

# BFU590Q

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, 3-pin SOT89 package.

The BFU590Q 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 11 dB at 900 MHz
- $P_{L(1dB)}$  22 dBm at 900 MHz
- 8 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

$T_{amb} = 25\text{ }^{\circ}\text{C}$  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	$T_{sp} \leq 90\text{ }^{\circ}\text{C}$ [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	$V_{CB} = 8\text{ V}$ ; $f = 1\text{ MHz}$	-	2.0	-	pF
$f_T$	transition frequency	$I_C = 80\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ; $f = 900\text{ MHz}$	-	8.0	-	GHz



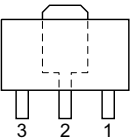
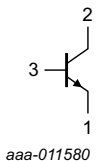
**Table 1. Quick reference data ...continued** $T_{amb} = 25\text{ }^{\circ}\text{C}$  unless otherwise specified

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]	-	11	-	dB
$P_{L(1dB)}$	output power at 1 dB gain compression	$I_C = 80\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ; $Z_S = Z_L = 50\text{ }\Omega$ ; $f = 900\text{ MHz}$	-	22	-	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		 aaa-011580
2	collector		
3	base		

## 3. Ordering information

**Table 3. Ordering information**

Type number	Package		
	Name	Description	Version
BFU590Q	-	plastic surface-mounted package; exposed die pad with good heat transfer; 3 leads	SOT89
OM7965	-	Customer evaluation kit for BFU580Q and BFU590Q [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)
- BFU580Q and BFU590Q samples
- USB stick with data sheets, application notes, models, S-parameter and noise files

## 4. Marking

**Table 4. Marking**

Type number	Marking
BFU590Q	S59

## 5. Design support

**Table 5. Available design support**

Download from the BFU590Q 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

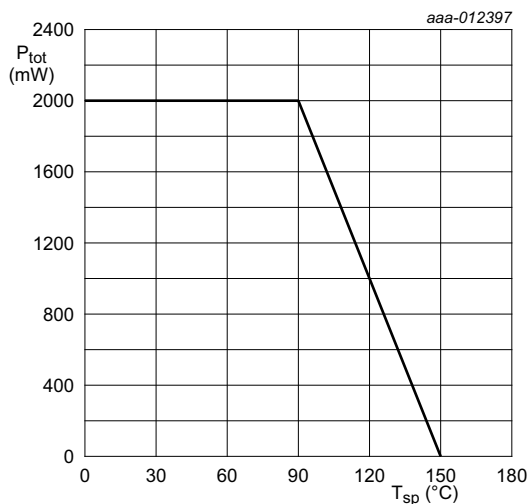
[1]  $T_{sp}$  is the temperature at the solder point of the collector lead.

$T_{sp}$  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	$V_{EB} = 0.5\text{ V}$ ; $f = 1\text{ MHz}$	-	3.6	-	pF
$C_{re}$	feedback capacitance	$V_{CE} = 8\text{ V}$ ; $f = 1\text{ MHz}$	-	1.3	-	pF
$C_c$	collector capacitance	$V_{CB} = 8\text{ V}$ ; $f = 1\text{ MHz}$	-	2	-	pF
$f_T$	transition frequency	$I_C = 50\text{ mA}$ ; $V_{CE} = 8\text{ V}$ ; $f = 900\text{ MHz}$	-	8.0	-	GHz

