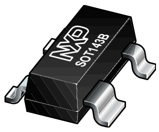


BFU520X

NPN wideband silicon RF transistor

Rev. 2 — 5 March 2014 | Product data sheet

1. Product profile

1.1 General description

NPN silicon RF transistor for high speed, low noise applications in a plastic, 4-pin dual-emitter SOT143B package.

The BFU520X 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

- Low noise, high breakdown RF transistor
- AEC-Q101 qualified
- Minimum noise figure (NF_{min}) = 0.7 dB at 900 MHz
- Maximum stable gain 20 dB at 900 MHz
- 11 GHz f_T silicon technology

1.3 Applications

- Applications requiring high supply voltages and high breakdown voltages
- Broadband amplifiers up to 2 GHz
- Low noise amplifiers for ISM applications
- ISM band oscillators

1.4 Quick reference data

Table 1. Quick reference data

T_{amb} = 25 °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		-	5	30	mA
P_{tot}	total power dissipation	$T_{sp} \leq 87$ °C [1]	-	-	450	mW
h_{FE}	DC current gain	I_C = 5 mA; V_{CE} = 8 V	60	95	200	
C_c	collector capacitance	V_{CB} = 8 V; f = 1 MHz	-	0.52	-	pF
f_T	transition frequency	I_C = 10 mA; V_{CE} = 8 V; f = 900 MHz	-	10.5	-	GHz

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

T_{amb} = 25 °C unless otherwise specified

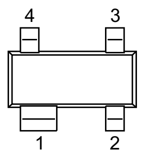
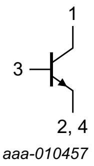
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$G_{p(max)}$	maximum power gain	I_C = 5 mA; V_{CE} = 8 V; f = 900 MHz [2]	-	20	-	dB
NF_{min}	minimum noise figure	I_C = 1 mA; V_{CE} = 8 V; f = 900 MHz; $\Gamma_S = \Gamma_{opt}$	-	0.7	-	dB
$P_{L(1dB)}$	output power at 1 dB gain compression	I_C = 10 mA; V_{CE} = 8 V; $Z_S = Z_L$ = 50 Ω; f = 900 MHz	-	6.5	-	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	collector		
2	emitter		
3	base		
4	emitter		

3. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
BFU520X	-	plastic surface-mounted package; 4 leads	SOT143B
OM7963	-	Customer evaluation kit for BFU520X, BFU530X and BFU550X [1]	-

[1] The customer evaluation kit contains the following:

a) Unpopulated RF amplifier Printed-Circuit Board (PCB)

b) Unpopulated RF amplifier Printed-Circuit Board (PCB) with emitter degeneration

c) Four SMA connectors for fitting unpopulated Printed-Circuit Board (PCB)

d) BFU520X, BFU530X and BFU550X samples

e) USB stick with data sheets, application notes, models, S-parameter and noise files

4. Marking

Table 4. Marking

Type number	Marking	Description
BFU520X	*TE	* = t : made in Malaysia
		* = w : made in China

5. Design support

Table 5. Available design support

Download from the BFU520X 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	
Noise parameters	yes	
Customer evaluation kit	yes	See Section 3 and Section 10.
Solder pattern	yes	
Application notes	yes	See Section 10.1 and Section 10.2.

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		-	50	mA
T_{stg}	storage temperature		−65	+150	°C
V_{ESD}	electrostatic discharge voltage	Human Body Model (HBM) According to JEDEC standard 22-A114E	-	±150	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		-	-	30	mA
P_i	input power	$Z_S = 50\ \Omega$	-	-	10	dBm
T_j	junction temperature		−40	-	+150	°C
P_{tot}	total power dissipation	$T_{sp} \leq 87$ °C [1]	-	-	450	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]	140	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.

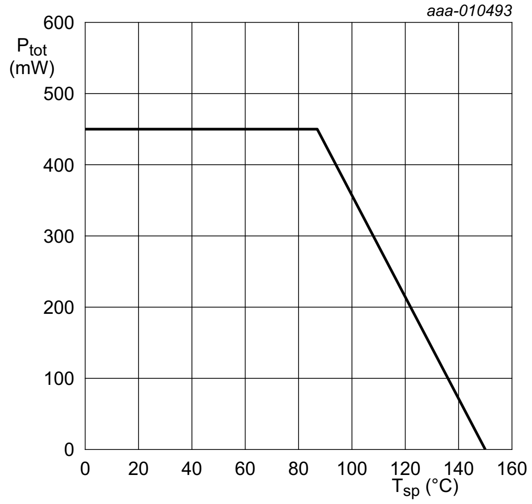


Fig 1. Power derating curve

9. Characteristics

Table 9. Characteristics
T_{amb} = 25 °C unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{(BR)CBO}$	collector-base breakdown voltage	I_C = 100 nA; I_E = 0 mA	24	-	-	V
$V_{(BR)CEO}$	collector-emitter breakdown voltage	I_C = 150 nA; I_B = 0 mA	12	-	-	V
I_C	collector current		-	5	30	mA
I_{CBO}	collector-base cut-off current	I_E = 0 mA; V_{CB} = 8 V	-	<1	-	nA
h_{FE}	DC current gain	I_C = 5 mA; V_{CE} = 8 V	60	95	200	
C_e	emitter capacitance	V_{EB} = 0.5 V; f = 1 MHz	-	0.74	-	pF
C_{re}	feedback capacitance	V_{CE} = 8 V; f = 1 MHz	-	0.28	-	pF
C_c	collector capacitance	V_{CB} = 8 V; f = 1 MHz	-	0.52	-	pF
f_T	transition frequency	I_C = 10 mA; V_{CE} = 8 V; f = 900 MHz	-	10.5	-	GHz

