



# BGU8006

SiGe:C Low Noise Amplifier MMIC for GPS, GLONASS, Galileo and Compass

Rev. 3 — 17 November 2016

Product data sheet

## 1. Product profile

### 1.1 General description

The BGU8006 is a Low Noise Amplifier (LNA) for GNSS receiver applications. It comes as extremely small and thin Wafer Level Chip Scale Package (WLCSP). The BGU8006 requires one external matching inductor and one external decoupling capacitor.

The BGU8006 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 17.2 dB gain at a noise figure of 0.60 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 and benefits

- Covers full GNSS L1 band, from 1559 MHz to 1610 MHz
- Noise figure (NF) = 0.60 dB
- Gain 17.2 dB
- High input 1 dB compression point of  $-7.5$  dBm
- High out of band  $IP3_i$  of 6 dBm
- Supply voltage 1.5 V to 3.1 V
- Optimized performance at very low 3.6 mA supply current
- Power-down mode current consumption  $< 1$   $\mu$ A
- Integrated temperature stabilized bias for easy design
- Requires only one input matching inductor and one supply decoupling capacitor
- Input and output DC decoupled
- ESD protection on all pins (HBM  $> 2$  kV)
- Integrated matching for the output
- Extremely small Wafer Level Chip Scale Package (WLCSP)  $0.65 \times 0.44 \times 0.2$  mm; 6 solder bumps; 0.22 mm bump pitch
- 180 GHz transit frequency - SiGe:C technology



### 1.3 Applications

- LNA for GPS, GLONASS, Galileo and Compass (BeiDou) in smart phones, feature phones, tablet, digital still cameras, digital video cameras, RF front-end modules, complete GNSS modules and personal health applications.

### 1.4 Quick reference data

**Table 1. Quick reference data**

$f = 1575$  MHz;  $V_{CC} = 2.85$  V;  $P_i < -40$  dBm;  $T_{amb} = 25$  °C; input matched to  $50 \Omega$  using a  $5.6$  nH inductor, see [Figure 2](#); unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{CC}$	supply voltage		1.5	-	3.1	V
$I_{CC}$	supply current	$V_{I(ENABLE)} \geq 0.8$ V				
		$P_i < -40$ dBm	-	3.6	-	mA
		$P_i = -20$ dBm	-	8.4	-	mA
$G_p$	power gain	$P_i < -40$ dBm	-	17.2	-	dB
		$P_i = -20$ dBm	-	19.0	-	dB
NF	noise figure	$P_i < -40$ dBm	[1]	-	0.60	dB
		$P_i < -40$ dBm	[2]	-	0.65	dB
$P_{i(1dB)}$	input power at 1 dB gain compression	$f = 1575$ MHz	-	-7.5	-	dBm
$IP3_i$	input third-order intercept point	$f = 1575$ MHz	[3]	-	6	dBm

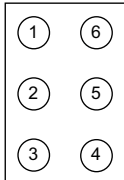
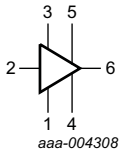
[1] PCB losses are subtracted.

[2] Including PCB losses.

[3]  $f_1 = 1713$  MHz;  $f_2 = 1851$  MHz;  $P_i = -20$  dBm per carrier.

## 2. Pinning information

**Table 2. Pinning**

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

Bump side view

## 3. Ordering information

**Table 3. Ordering information**

Type number	Package		
	Name	Description	Version
BGU8006	WLCSP6	extremely small wafer level chip scale package; 6 solder bumps; 0.22 mm bump pitch; body $0.65 \times 0.44 \times 0.2$ mm	WLCSP6
OM7829	EVB	BGU8006 evaluation board	

## 4. Marking

**Table 4. Marking codes**

Type number	Marking code
BGU8006	single character, indicating assembly month. <sup>[1]</sup>

