 MHz; V <sub>CE</sub> = 8 V [1]				
		I <sub>C</sub> = 10 mA	-	8	-	dB
		I <sub>C</sub> = 50 mA	-	8	-	dB
		I <sub>C</sub> = 80 mA	-	8	-	dB
S <sub>21</sub>   <sup>2</sup>	insertion power gain	f = 433 MHz; V <sub>CE</sub> = 8 V				
		I <sub>C</sub> = 10 mA	-	16	-	dB
		I <sub>C</sub> = 50 mA	-	17.5	-	dB
		I <sub>C</sub> = 80 mA	-	17.5	-	dB
		f = 900 MHz; V <sub>CE</sub> = 8 V				
		I <sub>C</sub> = 10 mA	-	10	-	dB
		I <sub>C</sub> = 50 mA	-	11	-	dB
		I <sub>C</sub> = 80 mA	-	11	-	dB
		f = 1800 MHz; V <sub>CE</sub> = 8 V				
		I <sub>C</sub> = 10 mA	-	4.5	-	dB
		I <sub>C</sub> = 50 mA	-	5.5	-	dB
		I <sub>C</sub> = 80 mA	-	5.5	-	dB
P <sub>L(1dB)</sub>	output power at 1 dB gain compression	f = 433 MHz; V <sub>CE</sub> = 8 V; Z <sub>S</sub> = Z <sub>L</sub> = 50 Ω				
		I <sub>C</sub> = 50 mA	-	20	-	dBm
		I <sub>C</sub> = 80 mA	-	22.5	-	dBm
		f = 900 MHz; V <sub>CE</sub> = 8 V; Z <sub>S</sub> = Z <sub>L</sub> = 50 Ω				
		I <sub>C</sub> = 50 mA	-	19.5	-	dBm
		I <sub>C</sub> = 80 mA	-	21.5	-	dBm
		f = 1800 MHz; V <sub>CE</sub> = 8 V; Z <sub>S</sub> = Z <sub>L</sub> = 50 Ω				
		I <sub>C</sub> = 50 mA	-	18.5	-	dBm
I <sub>C</sub> = 80 mA	-	21	-	dBm		

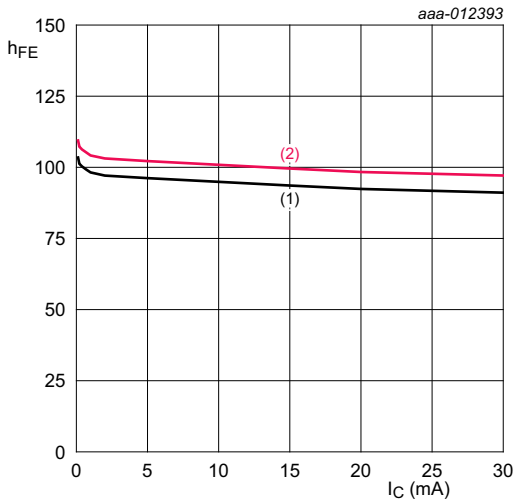
**Table 9. Characteristics ...continued**  
 $T_{amb} = 25\text{ }^{\circ}\text{C}$  unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
IP3 <sub>o</sub>	output third-order intercept point	$f_1 = 433\text{ MHz}; f_2 = 434\text{ MHz}; V_{CE} = 8\text{ V}; Z_S = Z_L = 50\text{ }\Omega$				
		$I_C = 50\text{ mA}$	-	29.5	-	dBm
		$I_C = 80\text{ mA}$	-	32	-	dBm
		$f_1 = 900\text{ MHz}; f_2 = 901\text{ MHz}; V_{CE} = 8\text{ V}; Z_S = Z_L = 50\text{ }\Omega$				
		$I_C = 50\text{ mA}$	-	29	-	dBm
		$I_C = 80\text{ mA}$	-	31	-	dBm
		$f_1 = 1800\text{ MHz}; f_2 = 1801\text{ MHz}; V_{CE} = 8\text{ V}; Z_S = Z_L = 50\text{ }\Omega$				
		$I_C = 50\text{ mA}$	-	28	-	dBm
		$I_C = 80\text{ mA}$	-	30.5	-	dBm

[1] If  $K > 1$  then  $G_{p(max)}$  is the maximum power gain. If  $K < 1$  then  $G_{p(max)} = \text{MSG}$ .