Table 9. Characteristics *...continued*

T_{amb} = 25 °C unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$G_{p(max)}$	maximum power gain	f = 433 MHz; V_{CE} = 8 V [1]				
		I_C = 1 mA	-	17	-	dB
		I_C = 5 mA	-	23.5	-	dB
		I_C = 10 mA	-	26	-	dB
		f = 900 MHz; V_{CE} = 8 V [1]				
		I_C = 1 mA	-	14	-	dB
		I_C = 5 mA	-	20	-	dB
		I_C = 10 mA	-	22	-	dB
		f = 1800 MHz; V_{CE} = 8 V [1]				
		I_C = 1 mA	-	11.5	-	dB
		I_C = 5 mA	-	17	-	dB
		I_C = 10 mA	-	18	-	dB
$\|s_{21}\|^2$	insertion power gain	f = 433 MHz; V_{CE} = 8 V				
		I_C = 1 mA	-	10.5	-	dB
		I_C = 5 mA	-	21	-	dB
		I_C = 10 mA	-	23.5	-	dB
		f = 900 MHz; V_{CE} = 8 V				
		I_C = 1 mA	-	9.5	-	dB
		I_C = 5 mA	-	17.5	-	dB
		I_C = 10 mA	-	19	-	dB
		f = 1800 MHz; V_{CE} = 8 V				
		I_C = 1 mA	-	6.5	-	dB
		I_C = 5 mA	-	12.5	-	dB
		I_C = 10 mA	-	13	-	dB
NF_{min}	minimum noise figure	f = 433 MHz; V_{CE} = 8 V; $\Gamma_S = \Gamma_{opt}$				
		I_C = 1 mA	-	0.6	-	dB
		I_C = 5 mA	-	0.75	-	dB
		I_C = 10 mA	-	0.95	-	dB
		f = 900 MHz; V_{CE} = 8 V; $\Gamma_S = \Gamma_{opt}$				
		I_C = 1 mA	-	0.7	-	dB
		I_C = 5 mA	-	0.8	-	dB
		I_C = 10 mA	-	1	-	dB
		f = 1800 MHz; V_{CE} = 8 V; $\Gamma_S = \Gamma_{opt}$				
		I_C = 1 mA	-	0.9	-	dB
		I_C = 5 mA	-	0.95	-	dB
		I_C = 10 mA	-	1.1	-	dB

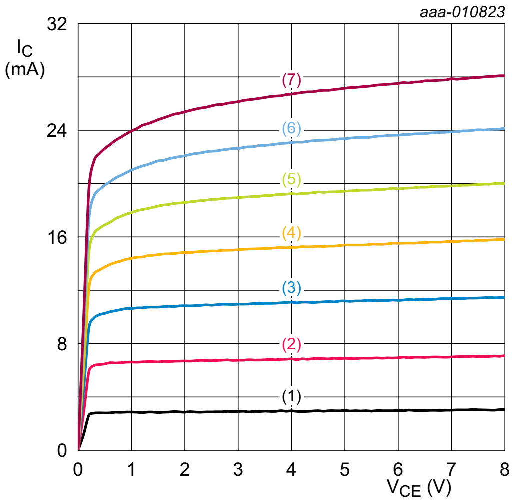
Table 9. Characteristics *...continued*

T_{amb} = 25 °C unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
G_{ass}	associated gain	f = 433 MHz; V_{CE} = 8 V; $\Gamma_S = \Gamma_{opt}$				
		I_C = 1 mA	-	25.5	-	dB
		I_C = 5 mA	-	25.5	-	dB
		I_C = 10 mA	-	26	-	dB
		f = 900 MHz; V_{CE} = 8 V; $\Gamma_S = \Gamma_{opt}$				
		I_C = 1 mA	-	18	-	dB
		I_C = 5 mA	-	19	-	dB
		I_C = 10 mA	-	20	-	dB
		f = 1800 MHz; V_{CE} = 8 V; $\Gamma_S = \Gamma_{opt}$				
		I_C = 1 mA	-	11.5	-	dB
		I_C = 5 mA	-	13.5	-	dB
		I_C = 10 mA	-	14	-	dB
$P_{L(1dB)}$	output power at 1 dB gain compression	f = 433 MHz; V_{CE} = 8 V; $Z_S = Z_L$ = 50 Ω				
		I_C = 5 mA	-	1	-	dBm
		I_C = 10 mA	-	5.5	-	dBm
		f = 900 MHz; V_{CE} = 8 V; $Z_S = Z_L$ = 50 Ω				
		I_C = 5 mA	-	0	-	dBm
		I_C = 10 mA	-	6.5	-	dBm
		f = 1800 MHz; V_{CE} = 8 V; $Z_S = Z_L$ = 50 Ω				
		I_C = 5 mA	-	3.5	-	dBm
		I_C = 10 mA	-	9.5	-	dBm
$IP3_o$	output third-order intercept point	f_1 = 433 MHz; f_2 = 434 MHz; V_{CE} = 8 V; $Z_S = Z_L$ = 50 Ω				
		I_C = 5 mA	-	10.5	-	dBm
		I_C = 10 mA	-	15	-	dBm
		f_1 = 900 MHz; f_2 = 901 MHz; V_{CE} = 8 V; $Z_S = Z_L$ = 50 Ω				
		I_C = 5 mA	-	9.5	-	dBm
		I_C = 10 mA	-	16	-	dBm
		f_1 = 1800 MHz; f_2 = 1801 MHz; V_{CE} = 8 V; $Z_S = Z_L$ = 50 Ω				
		I_C = 5 mA	-	13	-	dBm
		I_C = 10 mA	-	19.5	-	dBm

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

9.1 Graphs



T_{amb} = 25 °C.