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

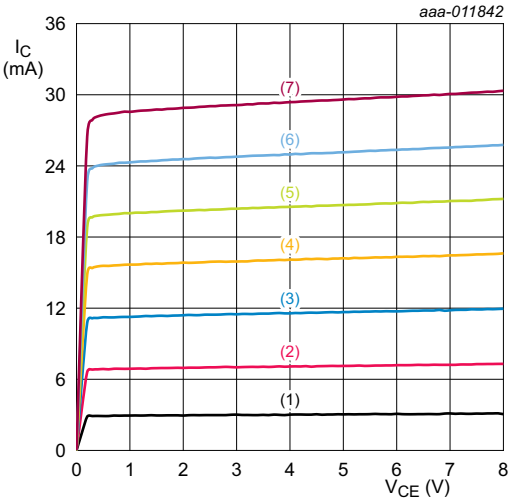
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$G_{p(max)}$	maximum power gain	$f = 433\text{ MHz}; V_{CE} = 8\text{ V}$ [1]				
		$I_C = 10\text{ mA}$	-	17	-	dB
		$I_C = 50\text{ mA}$	-	17.5	-	dB
		$I_C = 80\text{ mA}$	-	17.5	-	dB
		$f = 900\text{ MHz}; V_{CE} = 8\text{ V}$ [1]				
		$I_C = 10\text{ mA}$	-	11	-	dB
		$I_C = 50\text{ mA}$	-	11	-	dB
		$I_C = 80\text{ mA}$	-	11	-	dB
		$f = 1800\text{ MHz}; V_{CE} = 8\text{ V}$ [1]				
		$I_C = 10\text{ mA}$	-	6	-	dB
		$I_C = 50\text{ mA}$	-	6.5	-	dB
		$I_C = 80\text{ mA}$	-	6.5	-	dB
$ S_{21} ^2$	insertion power gain	$f = 433\text{ MHz}; V_{CE} = 8\text{ V}$				
		$I_C = 10\text{ mA}$	-	14.5	-	dB
		$I_C = 50\text{ mA}$	-	16	-	dB
		$I_C = 80\text{ mA}$	-	16	-	dB
		$f = 900\text{ MHz}; V_{CE} = 8\text{ V}$				
		$I_C = 10\text{ mA}$	-	9	-	dB
		$I_C = 50\text{ mA}$	-	10	-	dB
		$I_C = 80\text{ mA}$	-	10	-	dB
		$f = 1800\text{ MHz}; V_{CE} = 8\text{ V}$				
		$I_C = 10\text{ mA}$	-	3.5	-	dB
		$I_C = 50\text{ mA}$	-	4.5	-	dB
		$I_C = 80\text{ mA}$	-	4.5	-	dB
$P_{L(1dB)}$	output power at 1 dB gain compression	$f = 433\text{ MHz}; V_{CE} = 8\text{ V}; Z_S = Z_L = 50\text{ }\Omega$				
		$I_C = 50\text{ mA}$	-	20.5	-	dBm
		$I_C = 80\text{ mA}$	-	23	-	dBm
		$f = 900\text{ MHz}; V_{CE} = 8\text{ V}; Z_S = Z_L = 50\text{ }\Omega$				
		$I_C = 50\text{ mA}$	-	20	-	dBm
		$I_C = 80\text{ mA}$	-	22	-	dBm
		$f = 1800\text{ MHz}; V_{CE} = 8\text{ V}; Z_S = Z_L = 50\text{ }\Omega$				
		$I_C = 50\text{ mA}$	-	19.5	-	dBm
		$I_C = 80\text{ mA}$	-	22	-	dBm

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
IP3 <sub>o</sub>	output third-order intercept point	f <sub>1</sub> = 433 MHz; f <sub>2</sub> = 434 MHz; V <sub>CE</sub> = 8 V; Z <sub>S</sub> = Z <sub>L</sub> = 50 Ω				
		I <sub>C</sub> = 50 mA	-	30	-	dBm
		I <sub>C</sub> = 80 mA	-	32.5	-	dBm
		f <sub>1</sub> = 900 MHz; f <sub>2</sub> = 901 MHz; V <sub>CE</sub> = 8 V; Z <sub>S</sub> = Z <sub>L</sub> = 50 Ω				
		I <sub>C</sub> = 50 mA	-	29.5	-	dBm
		I <sub>C</sub> = 80 mA	-	31.5	-	dBm
		f <sub>1</sub> = 1800 MHz; f <sub>2</sub> = 1801 MHz; V <sub>CE</sub> = 8 V; Z <sub>S</sub> = Z <sub>L</sub> = 50 Ω				
		I <sub>C</sub> = 50 mA	-	29	-	dBm
		I <sub>C</sub> = 80 mA	-	31.5	-	dBm

[1] If K > 1 then G<sub>p(max)</sub> is the maximum power gain. If K < 1 then G<sub>p(max)</sub> = MSG.

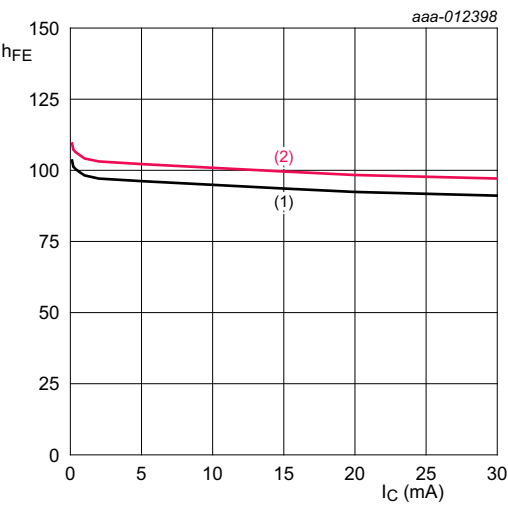
9.1 Graphs



T<sub>amb</sub> = 25 °C.