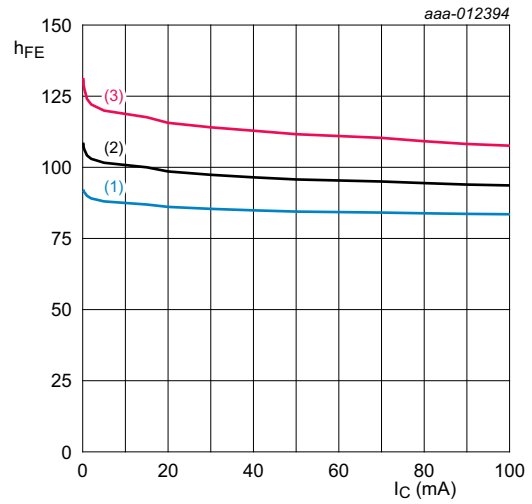
**9.1 Graphs**





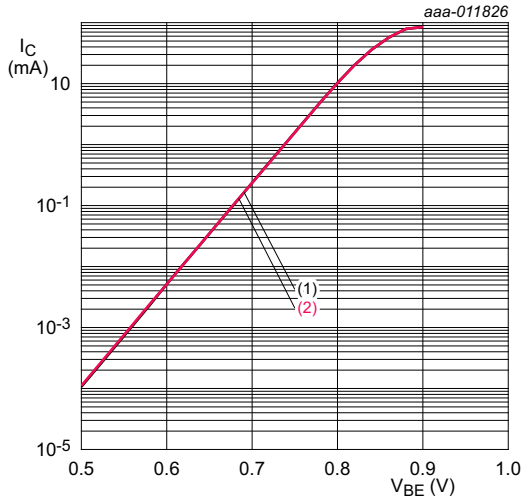
$T_{amb} = 25\text{ }^\circ\text{C}$ .  
 (1)  $V_{CE} = 3.0\text{ V}$   
 (2)  $V_{CE} = 8.0\text{ V}$

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



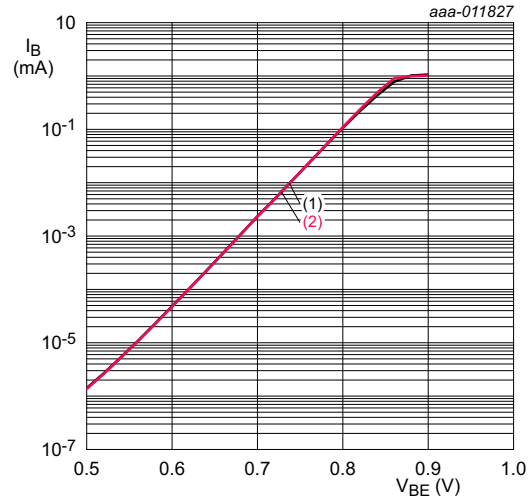
$V_{CE} = 8\text{ V}$ .  
 (1)  $T_{amb} = -40\text{ }^\circ\text{C}$   
 (2)  $T_{amb} = +25\text{ }^\circ\text{C}$   
 (3)  $T_{amb} = +125\text{ }^\circ\text{C}$

**Fig 4. DC current gain as a function of collector current; typical values**



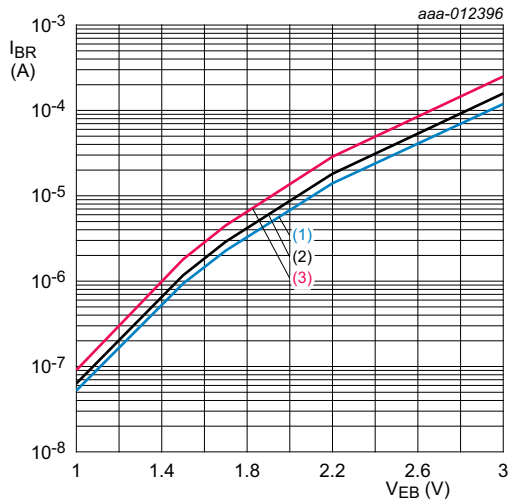
$T_{amb} = 25\text{ }^\circ\text{C}$ .  
 (1)  $V_{CE} = 3.0\text{ V}$   
 (2)  $V_{CE} = 8.0\text{ V}$

**Fig 5. Collector current as a function of base-emitter voltage; typical values**



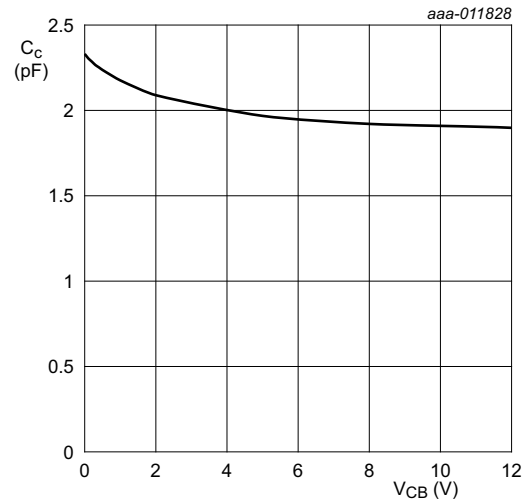
$T_{amb} = 25\text{ }^\circ\text{C}$ .  
 (1)  $V_{CE} = 3.0\text{ V}$   
 (2)  $V_{CE} = 8.0\text{ V}$