(1) I_B = 25 μA

(2) I_B = 75 μA

(3) I_B = 125 μA

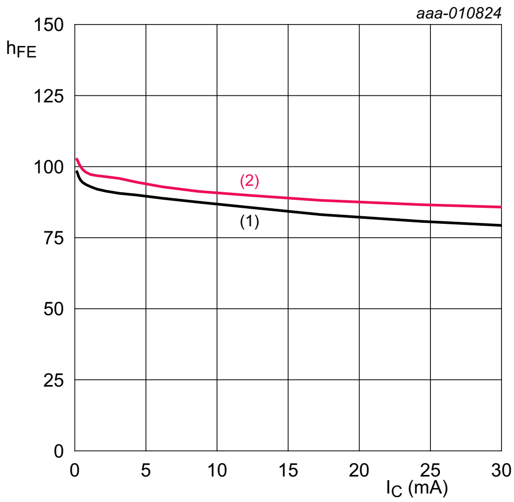
(4) I_B = 175 μA

(5) I_B = 225 μA

(6) I_B = 275 μA

(7) I_B = 325 μA

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

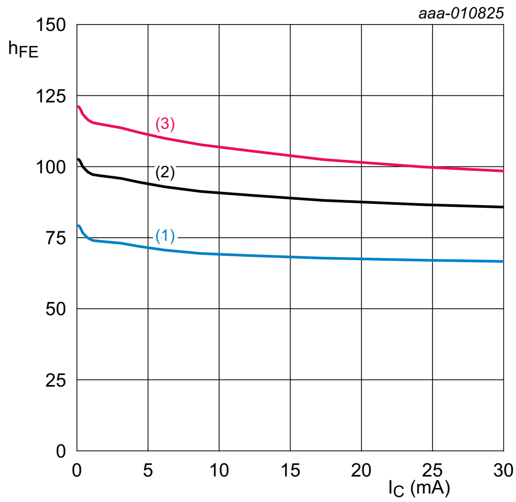


T_{amb} = 25 °C.

(1) V_{CE} = 3.0 V

(2) V_{CE} = 8.0 V

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



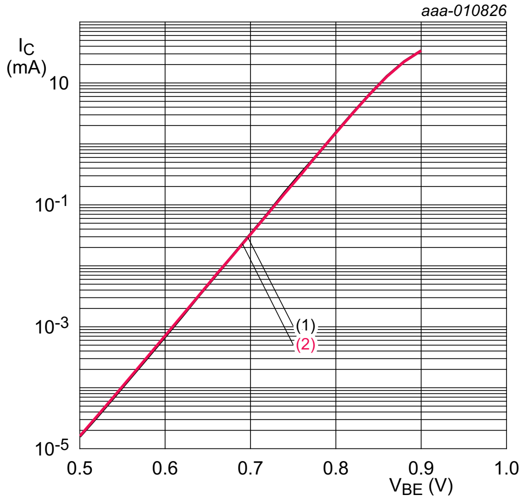
V_{CE} = 8 V.

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +125 °C

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

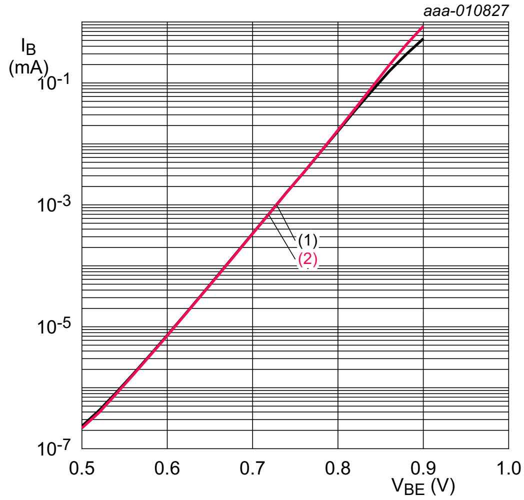


T_{amb} = 25 °C.

(1) V_{CE} = 3.0 V

(2) V_{CE} = 8.0 V

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

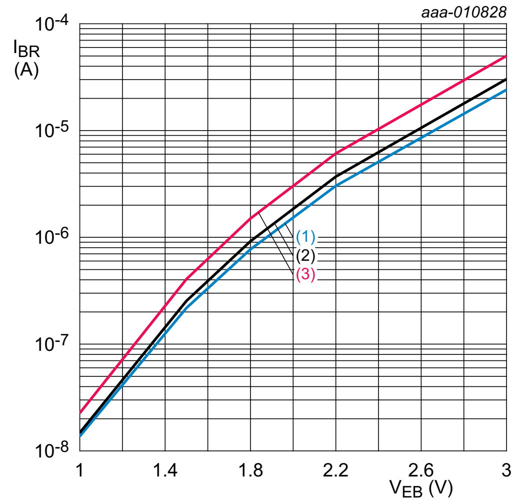


T_{amb} = 25 °C.

(1) V_{CE} = 3.0 V

(2) V_{CE} = 8.0 V

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



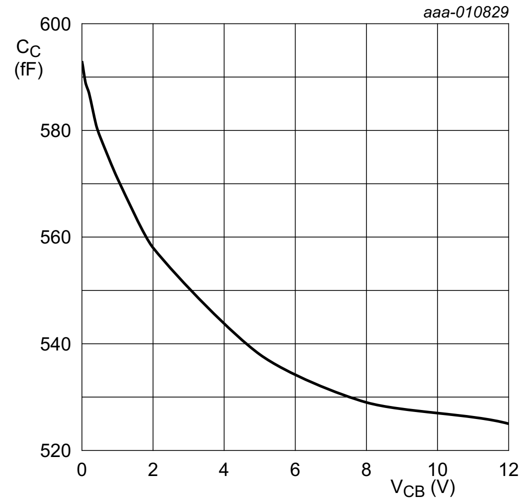
V_{CE} = 3 V.