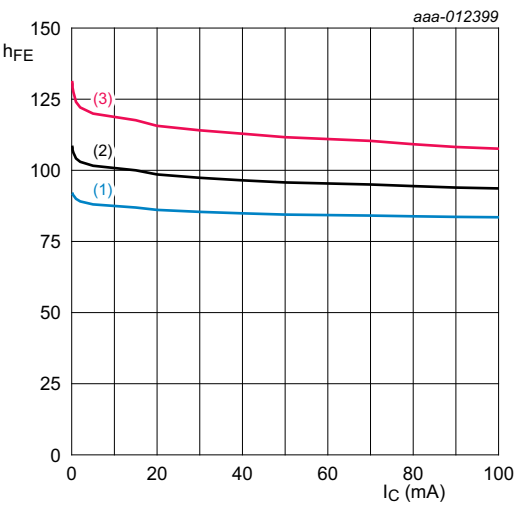
- (1) I<sub>B</sub> = 25 μA
- (2) I<sub>B</sub> = 75 μA
- (3) I<sub>B</sub> = 125 μA
- (4) I<sub>B</sub> = 175 μA
- (5) I<sub>B</sub> = 225 μA
- (6) I<sub>B</sub> = 275 μA
- (7) I<sub>B</sub> = 325 μA

Fig 2. Collector current as a function of collector-emitter voltage; typical values



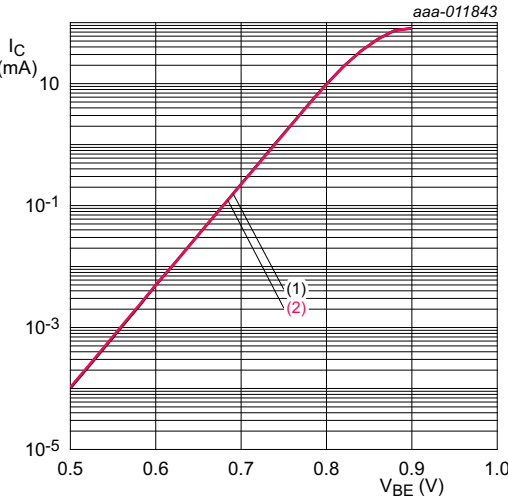
$T_{amb} = 25\text{ }^{\circ}\text{C}.$   
(1)  $V_{CE} = 3.0\text{ V}$   
(2)  $V_{CE} = 8.0\text{ V}$

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



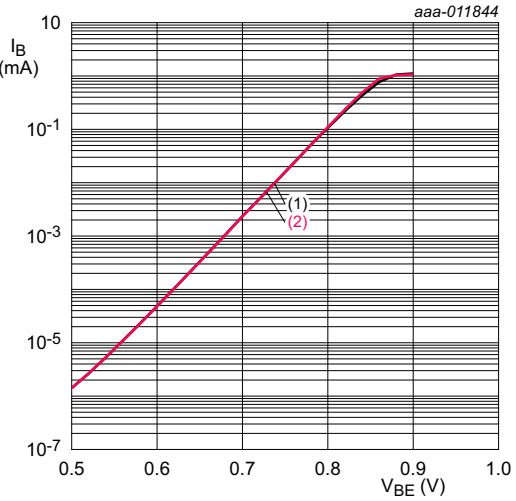
$V_{CE} = 8\text{ V}.$   
(1)  $T_{amb} = -40\text{ }^{\circ}\text{C}$   
(2)  $T_{amb} = +25\text{ }^{\circ}\text{C}$   
(3)  $T_{amb} = +125\text{ }^{\circ}\text{C}$

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



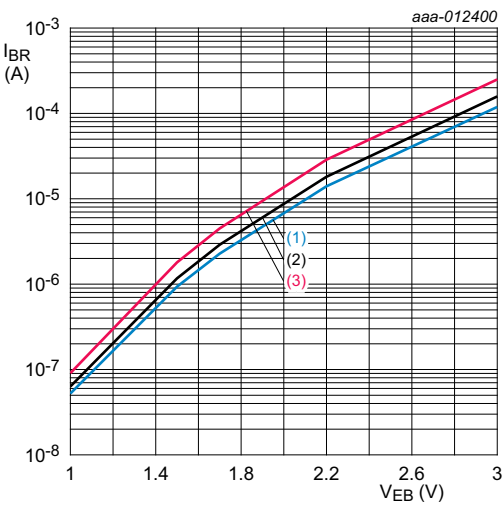
$T_{amb} = 25\text{ }^{\circ}\text{C}.$   
(1)  $V_{CE} = 3.0\text{ V}$   
(2)  $V_{CE} = 8.0\text{ V}$

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



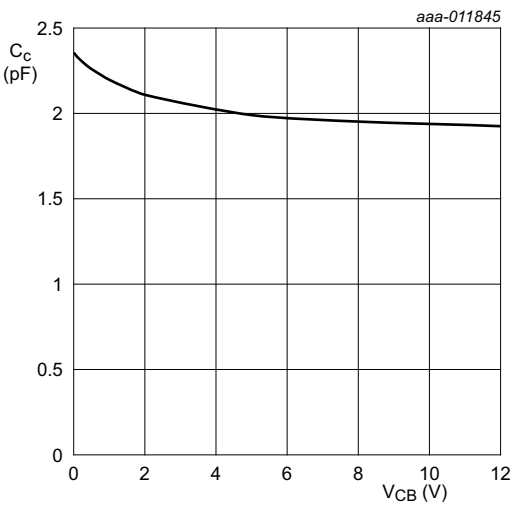
$T_{amb} = 25\text{ }^{\circ}\text{C}.$   
(1)  $V_{CE} = 3.0\text{ V}$   
(2)  $V_{CE} = 8.0\text{ V}$