**Fig 6. Base current as a function of base-emitter voltage; typical values**



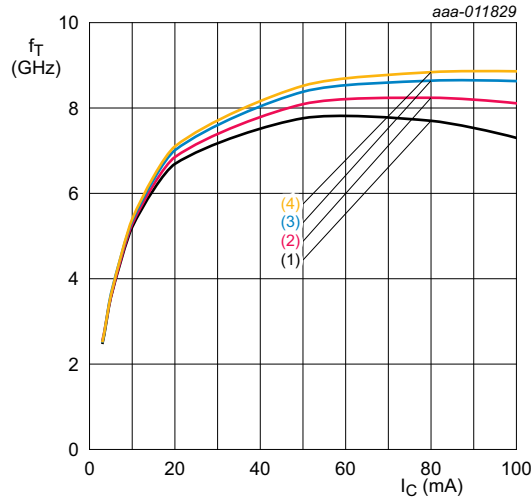
$V_{CE} = 3\text{ V}$ .  
 (1)  $T_{amb} = -40\text{ }^{\circ}\text{C}$   
 (2)  $T_{amb} = +25\text{ }^{\circ}\text{C}$   
 (3)  $T_{amb} = +125\text{ }^{\circ}\text{C}$

**Fig 7. Reverse base current as a function of emitter-base voltage; typical values**



$I_C = 0\text{ mA}$ ;  $f = 1\text{ MHz}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

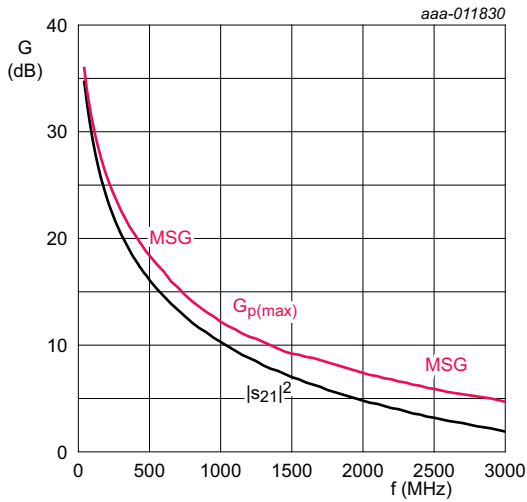
**Fig 8. Collector capacitance as a function of collector-base voltage; typical values**



$T_{amb} = 25\text{ }^{\circ}\text{C}$ .  
 (1)  $V_{CE} = 3.3\text{ V}$   
 (2)  $V_{CE} = 5.0\text{ V}$   
 (3)  $V_{CE} = 8.0\text{ V}$   
 (4)  $V_{CE} = 12.0\text{ V}$

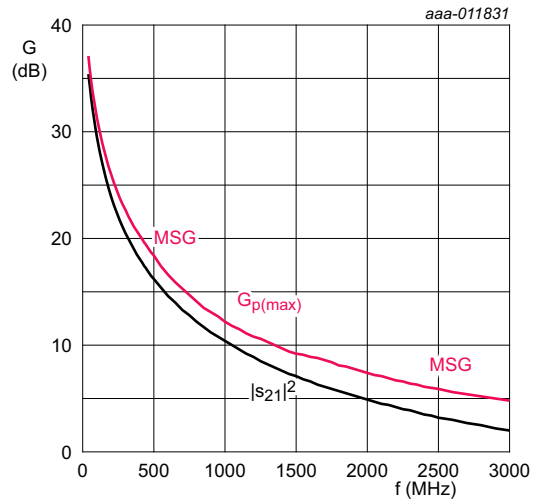
**Fig 9. Transition frequency as a function of collector current; typical values**





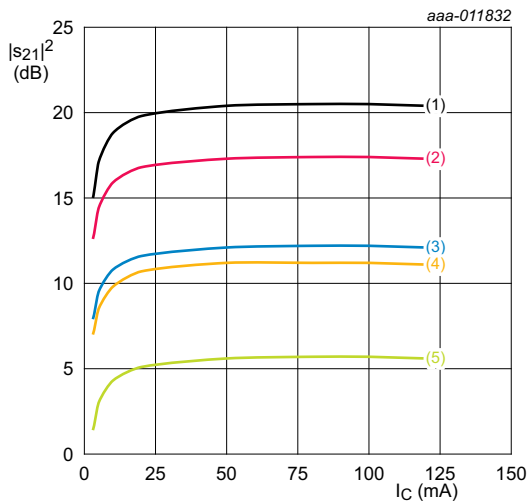
$I_C = 50 \text{ mA}; V_{CE} = 8 \text{ V}; T_{amb} = 25 \text{ }^\circ\text{C}.$

**Fig 10. Gain as a function of frequency; typical values**



$I_C = 80 \text{ mA}; V_{CE} = 8 \text{ V}; T_{amb} = 25 \text{ }^\circ\text{C}.$