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

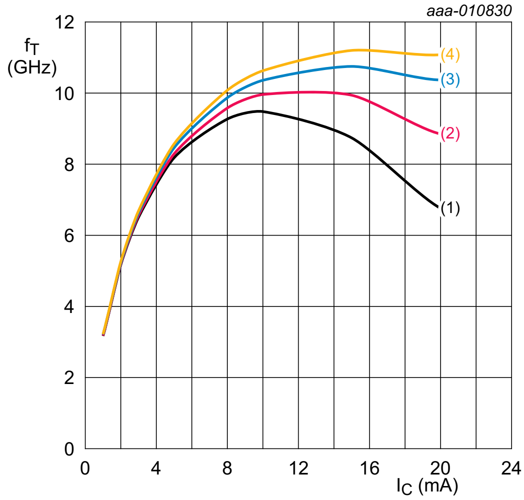
(3) T_{amb} = +125 °C

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



I_C = 0 mA; f = 1 MHz; T_{amb} = 25 °C.

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



T_{amb} = 25 °C.

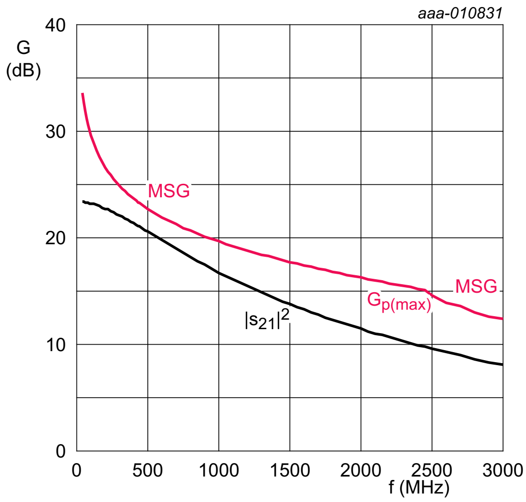
(1) V_{CE} = 3.3 V

(2) V_{CE} = 5.0 V

(3) V_{CE} = 8.0 V

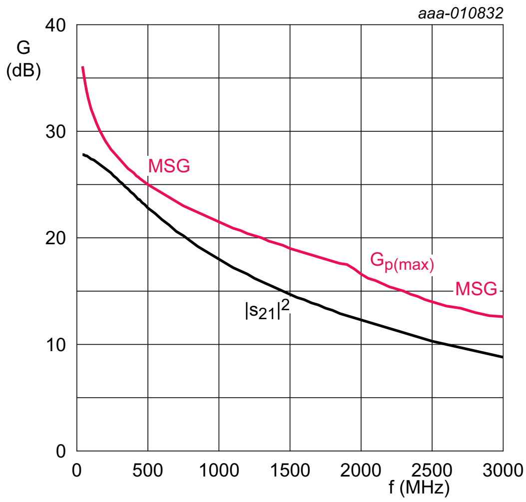
(4) V_{CE} = 12.0 V

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



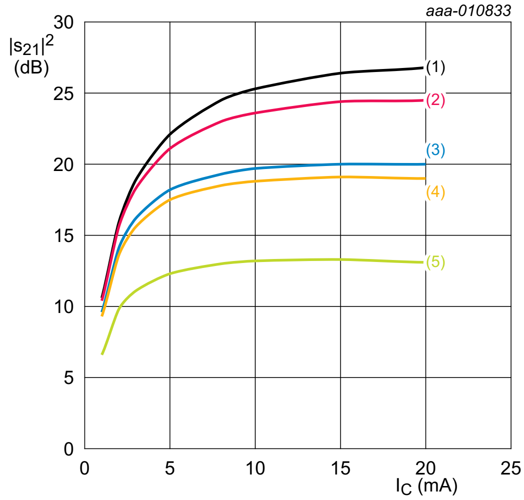
I_C = 5 mA; V_{CE} = 8 V; T_{amb} = 25 °C.

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



I_C = 10 mA; V_{CE} = 8 V; T_{amb} = 25 °C.

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



V_{CE} = 8 V; T_{amb} = 25 °C.

(1) f = 300 MHz

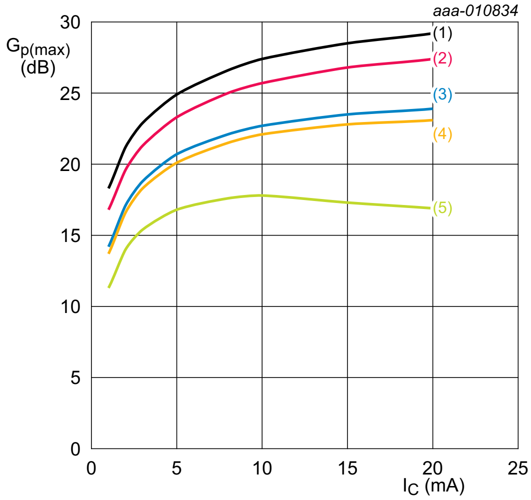
(2) f = 433 MHz

(3) f = 800 MHz

(4) f = 900 MHz

(5) f = 1800 MHz

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



V_{CE} = 8 V; T_{amb} = 25 °C.