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



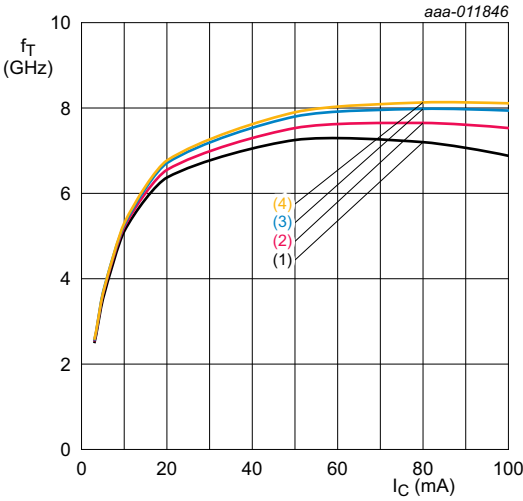
- $V_{CE} = 3\text{ V}$ .
- (1)  $T_{amb} = -40\text{ }^{\circ}\text{C}$
  - (2)  $T_{amb} = +25\text{ }^{\circ}\text{C}$
  - (3)  $T_{amb} = +125\text{ }^{\circ}\text{C}$

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



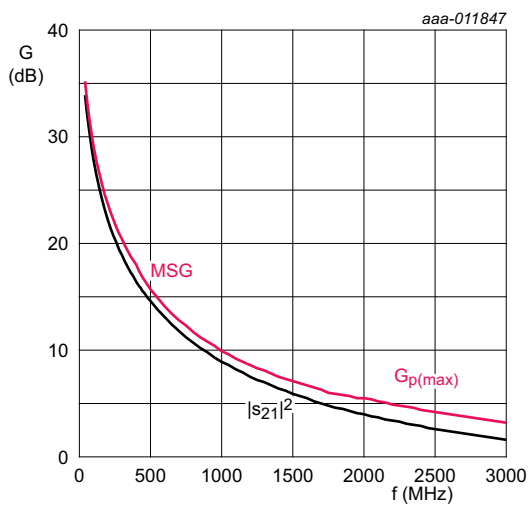


Fig 10. Gain as a function of frequency; typical values

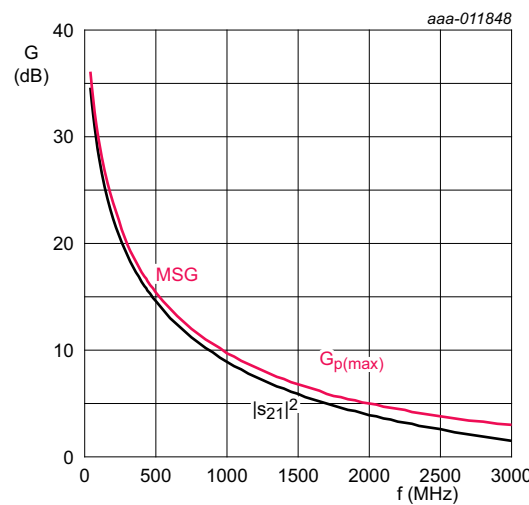
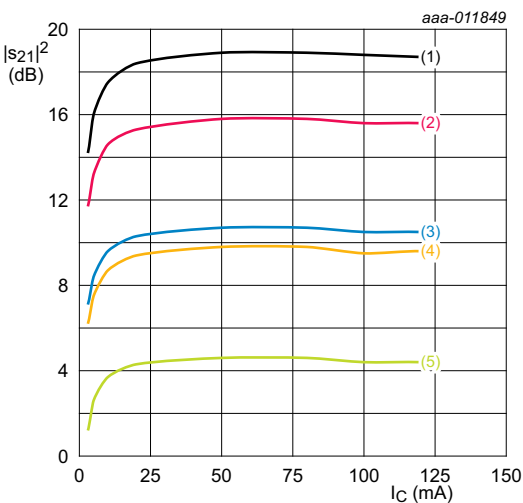
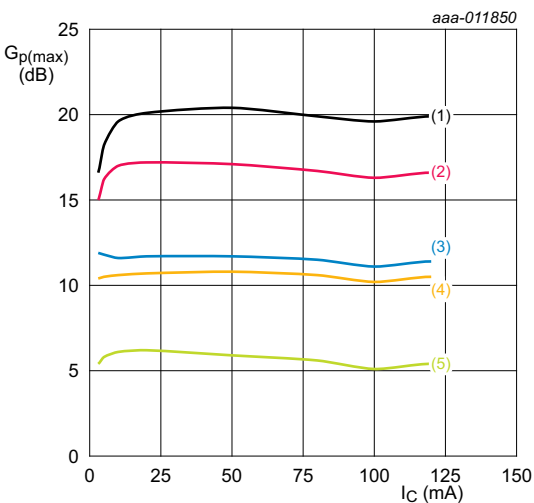


