BGU7005

SiGe:C Low Noise Amplifier MMIC for GPS

Rev. 01 — 28 October 2009 Preliminary data sheet

1. Product profile

1.1 General description

The BGU7005 is a Low Noise Amplifier (LNA) for GPS receiver applications in a plastic leadless 6-pin, extremely small SOT886 package. The BGU7005 requires only one external matching inductor and one external decoupling capacitor.

The BGU7005 adapts itself to the changing environment resulting from co-habitation of different radio systems in modern cellular handsets. It has been designed for low power consumption and optimal performance when jamming signals from co-existing cellular transmitters are present. At low jamming power levels it delivers 16.5 dB gain at a noise figure of 0.9 dB. During high jamming power levels, resulting for example from a cellular transmit burst, it temporarily increases its bias current to improve sensitivity.

CAUTION

This device is sensitive to ElectroStatic Discharge (ESD). Therefore care should be taken during transport and handling.

1.2 Features

- Small 6-pin leadless package 1 × 1.45 × 0.5 mm
- Low noise high gain MMIC
- Integrated temperature stabilized bias for easy design
- Requires only one input matching inductor and one supply decoupling capacitor
- Input and output DC decoupled
- Noise figure (NF) = 0.9 dB at 1.575 GHz
- Integrated matching for the output
- Gain 16.5 dB at 1.575 GHz
- High 1 dB compression point of –11 dBm
- High out of band $IP3_i$ of 9 dBm
- 110 GHz transit frequency - SiGe:C technology
- Supply voltage 1.5 V to 2.85 V, optimized for 1.8 V
- Power-down mode current consumption < 1 μA
- Optimized performance at low 4.5 mA supply current
- ESD protection on all pins (HBM > 1 kV)

1.3 Applications

- LNA for GPS in handsets, PDA's and Portable Navigation Devices

1.4 Quick reference data

Table 1. Quick reference data

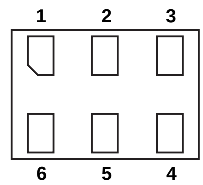
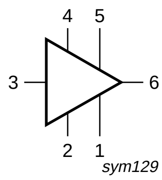
$f = 1575$ MHz; $V_{CC} = 1.8$ V; $P_i < -40$ dBm; $T_{amb} = 25$ °C; input matched to 50 Ω using a 5.6 nH inductor; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage	RF input AC coupled	1.5	-	2.85	V
I_{CC}	supply current	$V_{ENABLE} \geq 0.8$ V				
		$P_i < -40$ dBm	-	4.5	-	mA
		$P_i = -20$ dBm	-	12	-	mA
G_p	power gain	$P_i < -40$ dBm	14	16.5	19	dB
		$P_i = -20$ dBm	15	17.5	20	dB
NF	noise figure	$P_i < -40$ dBm	-	0.9	1.3	dB
		$P_i = -20$ dBm	-	1.2	1.6	dB
$P_{i(1dB)}$	input power at 1 dB gain compression	f = 1.575 GHz				
		$V_{CC} = 1.5$ V	–15	–12	-	dBm
		$V_{CC} = 1.8$ V	–14	–11	-	dBm
		$V_{CC} = 2.85$ V	–11	–8	-	dBm
$IP3_i$	input third-order intercept point	f = 1.575 GHz				
		$V_{CC} = 1.5$ V [1]	5	8	-	dBm
		$V_{CC} = 1.8$ V [1]	5	9	-	dBm
		$V_{CC} = 2.85$ V [1]	5	12	-	dBm

[1] $f_1 = 1713$ MHz; $f_2 = 1851$ MHz.

2. Pinning information

Table 2. Pinning

Pin	Description	Simplified outline	Graphic symbol
1	GND	 bottom view	
2	GND		
3	RF_IN		
4	V_{CC}		
5	ENABLE		
6	RF_OUT		

3. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
BGU7005	XSON6	plastic extremely thin small outline package; no leads; 6 terminals; body 1 x 1.45 x 0.5 mm	SOT886

4. Marking

Table 4. Marking codes

Type number	Marking code
BGU7005	AC

5. Limiting values

Table 5. Limiting values

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

Symbol	Parameter	Conditions		Min	Max	Unit
V_{CC}	supply voltage	RF input AC coupled		–0.2	+3.1	V
P_{tot}	total power dissipation	$T_{sp} \leq 130$ °C	[1]		55	mW
T_{stg}	storage temperature			-65	150	°C
T_j	junction temperature			-	150	°C

[1] T_{sp} is the temperature at the soldering point of the emitter lead.

6. Thermal characteristics

Table 6. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-sp)}$	thermal resistance from junction to solder point		225	K/W

7. Characteristics

Table 7. Characteristics

f = 1575 MHz; V_{CC} = 1.8 V; V_{ENABLE} >= 0.8 V; P_i < –40 dBm; T_{amb} = 25 °C; input matched to 50 Ω using a 5.6 nH inductor; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage	RF input AC coupled	1.5	-	2.85	V
I_{CC}	supply current	$V_{ENABLE} \geq 0.8$ V				
		P_i < –40 dBm	-	4.5	-	mA
		P_i = –20 dBm	-	12	-	mA
		$V_{ENABLE} \leq 0.35$ V	-	-	0.001	mA
T_{amb}	ambient temperature		–40	+25	+85	°C