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

(1) f = 300 MHz

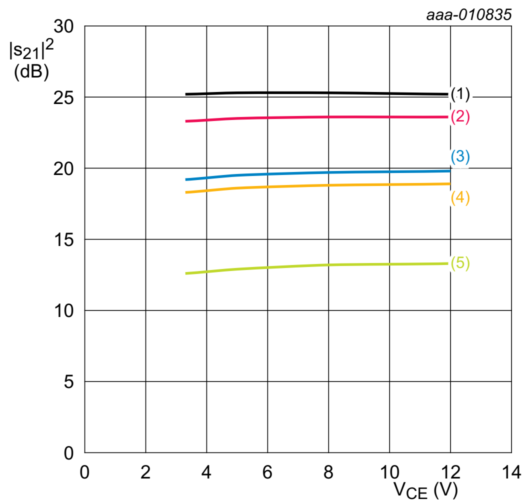
(2) f = 433 MHz

(3) f = 800 MHz

(4) f = 900 MHz

(5) f = 1800 MHz

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



I_C = 10 mA; T_{amb} = 25 °C.

(1) f = 300 MHz

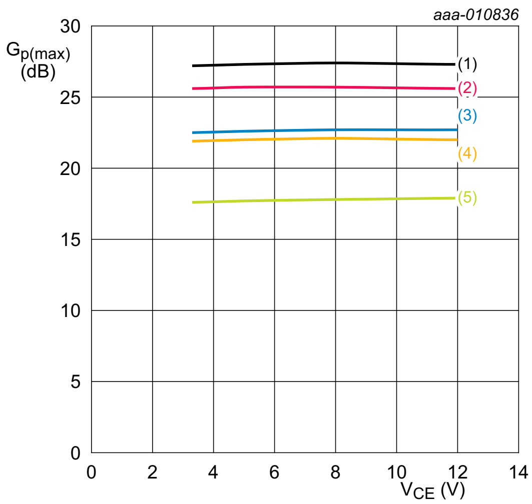
(2) f = 433 MHz

(3) f = 800 MHz

(4) f = 900 MHz

(5) f = 1800 MHz

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



I_C = 10 mA; T_{amb} = 25 °C.

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

(1) f = 300 MHz

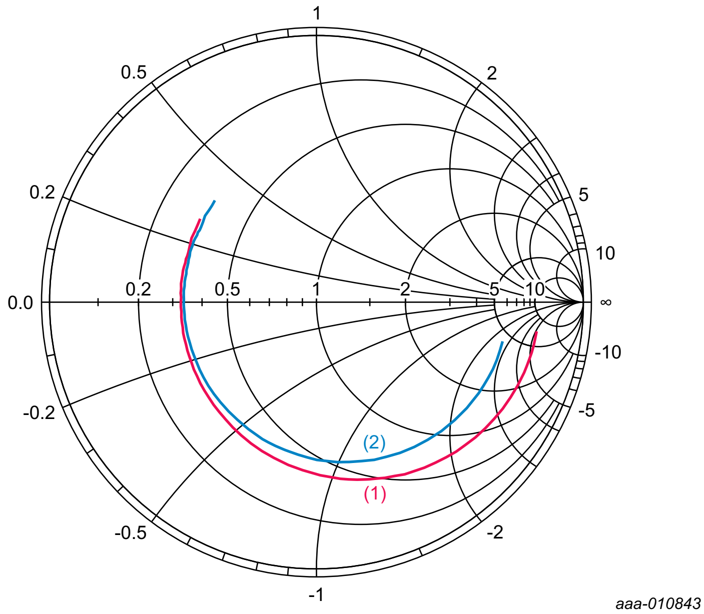
(2) f = 433 MHz

(3) f = 800 MHz

(4) f = 900 MHz

(5) f = 1800 MHz

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

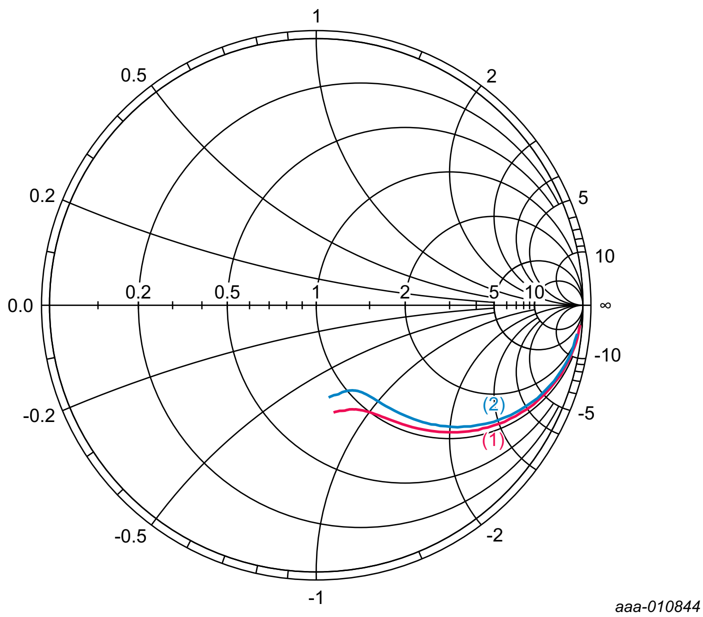


V_{CE} = 8 V; 40 MHz ≤ f ≤ 3 GHz.

(1) I_C = 5 mA

(2) I_C = 10 mA

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

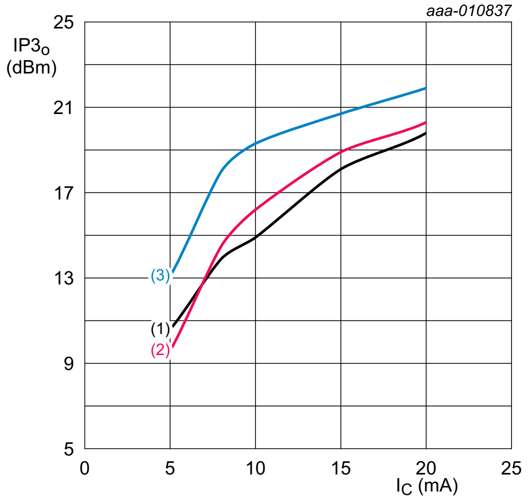


V_{CE} = 8 V; 40 MHz ≤ f ≤ 3 GHz.