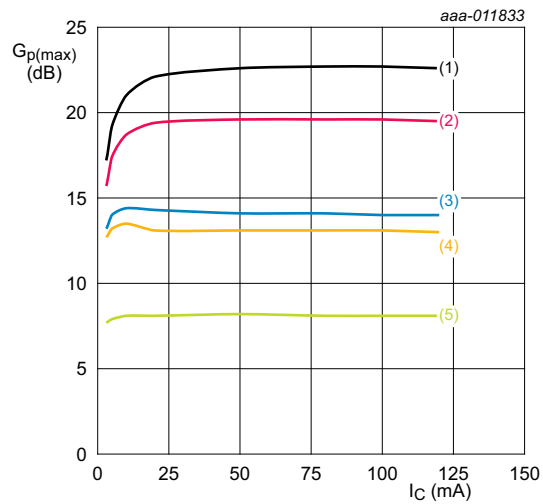
**Fig 11. Gain as a function of frequency; typical values**



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

- (1)  $f = 300 \text{ MHz}$
- (2)  $f = 433 \text{ MHz}$
- (3)  $f = 800 \text{ MHz}$
- (4)  $f = 900 \text{ MHz}$
- (5)  $f = 1800 \text{ MHz}$

**Fig 12. Insertion power gain as a function of collector current; typical values**

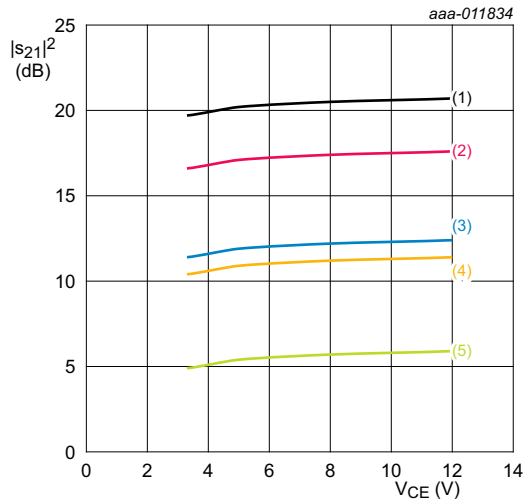


$V_{CE} = 8 \text{ V}; T_{amb} = 25 \text{ }^\circ\text{C}.$

If  $K > 1$  then  $G_{p(max)}$  = maximum power gain. If  $K < 1$  then  $G_{p(max)}$  = MSG.

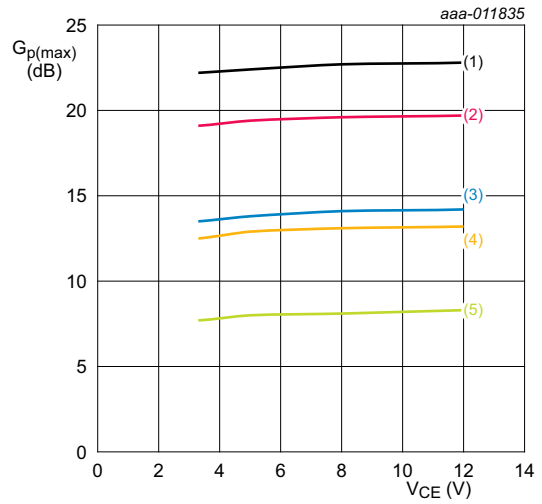
- (1)  $f = 300 \text{ MHz}$
- (2)  $f = 433 \text{ MHz}$
- (3)  $f = 800 \text{ MHz}$
- (4)  $f = 900 \text{ MHz}$
- (5)  $f = 1800 \text{ MHz}$

**Fig 13. Maximum power gain as a function of collector current; typical values**



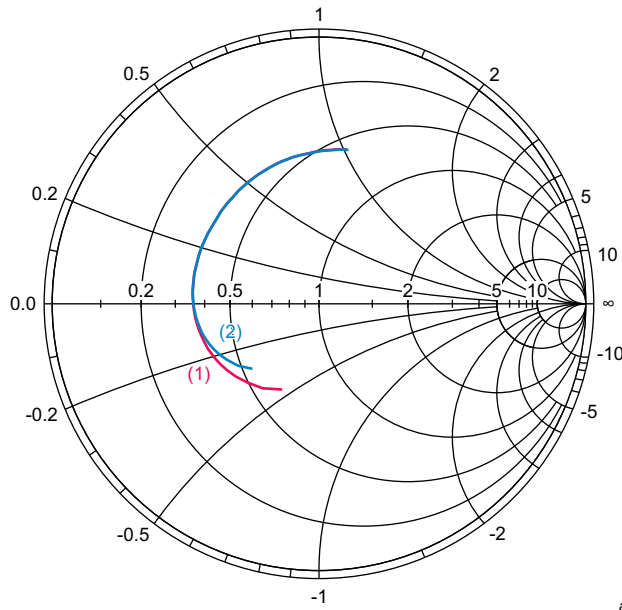
$I_C = 50 \text{ mA}; T_{amb} = 25 \text{ }^\circ\text{C}.$   
 (1)  $f = 300 \text{ MHz}$   
 (2)  $f = 433 \text{ MHz}$   
 (3)  $f = 800 \text{ MHz}$   
 (4)  $f = 900 \text{ MHz}$   
 (5)  $f = 1800 \text{ MHz}$