Table 7. Characteristics *...continued*

f = 1575 MHz; V_{CC} = 1.8 V; V_{ENABLE} >= 0.8 V; P_i < –40 dBm; T_{amb} = 25 °C; input matched to 50 Ω using a 5.6 nH inductor; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
G_p	power gain	T_{amb} = 25 °C					
		no jammer		14	16.5	19	dB
		P_i = –20 dBm; f_i = 1575 MHz		15	17.5	20	dB
		P_{jam} = –20 dBm; f_{jam} = 850 MHz		15	17.5	20	dB
		P_{jam} = –20 dBm; f_{jam} = 1850 MHz		15	17.5	20	dB
		–40 °C ≤ T_{amb} ≤ +85 °C					
		no jammer		13	-	20	dB
		P_i = –20 dBm; f_i = 1575 MHz		14	-	21	dB
		P_{jam} = –20 dBm; f_{jam} = 850 MHz		14	-	21	dB
		P_{jam} = –20 dBm; f_{jam} = 1850 MHz		14	-	21	dB
RL_{in}	input return loss	P_i < –40 dBm		5	8	-	dB
		P_i = –20 dBm		6	10	-	dB
RL_{out}	output return loss	P_i < –40 dBm		10	20	-	dB
		P_i = –20 dBm		10	14	-	dB
ISL	isolation			22	24	-	dB
NF	noise figure	T_{amb} = 25 °C					
		no jammer		-	0.9	1.3	dB
		P_i = –20 dBm; f_i = 1575 MHz		-	1.2	1.6	dB
		P_{jam} = –20 dBm; f_{jam} = 850 MHz		-	1.1	1.5	dB
		P_{jam} = –20 dBm; f_{jam} = 1850 MHz		-	1.3	1.7	dB
		–40 °C ≤ T_{amb} ≤ +85 °C					
		no jammer		-	-	1.7	dB
		P_i = –20 dBm; f_i = 1575 MHz		-	-	1.9	dB
		P_{jam} = –20 dBm; f_{jam} = 850 MHz		-	-	1.8	dB
		P_{jam} = –20 dBm; f_{jam} = 1850 MHz		-	-	2.0	dB
$P_{i(1dB)}$	input power at 1 dB gain compression	f = 1575 MHz					
		V_{CC} = 1.5 V		–15	–12	-	dBm
		V_{CC} = 1.8 V		–14	–11	-	dBm
		V_{CC} = 2.85 V		–11	–8	-	dBm
		f = 806 MHz to 928 MHz					
		V_{CC} = 1.5 V	[1]	–15	–12	-	dBm
		V_{CC} = 1.8 V	[1]	–14	–11	-	dBm
		V_{CC} = 2.85 V	[1]	–14	–11	-	dBm
		f = 1612 MHz to 1909 MHz					
		V_{CC} = 1.5 V	[1]	–13	–10	-	dBm
		V_{CC} = 1.8 V	[1]	–12	–9	-	dBm
		V_{CC} = 2.85 V	[1]	–10	–7	-	dBm

Table 7. Characteristics *...continued*

f = 1575 MHz; V_{CC} = 1.8 V; V_{ENABLE} >= 0.8 V; P_i < –40 dBm; T_{amb} = 25 °C; input matched to 50 Ω using a 5.6 nH inductor; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$IP3_i$	input third-order intercept point	f = 1.575 GHz					
		V_{CC} = 1.5 V	[2]	5	8	-	dBm
		V_{CC} = 1.8 V	[2]	5	9	-	dBm
		V_{CC} = 2.85 V	[2]	5	12	-	dBm
t_{on}	turn-on time		[3]	-	-	2	µs
t_{off}	turn-off time		[3]	-	-	1	µs
K	Rollett stability factor			1	-	-	

[1] Out of band.

[2] f_1 = 1713 MHz; f_2 = 1851 MHz.

[3] Within 10 % of the final gain.

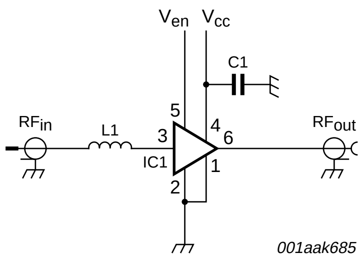
Table 8. ENABLE (pin 5)

–40 °C ≤ T_{amb} ≤ +85 °C; 1.5 V ≤ V_{CC} ≤ 2.85 V

V_{ENABLE} (V)	State
≤ 0.35	OFF
≥ 0.8	ON

8. Application information

8.1 GPS LNA



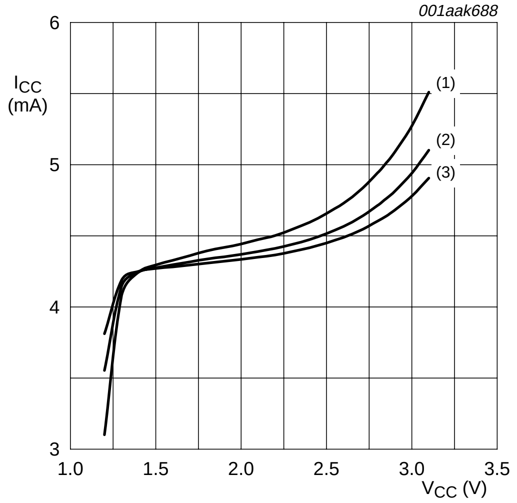
For a list of components see Table 9.

Fig 1. Schematics GPS LNA evaluation board

Table 9. List of components

For schematics see Figure 1.

Component	Description	Value	Supplier	Remarks
C1	decoupling capacitor	1 nF	various	
IC1	BGU7005	-	NXP	
L1	high quality matching inductor	5.6 nH	Murata LQW15A	



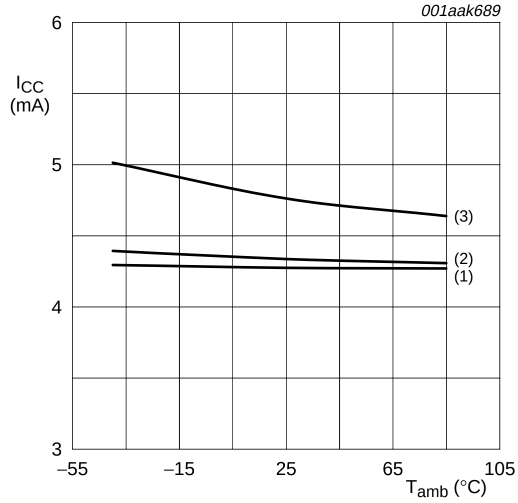
P_i = –45 dBm.