(1) I_C = 5 mA

(2) I_C = 10 mA

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



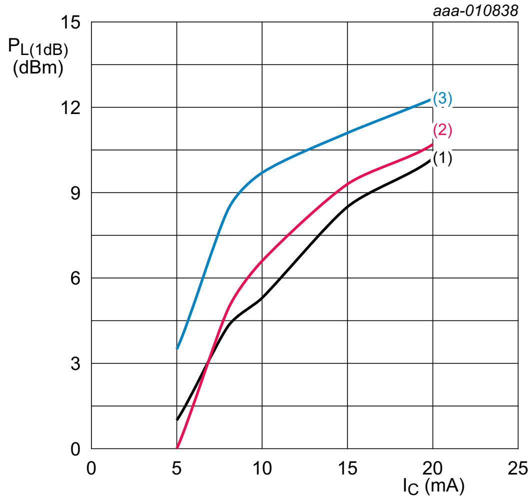
V_{CE} = 8 V; T_{amb} = 25 °C.

(1) f_1 = 433 MHz; f_2 = 434 MHz

(2) f_1 = 900 MHz; f_2 = 901 MHz

(3) f_1 = 1800 MHz; f_2 = 1801 MHz

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



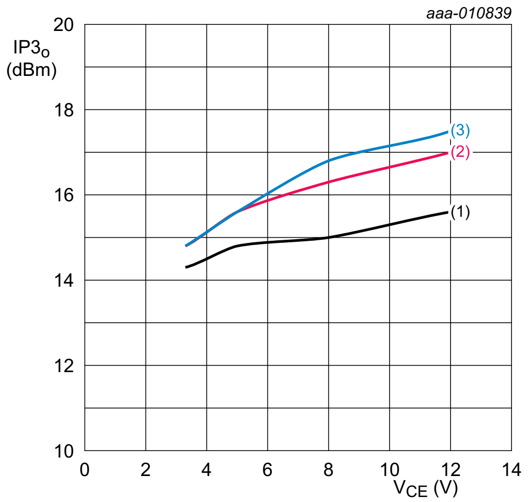
V_{CE} = 8 V; T_{amb} = 25 °C.

(1) f = 433 MHz

(2) f = 900 MHz

(3) f = 1800 MHz

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



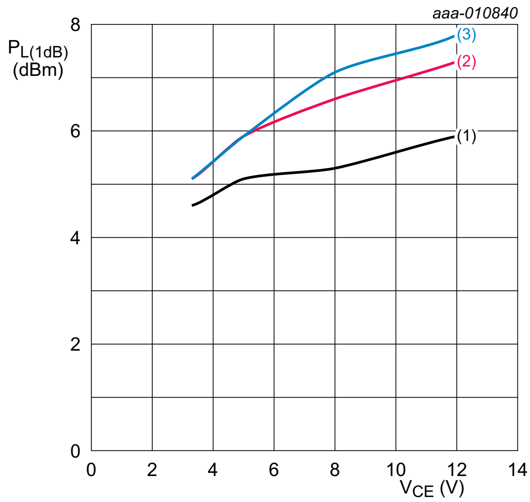
I_C = 10 mA; T_{amb} = 25 °C.

(1) f_1 = 433 MHz; f_2 = 434 MHz

(2) f_1 = 900 MHz; f_2 = 901 MHz

(3) f_1 = 1800 MHz; f_2 = 1801 MHz

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



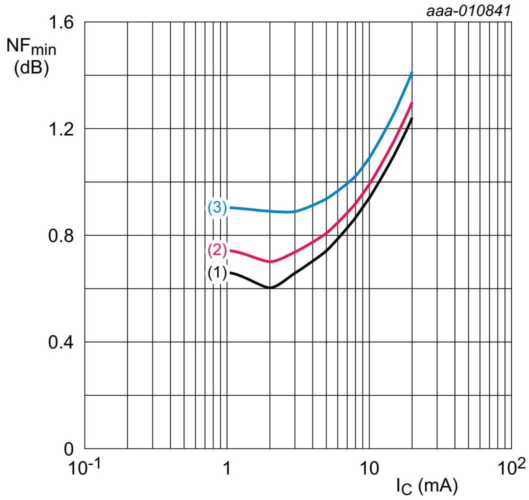
I_C = 10 mA; T_{amb} = 25 °C.

(1) f = 433 MHz

(2) f = 900 MHz

(3) f = 1800 MHz

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



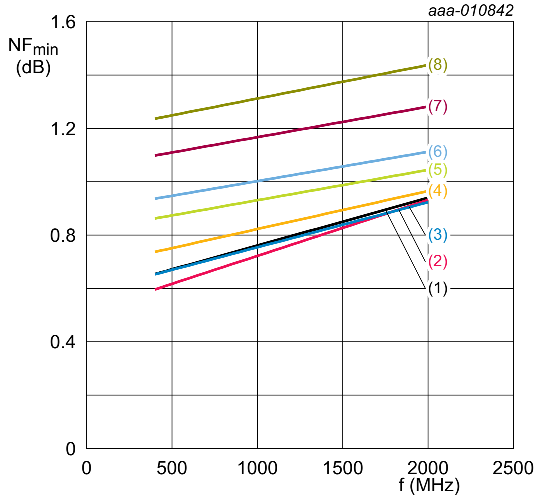
V_{CE} = 8 V; T_{amb} = 25 °C; $\Gamma_S = \Gamma_{opt}$.

(1) f = 433 MHz

(2) f = 900 MHz

(3) f = 1800 MHz

Fig 22. Minimum noise figure as a function of collector current; typical values



V_{CE} = 8 V; T_{amb} = 25 °C; $\Gamma_S = \Gamma_{opt}$.