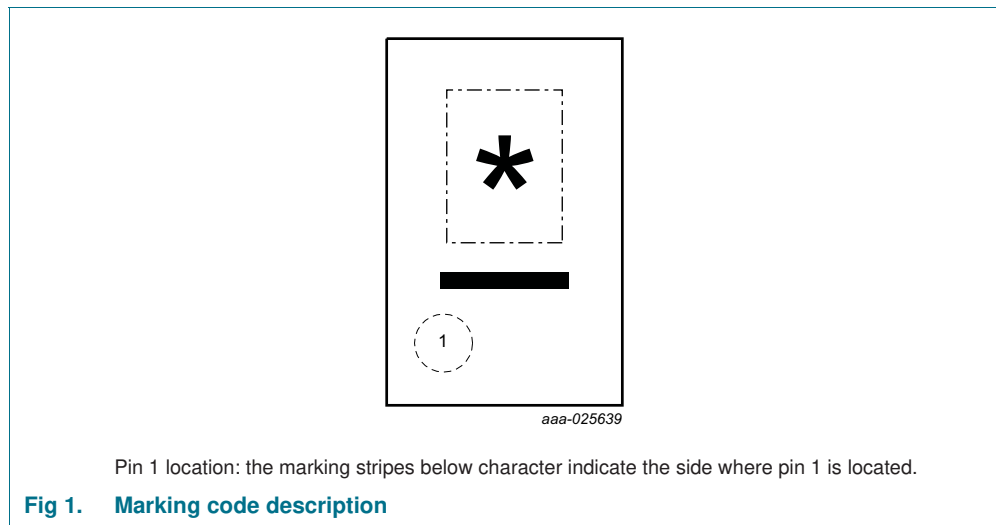
[1] Month code see [Table 5](#).

**Table 5. Calendar marking month code**

1 indicates pin 1.

Year	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
2015	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	<u>H</u>	<u>I</u>	<u>J</u>	<u>K</u>	<u>L</u>
2016	<u>M</u>	<u>N</u>	<u>O</u>	<u>P</u>	<u>Q</u>	<u>R</u>	<u>S</u>	<u>T</u>	<u>U</u>	<u>V</u>	<u>W</u>	<u>X</u>
2017	<u>Y</u>	<u>Z</u>	<u>b</u>	<u>d</u>	<u>f</u>	<u>h</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>9</u>

[1] Rotates every 3 years.



**Fig 1. Marking code description**

## 5. Limiting values

**Table 6. Limiting values**

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

Absolute Maximum Ratings are given as Limiting Values of stress conditions during operation, that must not be exceeded under the worst probable conditions.

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{CC}$	supply voltage		<sup>[1]</sup> -0.5	+5.0	V
$V_{I(ENABLE)}$	input voltage on pin ENABLE	$V_{I(ENABLE)} < V_{CC} + 0.6$ V	<sup>[1][2]</sup> -0.5	+5.0	V
$V_{I(RF\_IN)}$	input voltage on pin RF_IN	DC, $V_{I(RF\_IN)} < V_{CC} + 0.6$ V	<sup>[1][2][3]</sup> -0.5	+5.0	V
$V_{I(RF\_OUT)}$	input voltage on pin RF_OUT	DC, $V_{I(RF\_OUT)} < V_{CC} + 0.6$ V	<sup>[1][2][3]</sup> -0.5	+5.0	V
$P_i$	input power	1575 MHz	<sup>[1]</sup> -	10	dBm

**Table 6. Limiting values ...continued**

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

Absolute Maximum Ratings are given as Limiting Values of stress conditions during operation, that must not be exceeded under the worst probable conditions.

Symbol	Parameter	Conditions	Min	Max	Unit
$T_{stg}$	storage temperature		-65	+150	°C
$T_j$	junction temperature		-	150	°C
$V_{ESD}$	electrostatic discharge voltage	Human Body Model (HBM) According to JEDEC standard 22-A114E	-	$\pm 2$	kV
		Charged Device Model (CDM) According to JEDEC standard 22-C101B	-	$\pm 2$	kV

- [1] Stressed with pulses of 200 ms in duration, with application circuit as in [Figure 2](#).
- [2] Warning: due to internal ESD diode protection, the applied DC voltage should not exceed  $V_{CC} + 0.6$  V and shall not exceed 5.0 V in order to avoid excess current.
- [3] The RF input and RF output are AC coupled through internal DC blocking capacitors.