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 2. Supply current as a function of supply voltage; typical values



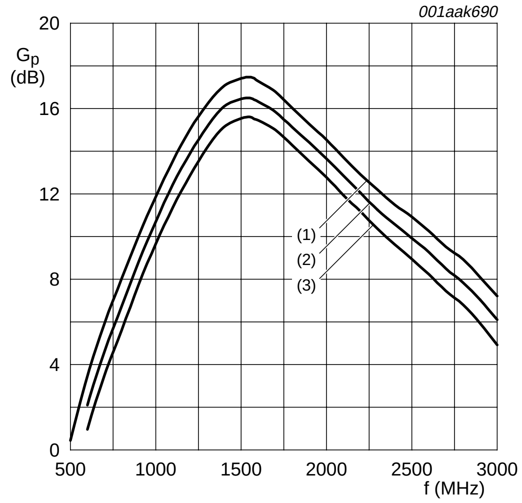
P_i = –45 dBm.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

Fig 3. Supply current as a function of ambient temperature; typical values



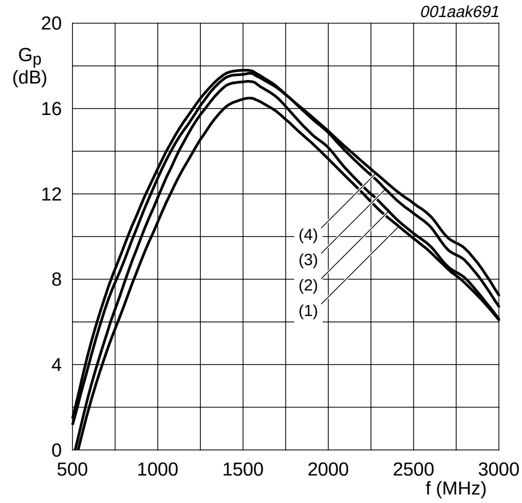
V_{CC} = 1.8 V; P_i = –45 dBm.

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 4. Power gain as a function of frequency; typical values



V_{CC} = 1.8 V; T_{amb} = 25 °C.

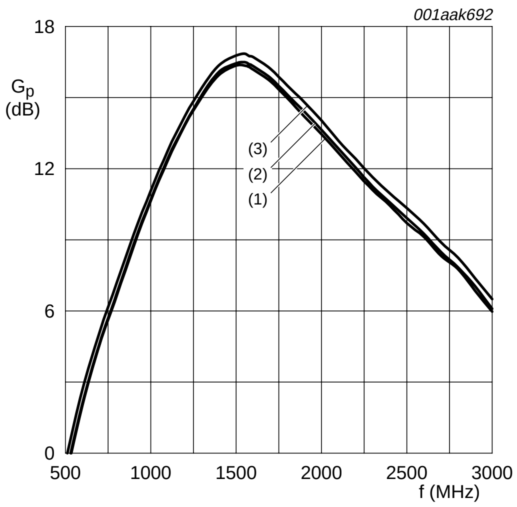
(1) P_i = –45 dBm

(2) P_i = –30 dBm

(3) P_i = –20 dBm

(4) P_i = –15 dBm

Fig 5. Power gain as a function of frequency; typical values



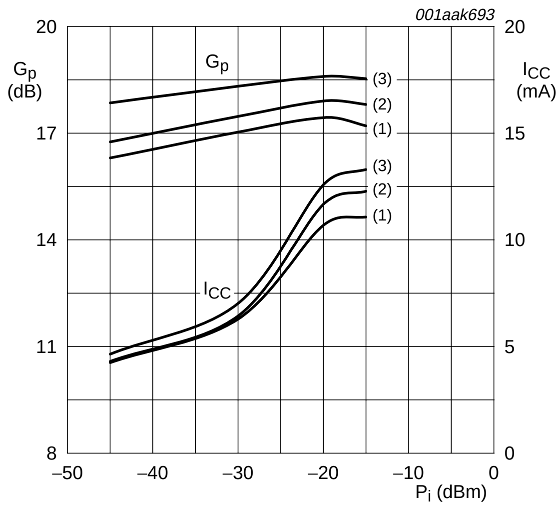
P_i = –45 dBm; T_{amb} = 25 °C.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

Fig 6. Power gain as a function of frequency; typical values



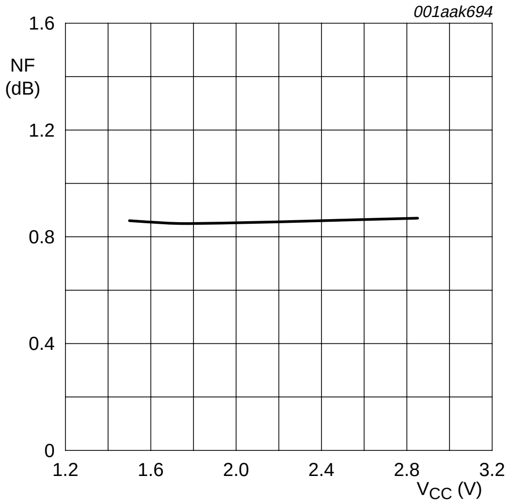
T_{amb} = 25 °C; f = 1575 MHz.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