**Fig 14. Insertion power gain as a function of collector-emitter voltage; typical values**



$I_C = 80 \text{ mA}; T_{amb} = 25 \text{ }^\circ\text{C}.$   
 If  $K > 1$  then  $G_{p(max)}$  = maximum power gain. If  $K < 1$  then  $G_{p(max)}$  = MSG.  
 (1)  $f = 300 \text{ MHz}$   
 (2)  $f = 433 \text{ MHz}$   
 (3)  $f = 800 \text{ MHz}$   
 (4)  $f = 900 \text{ MHz}$   
 (5)  $f = 1800 \text{ MHz}$

**Fig 15. Maximum power gain as a function of collector-emitter voltage; typical values**

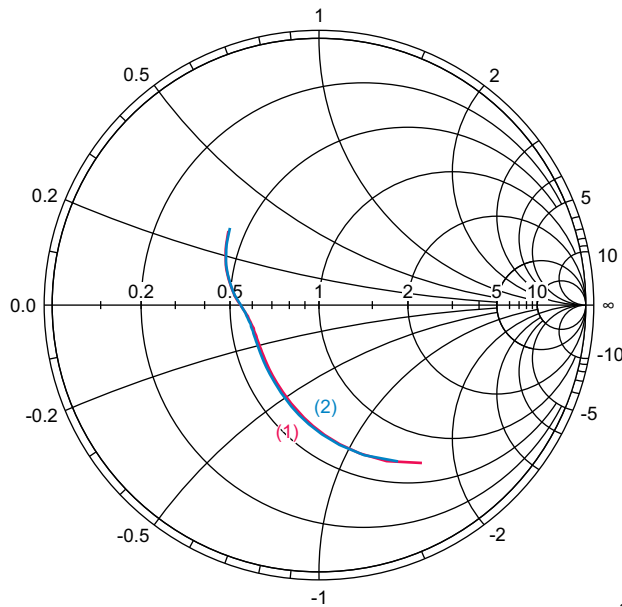


aaa-011836

$V_{CE} = 8\text{ V}; 40\text{ MHz} \leq f \leq 3\text{ GHz}.$

- (1)  $I_C = 50\text{ mA}$
- (2)  $I_C = 80\text{ mA}$

**Fig 16. Input reflection coefficient ( $s_{11}$ ); typical values**

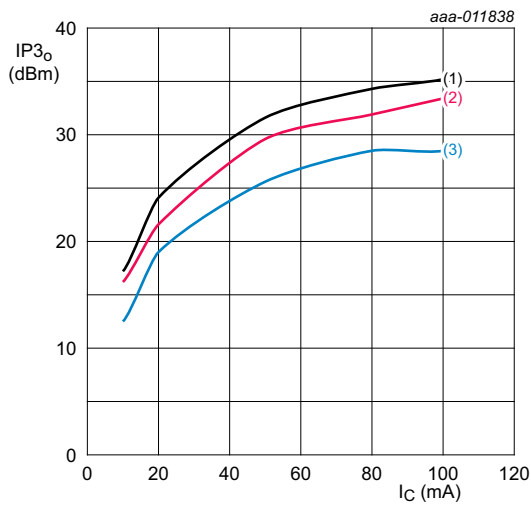


aaa-011837

$V_{CE} = 8\text{ V}; 40\text{ MHz} \leq f \leq 3\text{ GHz}.$

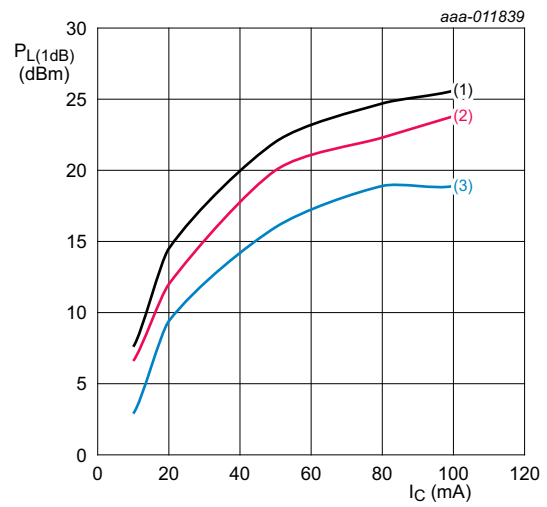
- (1)  $I_C = 50\text{ mA}$
- (2)  $I_C = 80\text{ mA}$