## 6. Recommended operating conditions

**Table 7. Operating conditions**

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{CC}$	supply voltage		1.5	-	3.1	V
$T_{amb}$	ambient temperature		-40	+25	+85	°C
$V_{I(ENABLE)}$	input voltage on pin ENABLE	OFF state	-	-	0.35	V
		ON state	0.8	-	-	V

## 7. Thermal characteristics

**Table 8. Thermal characteristics**

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-sp)}$	thermal resistance from junction to solder point		217	K/W

## 8. Characteristics

**Table 9. Characteristics at  $V_{CC} = 1.8$  V**

$f = 1575$  MHz;  $V_{CC} = 1.8$  V;  $V_{I(ENABLE)} \geq 0.8$  V;  $P_i < -40$  dBm;  $T_{amb} = 25$  °C; input matched to  $50 \Omega$  using a  $5.6$  nH inductor, see [Figure 2](#); unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$I_{CC}$	supply current	$V_{I(ENABLE)} \geq 0.8$ V				
		$P_i < -40$ dBm	-	3.5	-	mA
		$P_i = -20$ dBm	-	8	-	mA
		$V_{I(ENABLE)} \leq 0.35$ V	-	-	1	$\mu$ A
$G_p$	power gain	no jammer	-	17.0	-	dB
		$P_{jam} = -20$ dBm; $f_{jam} = 850$ MHz	-	17.5	-	dB
		$P_{jam} = -20$ dBm; $f_{jam} = 1850$ MHz	-	19.0	-	dB

**Table 9. Characteristics at  $V_{CC} = 1.8\text{ V}$  ...continued**

$f = 1575\text{ MHz}$ ;  $V_{CC} = 1.8\text{ V}$ ;  $V_{I(ENABLE)} \geq 0.8\text{ V}$ ;  $P_i < -40\text{ dBm}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ ; input matched to  $50\text{ }\Omega$  using a  $5.6\text{ nH}$  inductor, see [Figure 2](#); unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
RL <sub>in</sub>	input return loss	$P_i < -40\text{ dBm}$	-	9	-	dB	
		$P_i = -20\text{ dBm}$	-	14	-	dB	
RL <sub>out</sub>	output return loss	$P_i < -40\text{ dBm}$	-	13	-	dB	
		$P_i = -20\text{ dBm}$	-	11	-	dB	
ISL	isolation		-	27	-	dB	
NF	noise figure	$P_i = -40\text{ dBm}$ , no jammer	[1]	-	0.60	-	dB
		$P_i = -40\text{ dBm}$ , no jammer	[2]	-	0.65	-	dB
		$P_{jam} = -20\text{ dBm}$ ; $f_{jam} = 850\text{ MHz}$	[2]	-	0.7	-	dB
		$P_{jam} = -20\text{ dBm}$ ; $f_{jam} = 1850\text{ MHz}$	[2]	-	0.9	-	dB
P <sub>i(1dB)</sub>	input power at 1 dB gain compression		-	-11.2	-	dBm	
IP3 <sub>i</sub>	input third-order intercept point	$f = 1.575\text{ GHz}$	[3]	-	0	-	dBm
t <sub>on</sub>	turn-on time	time from $V_{I(ENABLE)}$ ON, to 90 % of the gain	-	-	2	$\mu\text{s}$	
t <sub>off</sub>	turn-off time	time from $V_{I(ENABLE)}$ OFF, to 10 % of the gain	-	-	1	$\mu\text{s}$	

[1] PCB losses are subtracted

[2] Including PCB losses

[3]  $f_1 = 1713\text{ MHz}$ ;  $f_2 = 1851\text{ MHz}$ ,  $P_i = -20\text{ dBm}$  per carrier.