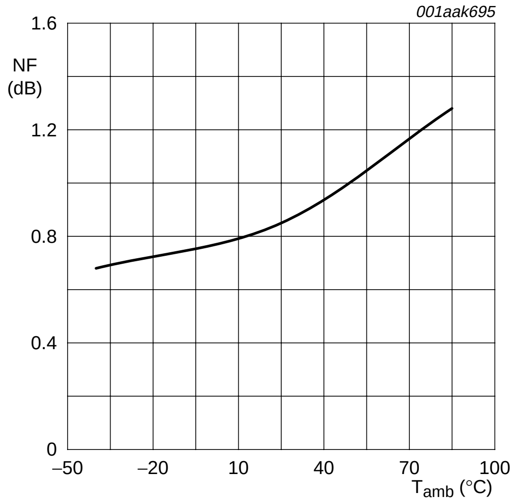
(3) V_{CC} = 2.85 V

Fig 7. Power gain as a function of input power; typical values



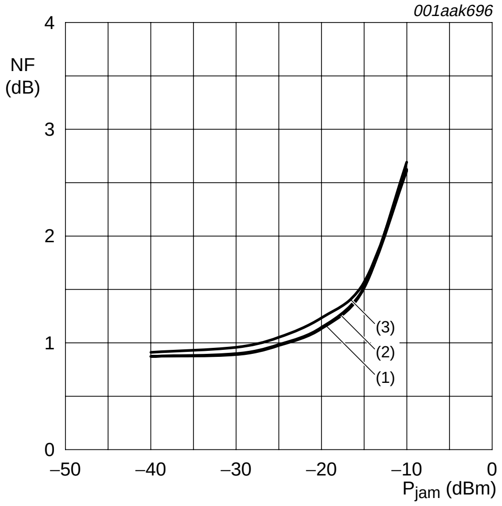
f = 1575 MHz; T_{amb} = 25 °C; no jammer.

Fig 8. Noise figure as a function of supply current; typical values



f = 1575 MHz; V_{CC} = 1.8 V; no jammer.

Fig 9. Noise figure as a function of ambient temperature; typical values



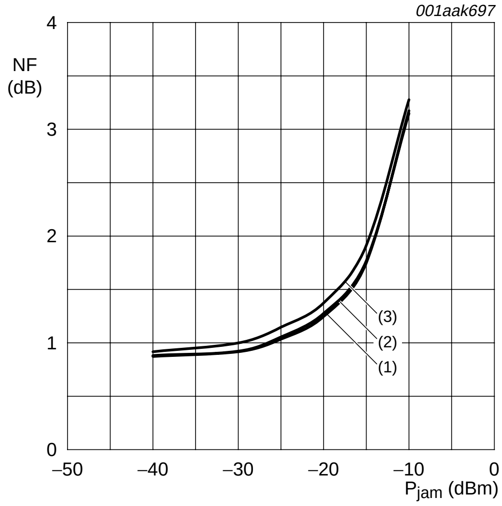
f_{jam}= 850 MHz; T_{amb} = 25 °C; f = 1575 MHz.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

Fig 10. Noise figure as a function of jamming power; typical values



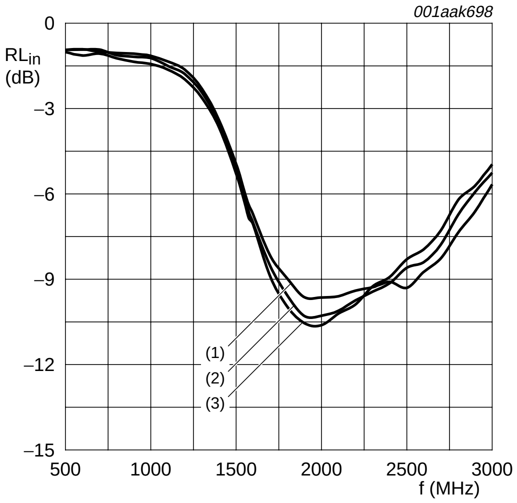
f_{jam}= 1850 MHz; T_{amb} = 25 °C; f = 1575 MHz.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

Fig 11. Noise figure as a function of jamming power; typical values



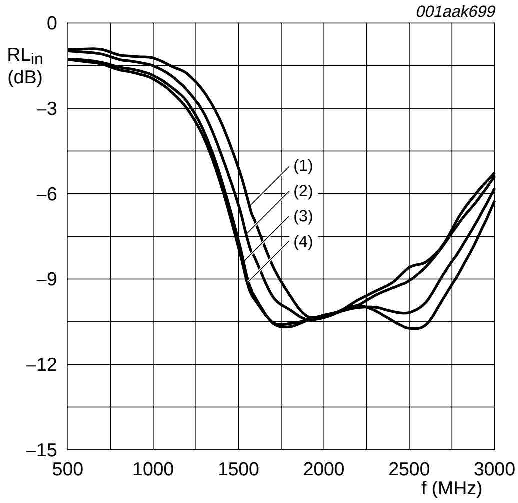
V_{CC} = 1.8 V; P_i = −45 dBm.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 12. Input return loss as a function of frequency; typical values



V_{CC} = 1.8 V; T_{amb} = 25 °C.

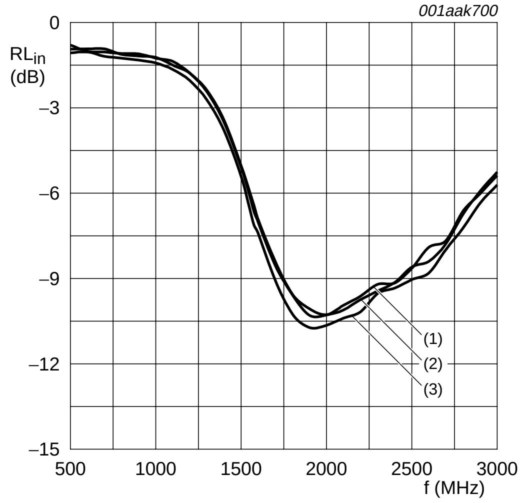
(1) P_i = −45 dBm

(2) P_i = −30 dBm

(3) P_i = −20 dBm

(4) P_i = −15 dBm

Fig 13. Input return loss as a function of frequency; typical values



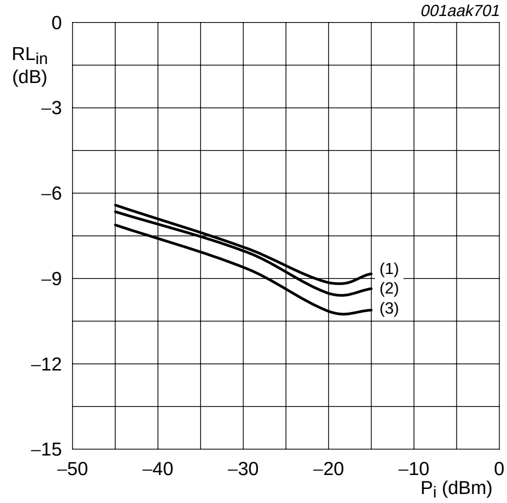
P_i = −45 dBm; T_{amb} = 25 °C.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