(1) I_C = 1 mA

(2) I_C = 2 mA

(3) I_C = 3 mA

(4) I_C = 5 mA

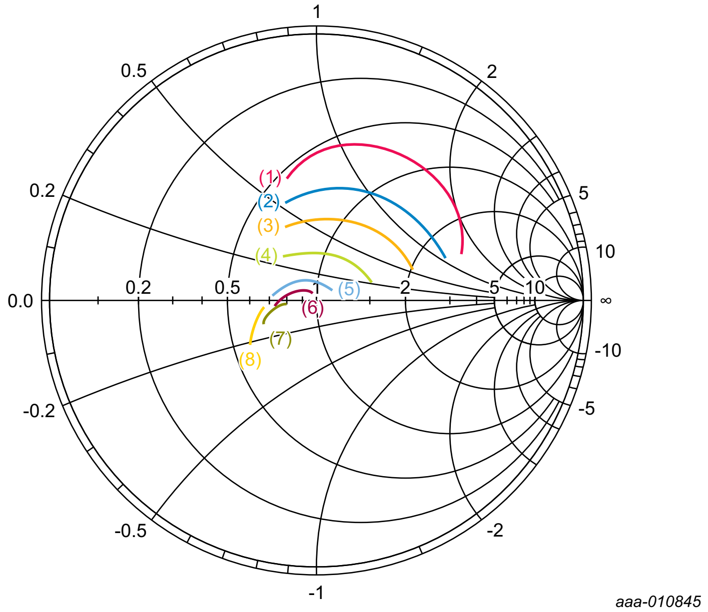
(5) I_C = 8 mA

(6) I_C = 10 mA

(7) I_C = 15 mA

(8) I_C = 20 mA

Fig 23. Minimum noise figure as a function of frequency; typical values



V_{CE} = 8 V; 400 MHz ≤ f ≤ 2 GHz.

(1) I_C = 1 mA

(2) I_C = 2 mA

(3) I_C = 3 mA

(4) I_C = 5 mA

(5) I_C = 8 mA

(6) I_C = 10 mA

(7) I_C = 15 mA

(8) I_C = 20 mA

Fig 24. Optimum reflection coefficient (Γ_{opt}); 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 ISM band LNA

433 ISM band LNA, optimized for low noise.

More detailed information of the application example can be found in the application note: *AN11433.*

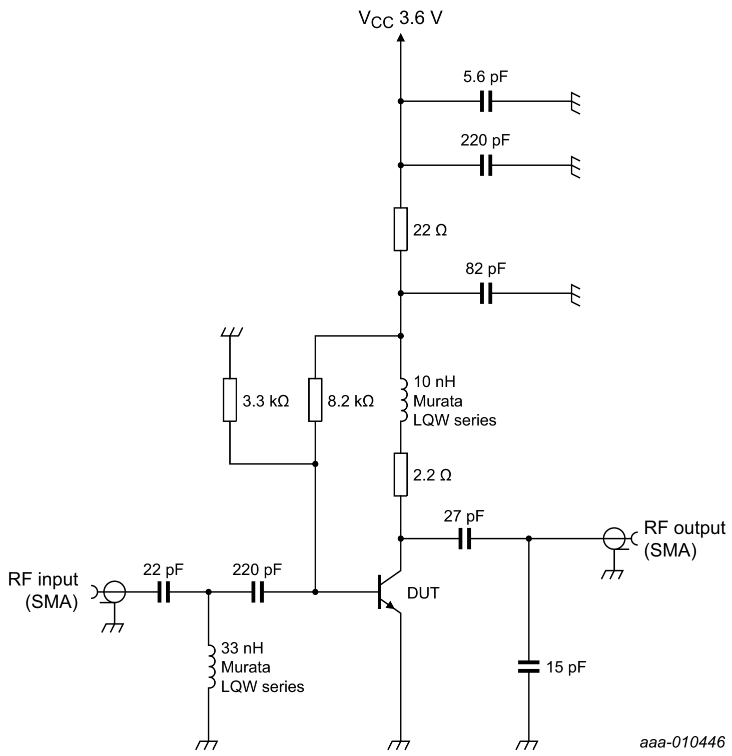


Fig 25. Schematic 433 MHz ISM band LNA

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

Table 10. Application performance data at 433 MHz

I_{CC} = 7 mA; V_{CC} = 3.6 V

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\|s_{21}\|^2$	insertion power gain		-	19	-	dB
NF	noise figure		-	1.0	-	dB
$IP3_o$	output third-order intercept point	f_1 = 433.1 MHz; f_2 = 433.2 MHz; P_i = −30 dBm per carrier	-	11	-	dBm

10.2 Application example: 866 ISM band LNA

866 ISM band LNA, optimized for low noise.

More detailed information of the application example can be found in the application note: *AN11434.*