Fig 11. Gain as a function of frequency; typical values



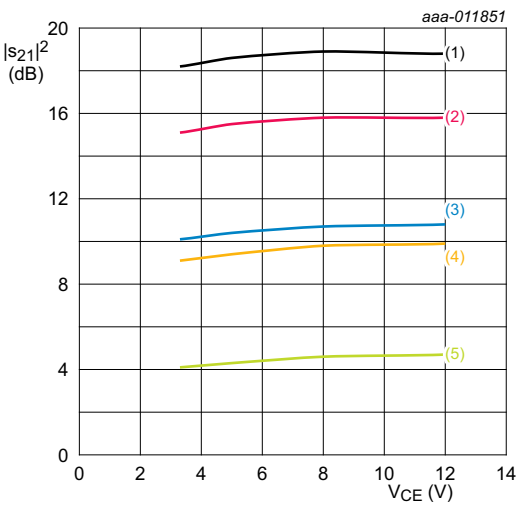
- (1)  $f = 300 \text{ MHz}$
- (2)  $f = 433 \text{ MHz}$
- (3)  $f = 800 \text{ MHz}$
- (4)  $f = 900 \text{ MHz}$
- (5)  $f = 1800 \text{ MHz}$

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



- 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)  $f = 1800 \text{ MHz}$

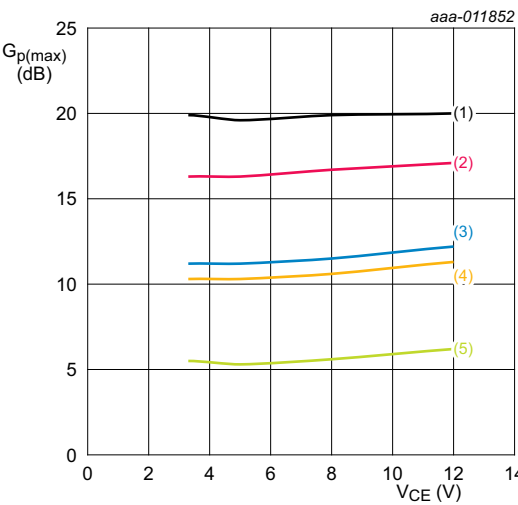
Fig 13. Maximum power gain as a function of collector current; typical values



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

- (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

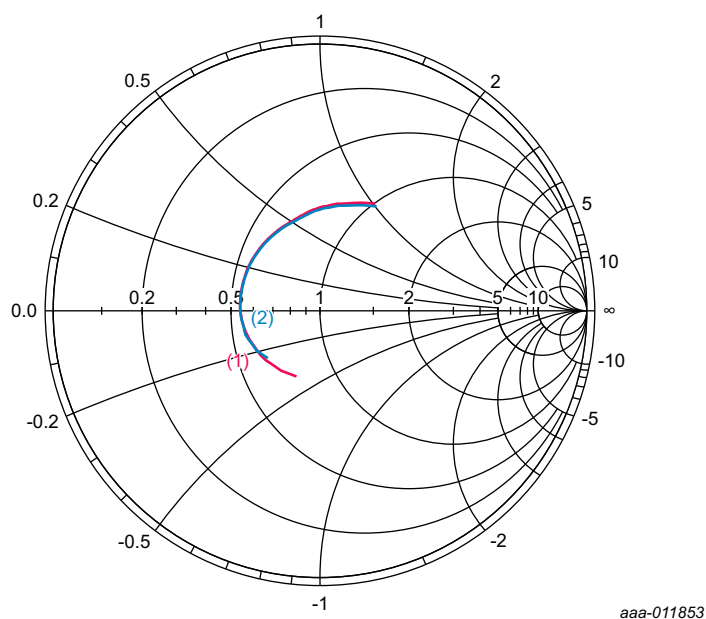


$I_C = 80 \text{ mA}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ .

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

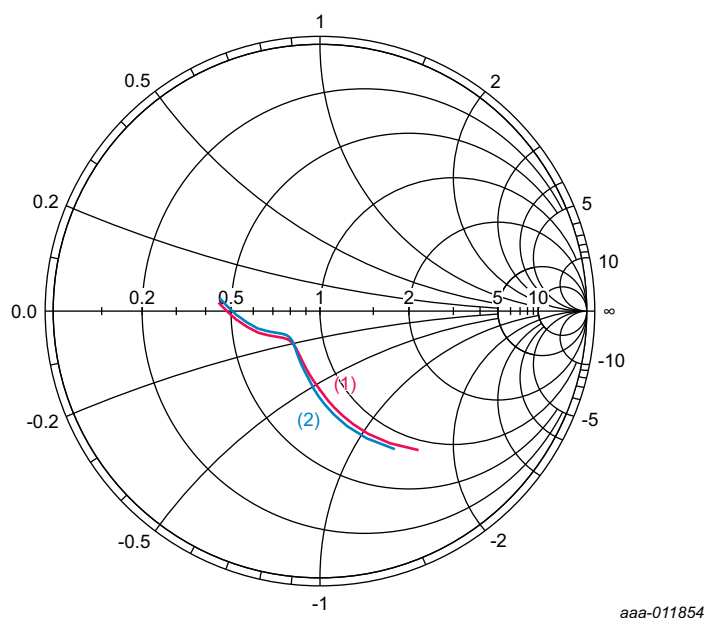


$V_{CE} = 8 \text{ V}; 40 \text{ MHz} \leq f \leq 3 \text{ GHz}.$

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

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

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

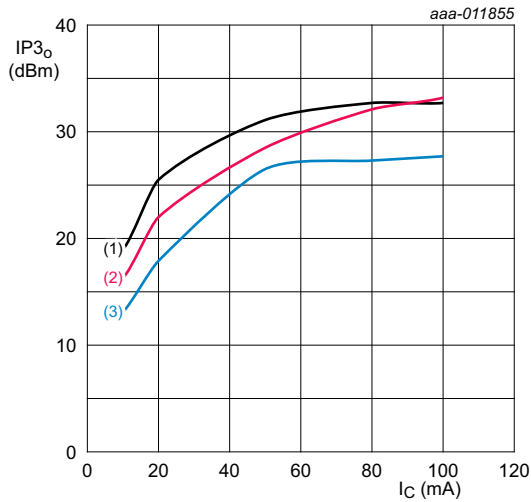


$V_{CE} = 8 \text{ V}; 40 \text{ MHz} \leq f \leq 3 \text{ GHz}.$

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

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

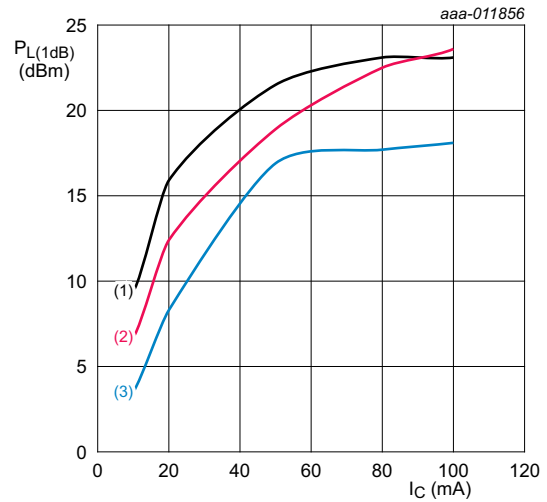
**Fig 17. Output reflection coefficient ( $s_{22}$ ); typical values**



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

- (1)  $f_1 = 433 \text{ MHz}$ ;  $f_2 = 434 \text{ MHz}$
- (2)  $f_1 = 900 \text{ MHz}$ ;  $f_2 = 901 \text{ MHz}$
- (3)  $f_1 = 1800 \text{ MHz}$ ;  $f_2 = 1801 \text{ MHz}$

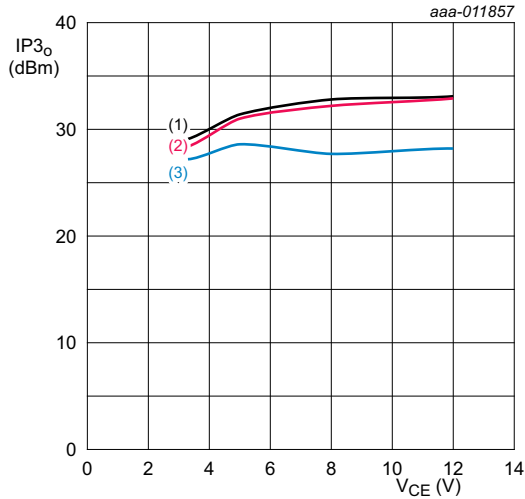
**Fig 18. Output third-order intercept point as a function of collector current; typical values**



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

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

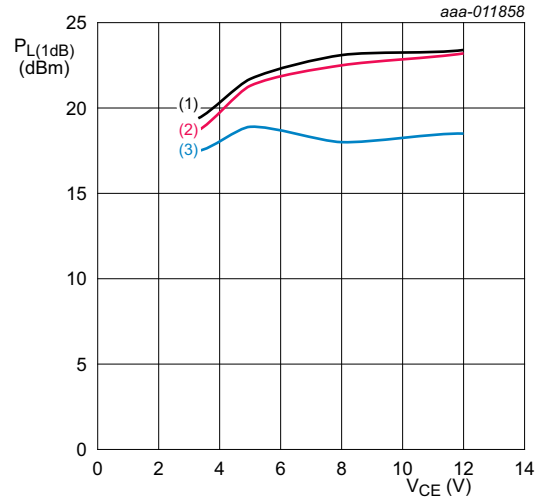
**Fig 19. Output power at 1 dB gain compression as a function of collector current; typical values**



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

- (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: AN11504.