Fig 14. Input return loss as a function of frequency; typical values



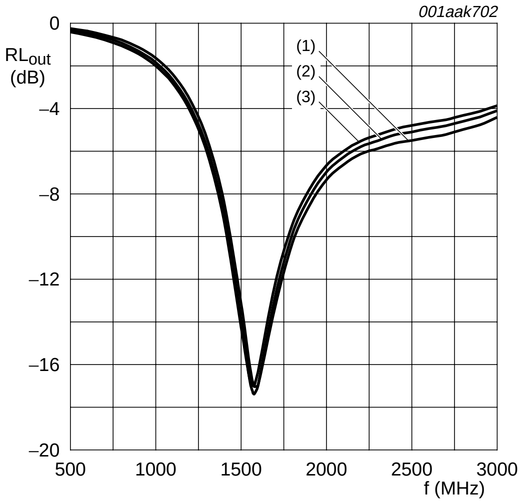
T_{amb} = 25 °C; f = 1575 MHz.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

Fig 15. Input return loss as a function of input power; typical values



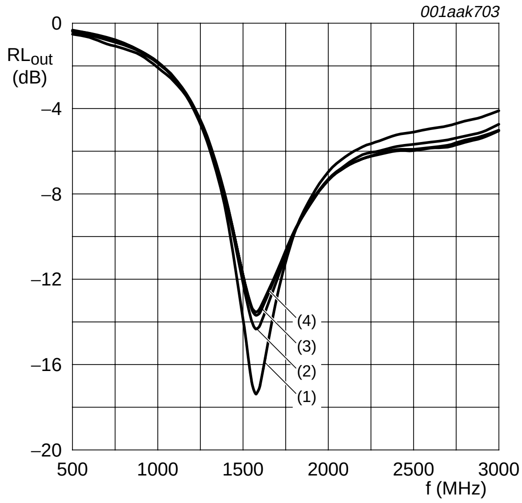
V_{CC} = 1.8 V; P_i = −45 dBm.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 16. Output return loss as a function of frequency; typical values



V_{CC} = 1.8 V; T_{amb} = 25 °C.

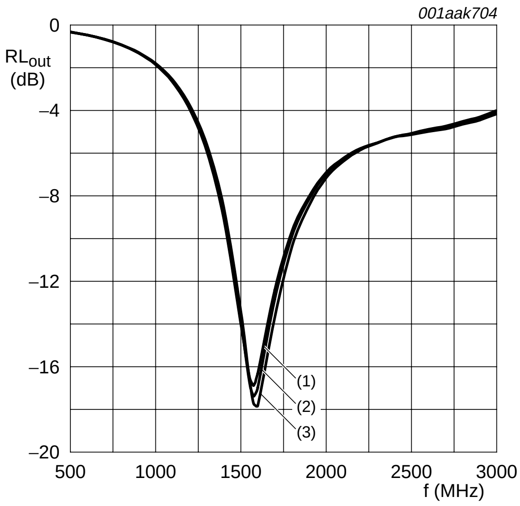
(1) P_i = −45 dBm

(2) P_i = −30 dBm

(3) P_i = −20 dBm

(4) P_i = −15 dBm

Fig 17. Output return loss as a function of frequency; typical values



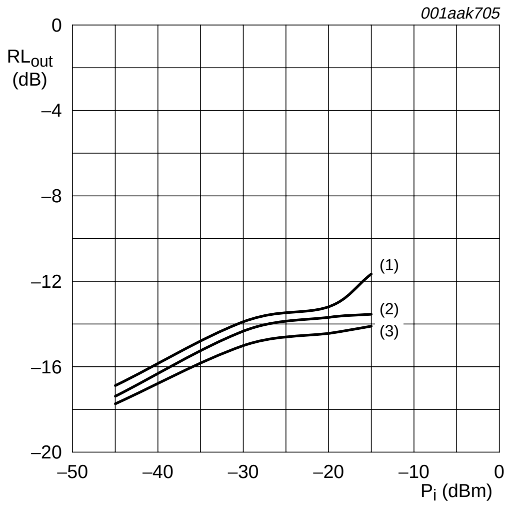
P_i = −45 dBm; T_{amb} = 25 °C.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

Fig 18. Output return loss as a function of frequency; typical values



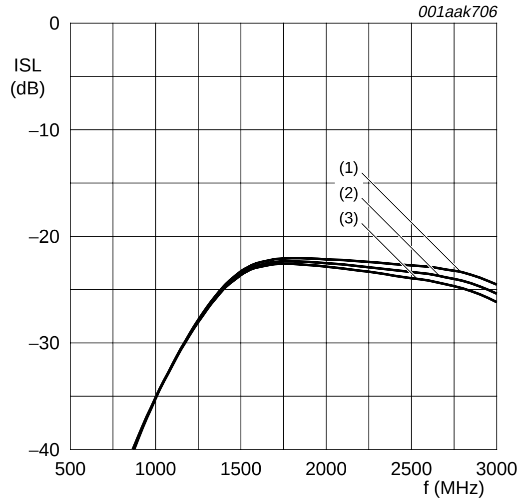
T_{amb} = 25 °C; f = 1575 MHz.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

Fig 19. Output return loss as a function of input power; typical values



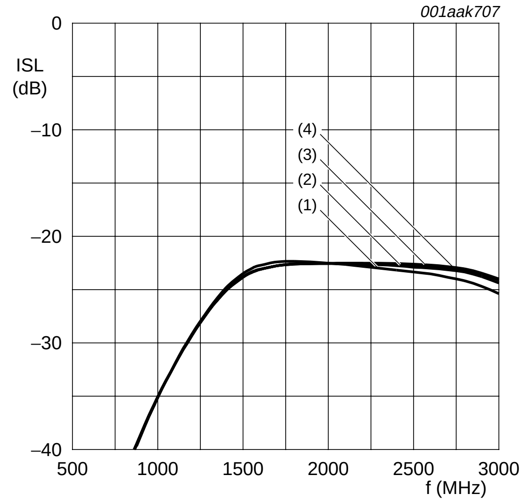
V_{CC} = 1.8 V; P_i = −45 dBm.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 20. Isolation as a function of frequency; typical values



V_{CC} = 1.8 V; T_{amb} = 25 °C.