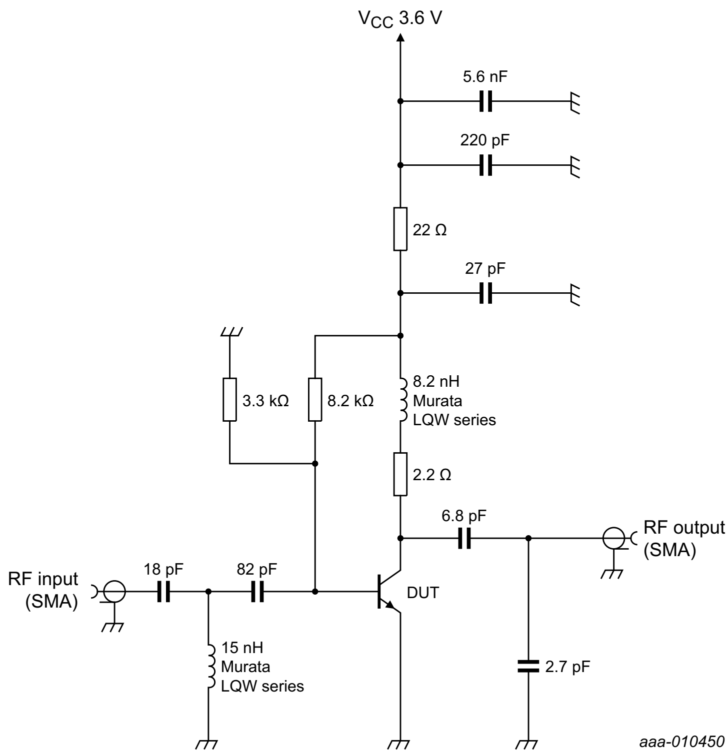


Fig 26. Schematic 866 MHz ISM band LNA

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

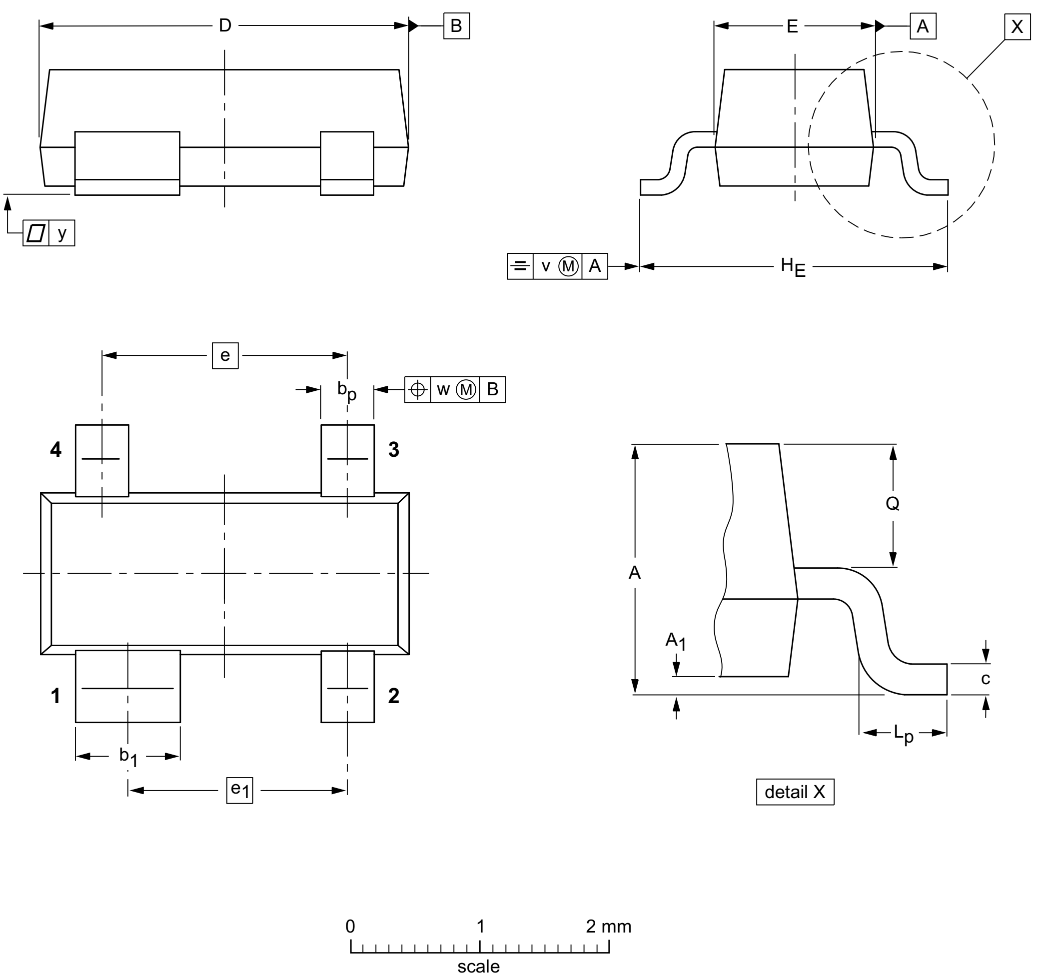
Table 11. Application performance data at 866 MHz

I_{CC} = 7 mA; V_{CC} = 3.6 V

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\|s_{21}\|^2$	insertion power gain		-	16	-	dB
NF	noise figure		-	1.1	-	dB
$IP3_o$	output third-order intercept point	f_1 = 866.1 MHz; f_2 = 866.2 MHz; P_i = –30 dBm per carrier	-	14	-	dBm

11. Package outline

Plastic surface-mounted package; 4 leads **SOT143B**



DIMENSIONS (mm are the original dimensions)

UNIT	A	A$_1$ max	b$_p$	b$_1$	c	D	E	e	e$_1$	H$_E$	L$_p$	Q	v	w	y
mm	1.1 0.9	0.1	0.48 0.38	0.88 0.78	0.15 0.09	3.0 2.8	1.4 1.2	1.9	1.7	2.5 2.1	0.45 0.15	0.55 0.45	0.2	0.1	0.1

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT143B						~~04-11-16~~ 06-03-16

Fig 27. Package outline SOT143B

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
SMA	SubMiniature version A

14. Revision history

Table 13. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
BFU520X v.2	20140305	Product data sheet	-	BFU520X v.1
Modifications:	• Section 10.1 on page 16: a remarks has been added below Figure 25. • Section 10.2 on page 17: a remarks has been added below Figure 26.			
BFU520X v.1	20140220	Product data sheet	-	-

15. Legal information

15.1 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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