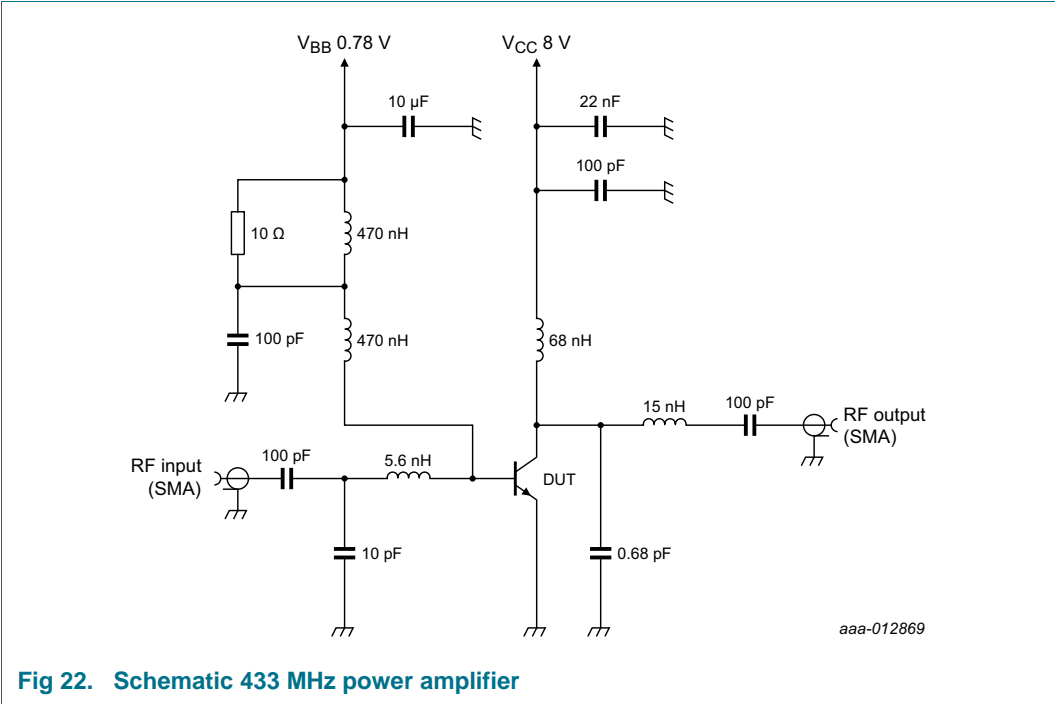


Fig 22. Schematic 433 MHz power amplifier

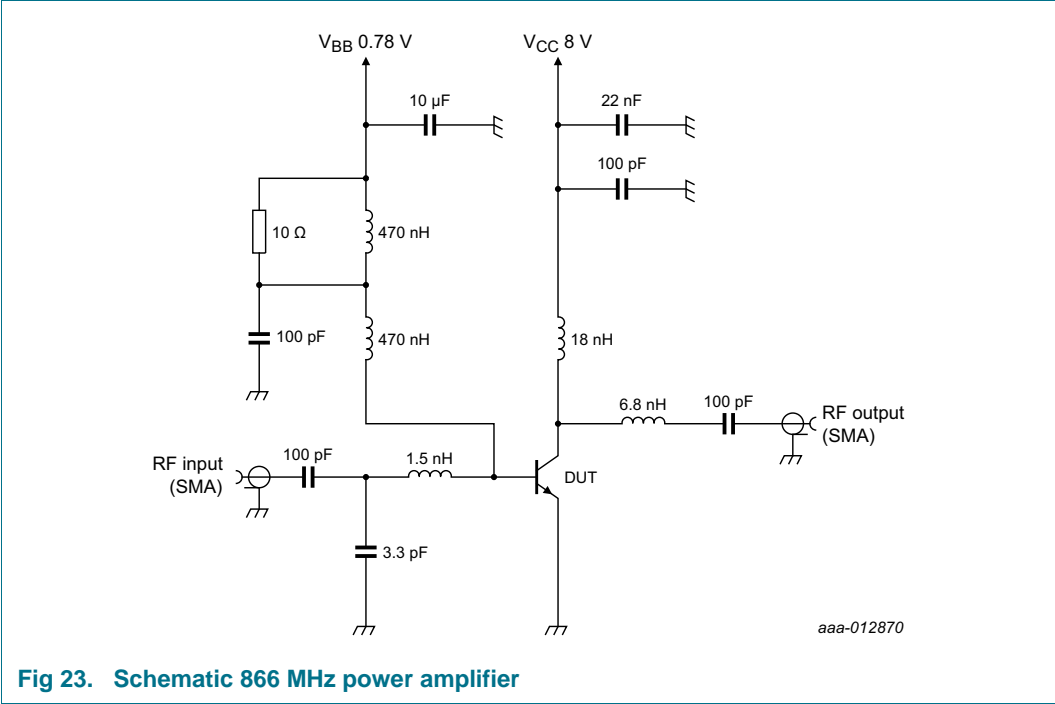
Remark: fine tuning of components maybe required depending on PCB parasitics.