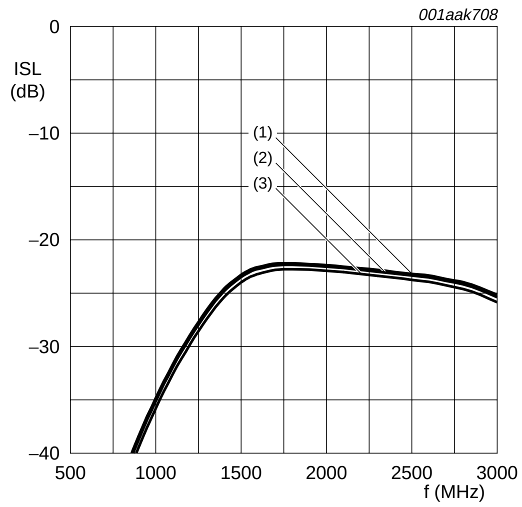
(1) P_i = −45 dBm

(2) P_i = −30 dBm

(3) P_i = −20 dBm

(4) P_i = −15 dBm

Fig 21. Isolation as a function of frequency; typical values



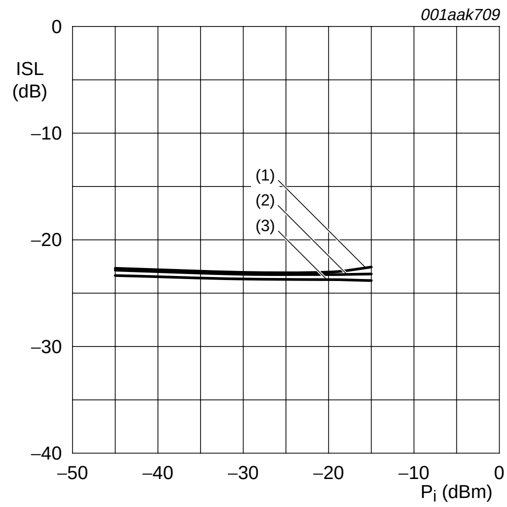
P_i = −45 dBm; T_{amb} = 25 °C.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

Fig 22. Isolation as a function of frequency; typical values



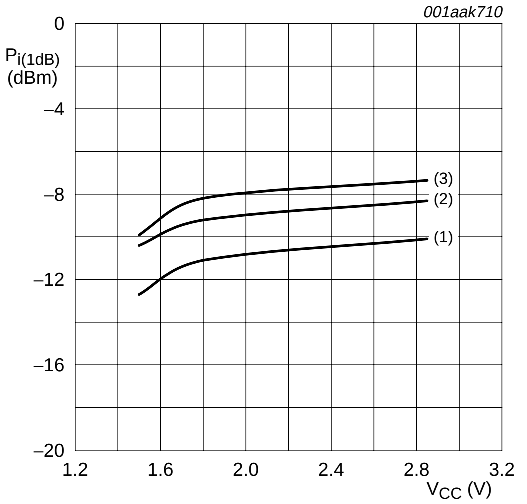
T_{amb} = 25 °C; f = 1575 MHz.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

Fig 23. Isolation as a function of input power; typical values



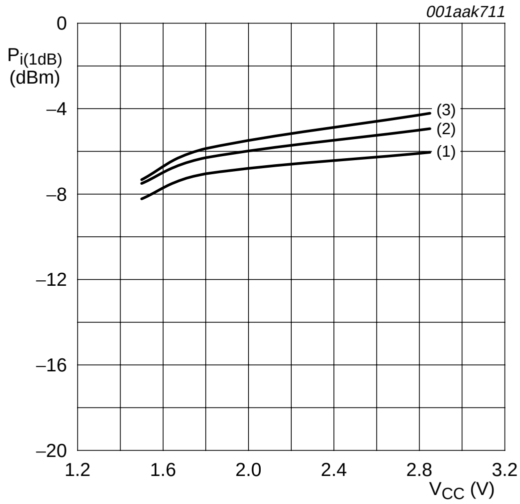
f = 850 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 24. Input power at 1 dB gain compression as a function of supply voltage; typical values



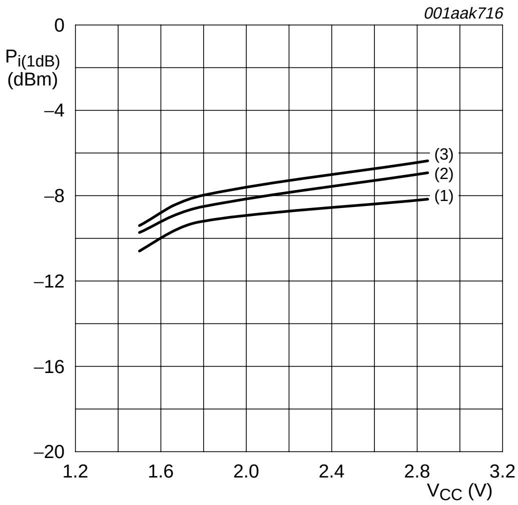
f = 1850 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 25. Input power at 1 dB gain compression as a function of supply voltage; typical values