**Fig 17. Output reflection coefficient ( $s_{22}$ ); typical values**



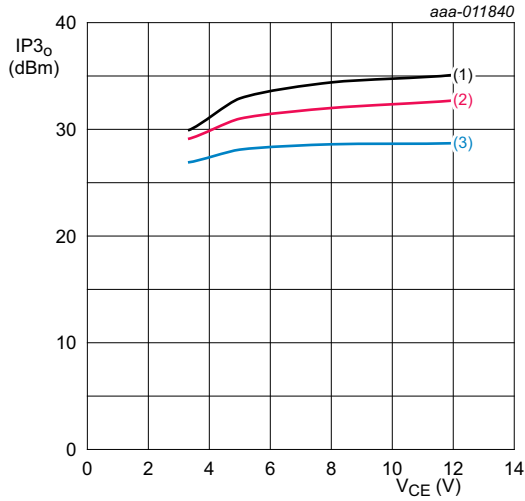
- $V_{CE} = 8\text{ V}; T_{amb} = 25\text{ }^{\circ}\text{C}.$
- (1)  $f_1 = 433\text{ MHz}; f_2 = 434\text{ MHz}$
  - (2)  $f_1 = 900\text{ MHz}; f_2 = 901\text{ MHz}$
  - (3)  $f_1 = 1800\text{ MHz}; f_2 = 1801\text{ MHz}$

**Fig 18. Output third-order intercept point as a function of collector current; typical values**



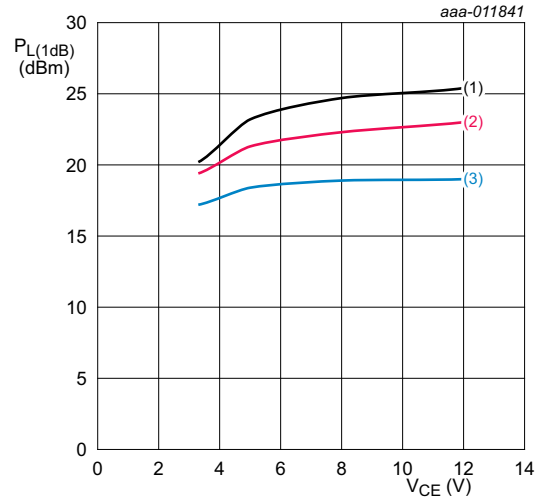
- $V_{CE} = 8\text{ V}; T_{amb} = 25\text{ }^{\circ}\text{C}.$
- (1)  $f = 433\text{ MHz}$
  - (2)  $f = 900\text{ MHz}$
  - (3)  $f = 1800\text{ MHz}$

**Fig 19. Output power at 1 dB gain compression as a function of collector current; typical values**



- $I_C = 80\text{ mA}; T_{amb} = 25\text{ }^{\circ}\text{C}.$
- (1)  $f_1 = 433\text{ MHz}; f_2 = 434\text{ MHz}$
  - (2)  $f_1 = 900\text{ MHz}; f_2 = 901\text{ MHz}$
  - (3)  $f_1 = 1800\text{ MHz}; f_2 = 1801\text{ MHz}$

**Fig 20. Output third-order intercept point as a function of collector-emitter voltage; typical values**



- $I_C = 80\text{ mA}; T_{amb} = 25\text{ }^{\circ}\text{C}.$
- (1)  $f = 433\text{ MHz}$
  - (2)  $f = 900\text{ MHz}$
  - (3)  $f = 1800\text{ MHz}$

**Fig 21. Output power at 1 dB gain compression as a function of collector-emitter voltage; typical values**

## 10. Application information

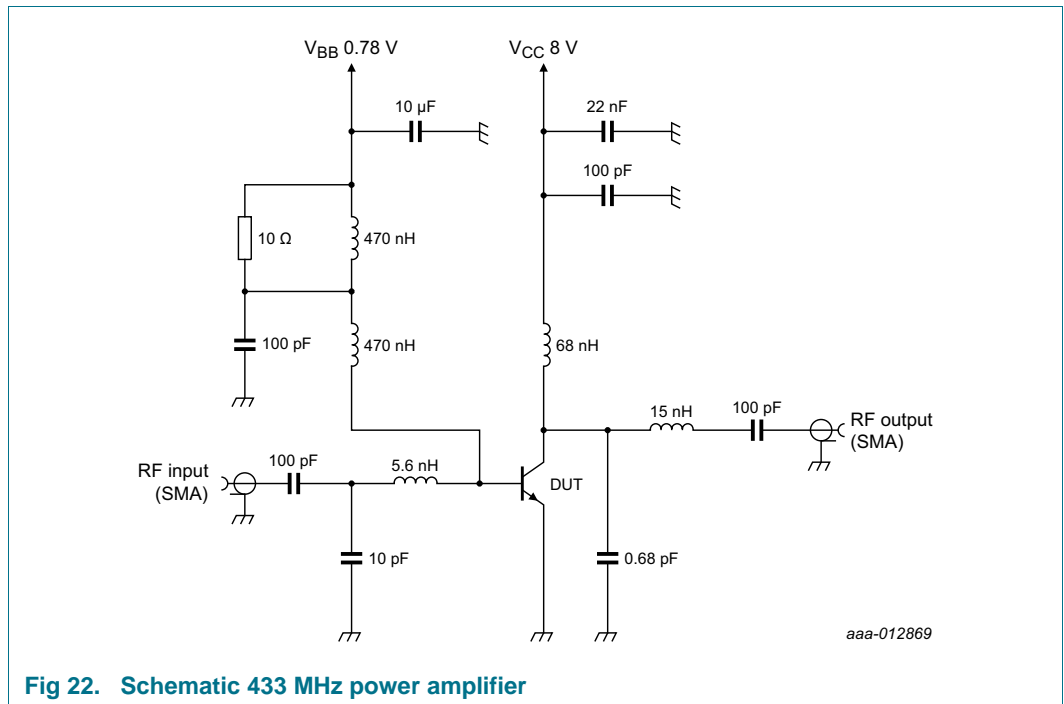
More information about the following application example can be found in the application notes. See [Section 5 “Design support”](#).