**Table 10. Application performance data at 433 MHz**  
*I<sub>CC</sub> = 100 mA; V<sub>CC</sub> = 8 V*

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
S <sub>21</sub>   <sup>2</sup>	insertion power gain		-	15	-	dB
S <sub>11</sub>   <sup>2</sup>	input return loss		-	-7	-	dB
P <sub>L(1dB)</sub>	output power at 1 dB gain compression		-	26	-	dBm
η <sub>C</sub>	collector efficiency		-	60	-	%

10.2 Application example: 866 MHz PA

More detailed information of the application example can be found in the application note: AN11502.



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

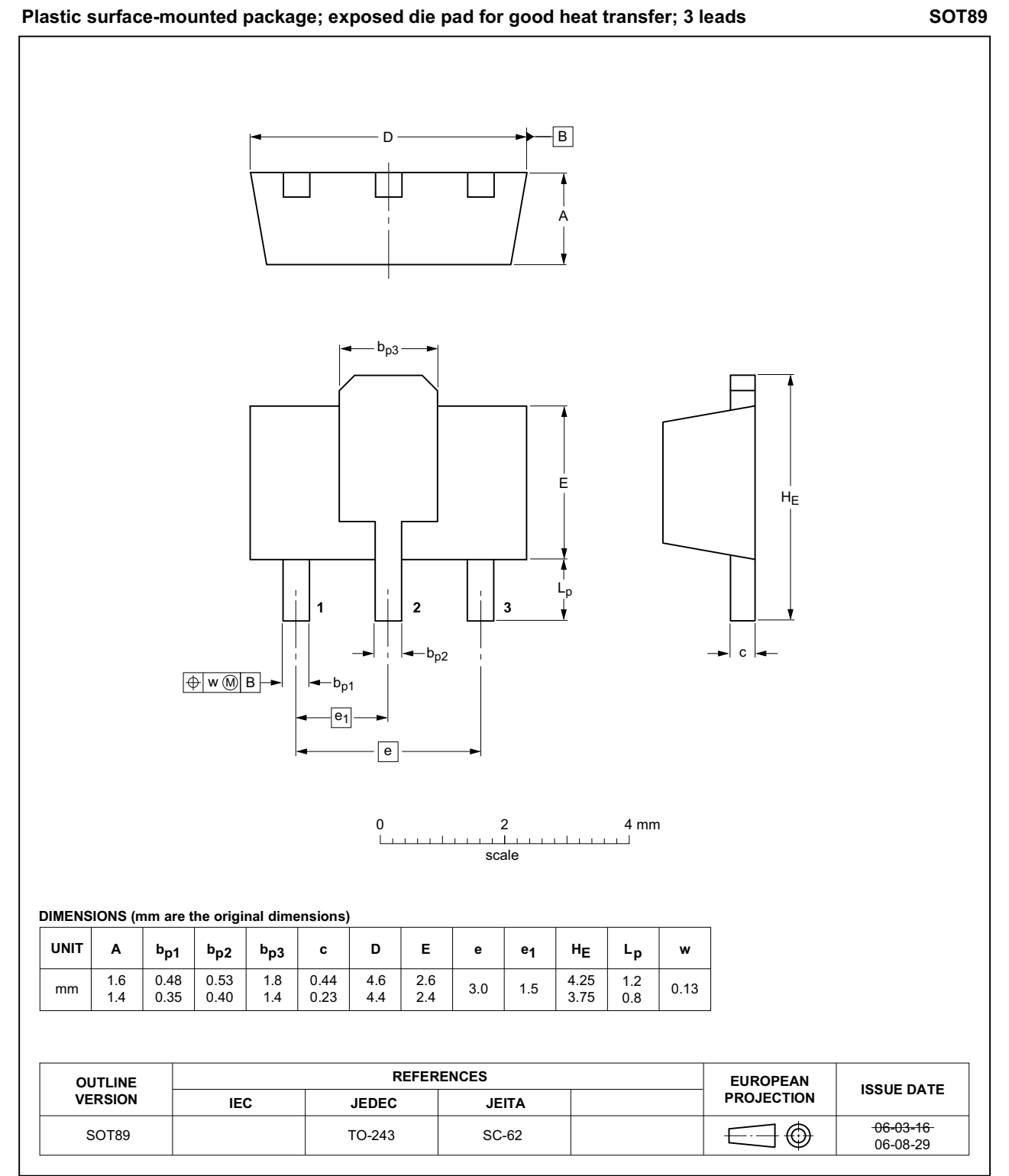


Fig 24. Package outline SOT89

## 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
BFU590Q 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.
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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