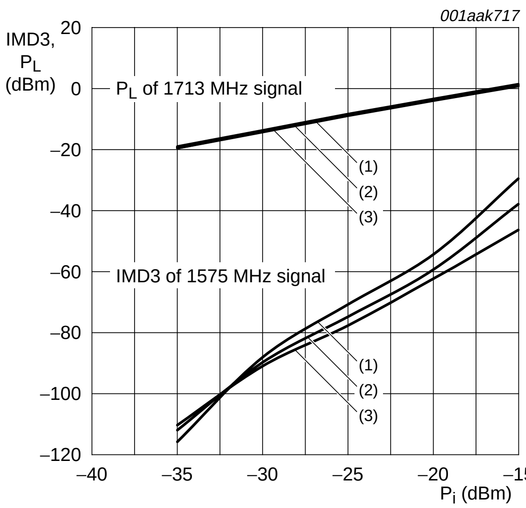
f = 1575 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 26. Input power at 1 dB gain compression as a function of supply voltage; typical values



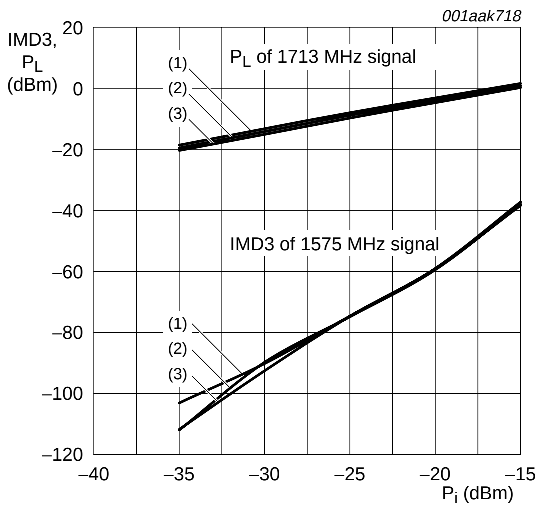
f = 1575 MHz; f_1 = 1713 MHz; f_2 = 1851 MHz; T_{amb} = 25 °C.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

Fig 27. Third order intermodulation distortion and output power as function of input power; typical values



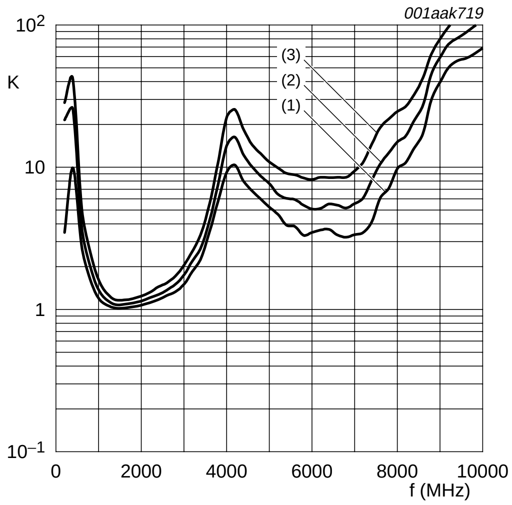
f = 1575 MHz; f_1 = 1713 MHz; f_2 = 1851 MHz; V_{CC} = 1.8 V.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 28. Third order intermodulation distortion and output power as function of input power; typical values



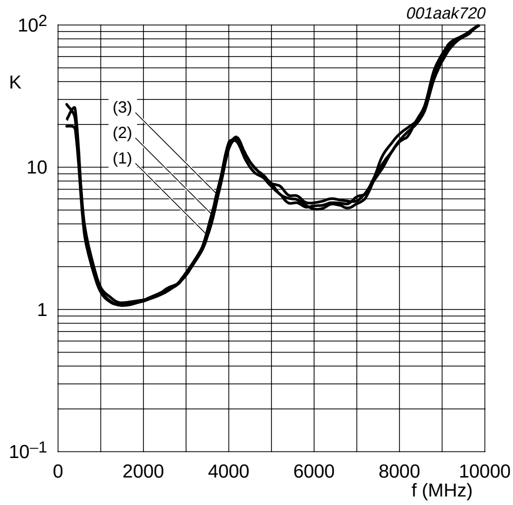
T_{amb} = 25 °C; P_i = –45 dBm.

(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

Fig 29. Rollett stability factor as a function of frequency; typical values



V_{CC} = 1.8 V; P_i = –45 dBm.

(1) T_{amb} = –40 °C

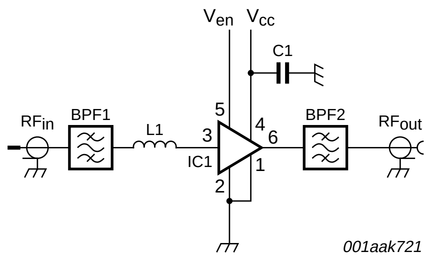
(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 30. Rollett stability factor as a function of frequency; typical values

8.2 GPS front-end

The GPS LNA is typically used in a GPS front-end. A GPS front-end application circuit and its characteristics is provided here.



For a list of components see Table 10.

Fig 31. Schematics GPS front-end evaluation board

Table 10. List of components

For schematics see Figure 31.

Component	Description	Value	Supplier	Remarks
BPF1, BPF2	GPS SAW filter	-	Murata SAFEA1G57KE0F00	Alternatives from Epcos: • B9444 Alternatives from Murata: • SAFEA1G57KH0F00 • SAFEA1G57KB0F00 Alternatives from Fujitsu: • FAR-F6KA-1G5754-L4AA • FAR-F6KA-1G5754-L4AJ
C1	decoupling capacitor	1 nF	Various	
IC1	BGU7005	-	NXP	
L1	high quality matching inductor	5.6 nH	Murata LQW15A	