The following application example can be implemented using the evaluation kit. See [Section 3 “Ordering information”](#) for the order type number.

The following application example can be simulated using the simulation package. See [Section 5 “Design support”](#).

### 10.1 Application example: 433 MHz PA

More detailed information of the application example can be found in the application note: *AN11503*.



**Fig 22. Schematic 433 MHz power amplifier**

Remark: fine tuning of components maybe required depending on PCB parasitics.

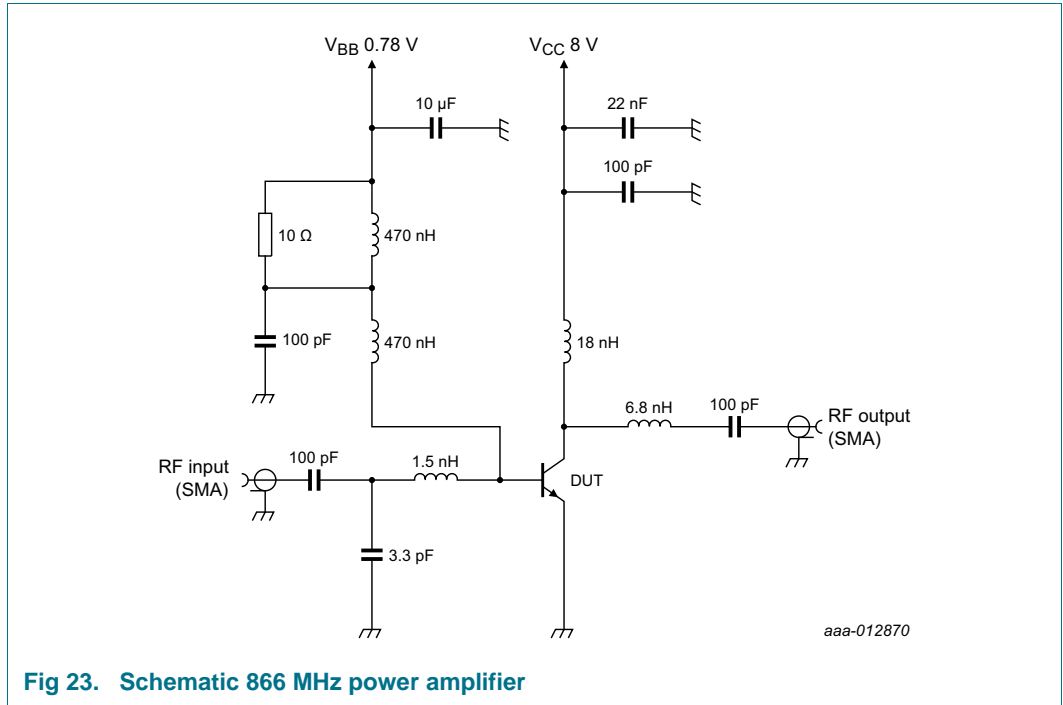
**Table 10. Application performance data at 433 MHz**

$I_{CC} = 100 \text{ mA}$ ;  $V_{CC} = 8 \text{ V}$

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$ S_{21} ^2$	insertion power gain		-	15	-	dB
$ S_{11} ^2$	input return loss		-	-7	-	dB
$P_{L(1dB)}$	output power at 1 dB gain compression		-	26	-	dBm
$\eta_C$	collector efficiency		-	60	-	%

**10.2 Application example: 866 MHz PA**

More detailed information of the application example can be found in the application note: AN11501.



**Fig 23. Schematic 866 MHz power amplifier**

Remark: fine tuning of components may be required depending on PCB parasitics.