8.3 Characteristics GPS front-end

Table 11. Characteristics GPS front-end

f = 1575 MHz; V_{CC} = 1.8 V; V_{ENABLE} >= 0.8 V; power at LNA input P_i < –40 dBm; T_{amb} = 25 °C; input and output matched to 50 Ω; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{CC}	supply voltage	RF input AC coupled		1.5	-	2.85	V
I_{CC}	supply current			-	4.5	-	mA
T_{amb}	ambient temperature			–40	+25	+85	°C
G_p	power gain	power at LNA input P_i < –40 dBm	[1]	-	14.5	-	dB
		power at LNA input P_i = –20 dBm	[1]	-	15.5	-	dB
RL_{in}	input return loss	power at LNA input P_i < –40 dBm	[1]	-	8.5	-	dB
		power at LNA input P_i = –20 dBm	[1]	-	10.5	-	dB
RL_{out}	output return loss	power at LNA input P_i < –40 dBm	[1]	-	14.5	-	dB
		power at LNA input P_i = –20 dBm	[1]	-	12.5	-	dB
NF	noise figure	power at LNA input P_i < –40 dBm	[1]	-	1.8	-	dB
		power at LNA input P_i = –20 dBm	[1]	-	1.9	-	dB
$P_{i(1dB)}$	input power at 1 dB gain compression	f = 1575 MHz			–8.2		dBm
		f = 806 MHz to 928 MHz	[2]		31		dBm
		f = 1612 MHz to 1909 MHz	[2]		40		dBm
$IP3_i$	input third-order intercept point		[3]		64		dBm
α	attenuation	f = 850 MHz	[4]	95	-	-	dBc
		f = 1850 MHz	[4]	90	-	-	dBc
t_{on}	turn-on time		[5]	-	-	2	µs
t_{off}	turn-off time		[5]	-	-	1	µs

[1] Power at GPS front-end input = power at LNA input + attenuation BPF1.

[2] Out of band.

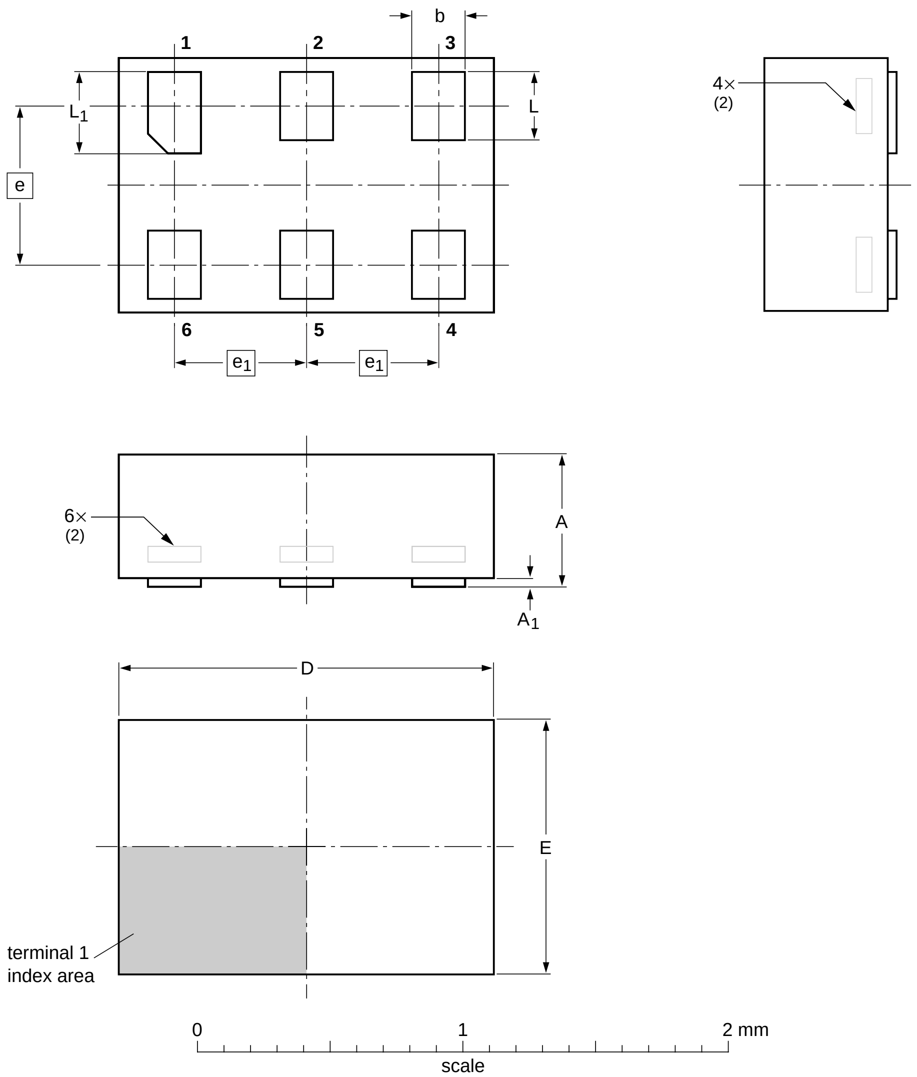
[3] f_1 = 1713 MHz; f_2 = 1851 MHz.

[4] Relative to f = 1575 MHz.

[5] Within 10 % of the final gain.

9. Package outline

XSON6: plastic extremely thin small outline package; no leads; 6 terminals; body 1 x 1.45 x 0.5 mm **SOT886**



DIMENSIONS (mm are the original dimensions)

UNIT	A(1) max	A_1 max	b	D	E	e	e_1	L	L_1
mm	0.5	0.04	0.25 0.17	1.5 1.4	1.05 0.95	0.6	0.5	0.35 0.27	0.40 0.32

Notes

1. Including plating thickness.
2. Can be visible in some manufacturing processes.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT886		MO-252				~~04-07-15~~ 04-07-22

Fig 32. Package outline SOT886 (XSON6)

10. Abbreviations

Table 12. Abbreviations

Acronym	Description
AC	Alternating Current
FM	Frequency Modulation
GPS	Global Positioning System
HBM	Human Body Model
LNA	Low Noise Amplifier
MMIC	Monolithic Microwave Integrated Circuit
PDA	Personal Digital Assistant
RF	Radio Frequency
SAW	Surface Acoustic Wave
SiGe:C	Silicon Germanium Carbon

11. Revision history

Table 13. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
BGU7005_1	20091028	Preliminary data sheet	-	-

12. Legal information

12.1 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".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

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14. Contents

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