**Table 11. Application performance data at 866 MHz**

$I_{CC} = 100\text{ mA}$ ;  $V_{CC} = 8\text{ V}$

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$ S_{21} ^2$	insertion power gain		-	10	-	dB
$ S_{11} ^2$	input return loss		-	-12	-	dB
$P_{L(1dB)}$	output power at 1 dB gain compression		-	27	-	dBm
$\eta_C$	collector efficiency		-	55	-	%

## 11. Package outline

Plastic surface-mounted package with increased heatsink; 4 leads

SOT223

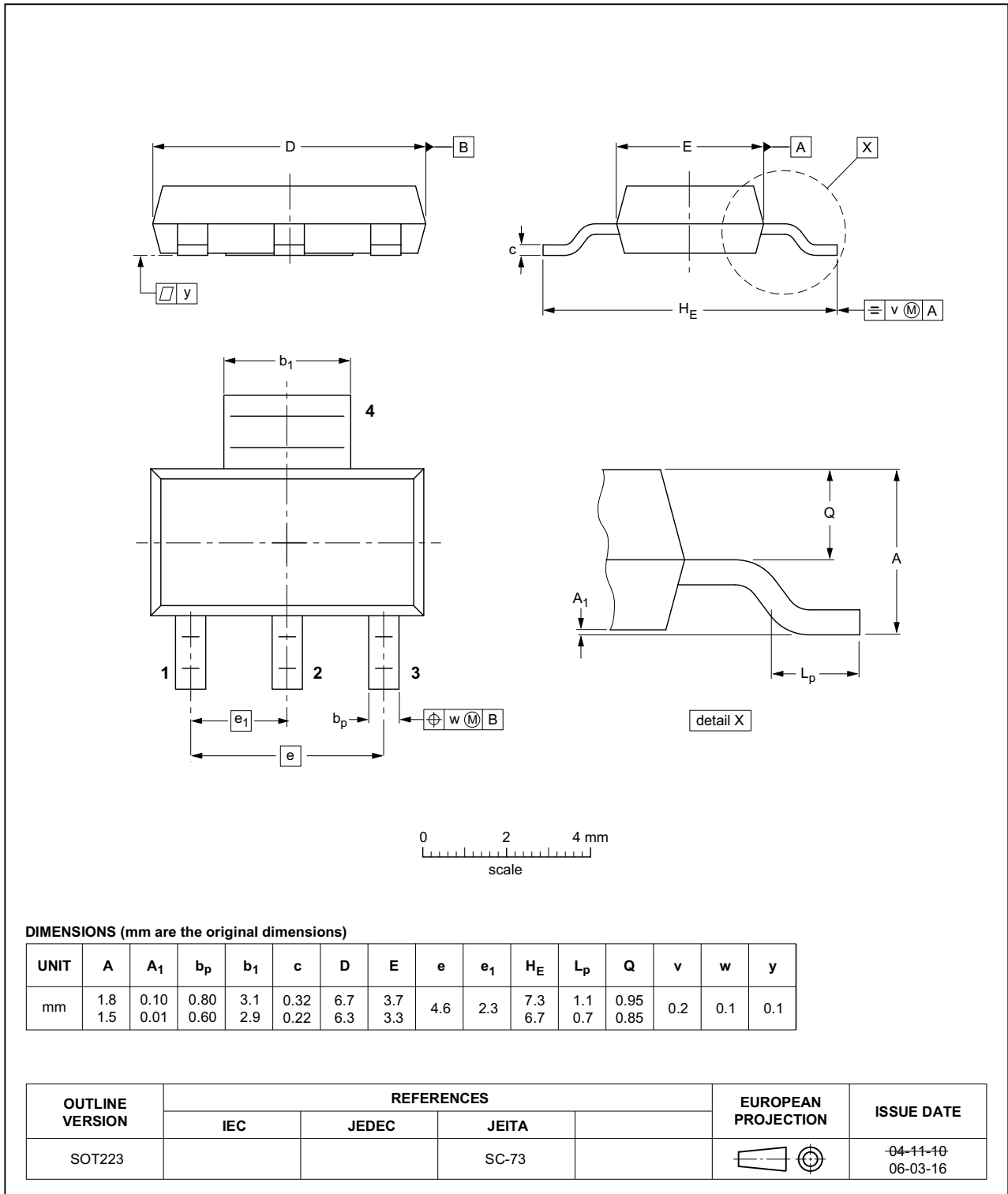


Fig 24. Package outline SOT223

## 12. Handling information

### CAUTION



This device is sensitive to ElectroStatic Discharge (ESD). Observe precautions for handling electrostatic sensitive devices.

Such precautions are described in the *ANSI/ESD S20.20*, *IEC/ST 61340-5*, *JESD625-A* or equivalent standards.

## 13. Abbreviations

Table 12. Abbreviations

Acronym	Description
AEC	Automotive Electronics Council
ISM	Industrial, Scientific and Medical
LNA	Low-Noise Amplifier
MSG	Maximum Stable Gain
NPN	Negative-Positive-Negative
PA	Power Amplifier
SMA	SubMiniature version A

## 14. Revision history

Table 13. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
BFU590G v.1	20140428	Product data sheet	-	-



## 15. Legal information

### 15.1 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.
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[1] Please consult the most recently issued document before initiating or completing a design.

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