**Table 10. Characteristics at  $V_{CC} = 2.85\text{ V}$** 

$f = 1575\text{ MHz}$ ;  $V_{CC} = 2.85\text{ V}$ ;  $V_{I(ENABLE)} \geq 0.8\text{ V}$ ;  $P_i < -40\text{ dBm}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ ; input matched to  $50\text{ }\Omega$  using a  $5.6\text{ nH}$  inductor, see [Figure 2](#); unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
I <sub>CC</sub>	supply current	$V_{I(ENABLE)} \geq 0.8\text{ V}$					
		$P_i < -40\text{ dBm}$	-	3.6	-	mA	
		$P_i = -20\text{ dBm}$	-	8.4	-	mA	
		$V_{I(ENABLE)} \leq 0.35\text{ V}$	-	-	1	$\mu\text{A}$	
G <sub>p</sub>	power gain	no jammer	-	17.2	-	dB	
		$P_{jam} = -20\text{ dBm}$ ; $f_{jam} = 850\text{ MHz}$	-	18.0	-	dB	
		$P_{jam} = -20\text{ dBm}$ ; $f_{jam} = 1850\text{ MHz}$	-	19.0	-	dB	
RL <sub>in</sub>	input return loss	$P_i < -40\text{ dBm}$	-	9	-	dB	
		$P_i = -20\text{ dBm}$	-	15	-	dB	
RL <sub>out</sub>	output return loss	$P_i < -40\text{ dBm}$	-	13	-	dB	
		$P_i = -20\text{ dBm}$	-	11	-	dB	
ISL	isolation		-	27	-	dB	
NF	noise figure	$P_i = -40\text{ dBm}$ , no jammer	[1]	-	0.60	-	dB
		$P_i = -40\text{ dBm}$ , no jammer	[2]	-	0.65	-	dB
		$P_{jam} = -20\text{ dBm}$ ; $f_{jam} = 850\text{ MHz}$	[2]	-	0.65	-	dB
		$P_{jam} = -20\text{ dBm}$ ; $f_{jam} = 1850\text{ MHz}$	[2]	-	0.9	-	dB

**Table 10. Characteristics at  $V_{CC} = 2.85\text{ V}$  ...continued**

$f = 1575\text{ MHz}$ ;  $V_{CC} = 2.85\text{ V}$ ;  $V_{I(ENABLE)} \geq 0.8\text{ V}$ ;  $P_i < -40\text{ dBm}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ ; input matched to  $50\ \Omega$  using a  $5.6\text{ nH}$  inductor, see [Figure 2](#); unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$P_{i(1dB)}$	input power at 1 dB gain compression	$f = 1575\text{ MHz}$	-	-7.5	-	dBm
$IP3_i$	input third-order intercept point	$f = 1.575\text{ GHz}$	[3]	-	6	dBm
$t_{on}$	turn-on time	time from $V_{I(ENABLE)}$ ON, to 90 % of the gain	-	-	2	$\mu\text{s}$
$t_{off}$	turn-off time	time from $V_{I(ENABLE)}$ OFF, to 10 % of the gain	-	-	1	$\mu\text{s}$

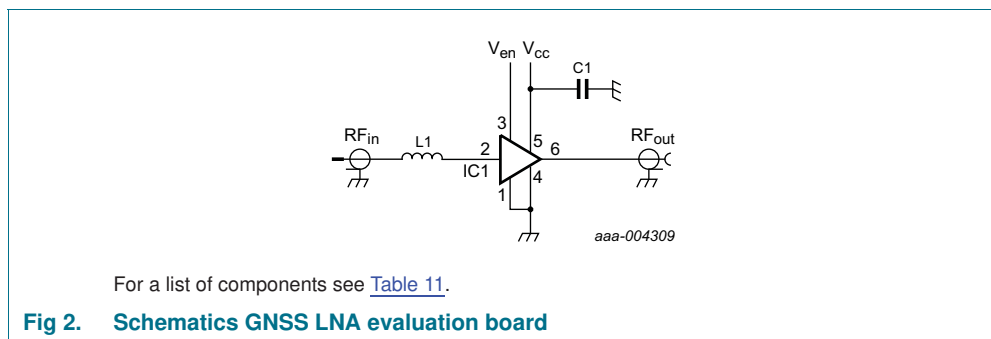
[1] PCB losses are subtracted

[2] Including PCB losses

[3]  $f_1 = 1713\text{ MHz}$ ;  $f_2 = 1851\text{ MHz}$ ,  $P_i = -20\text{ dBm}$  per carrier

## 9. Application information

### 9.1 GNSS LNA

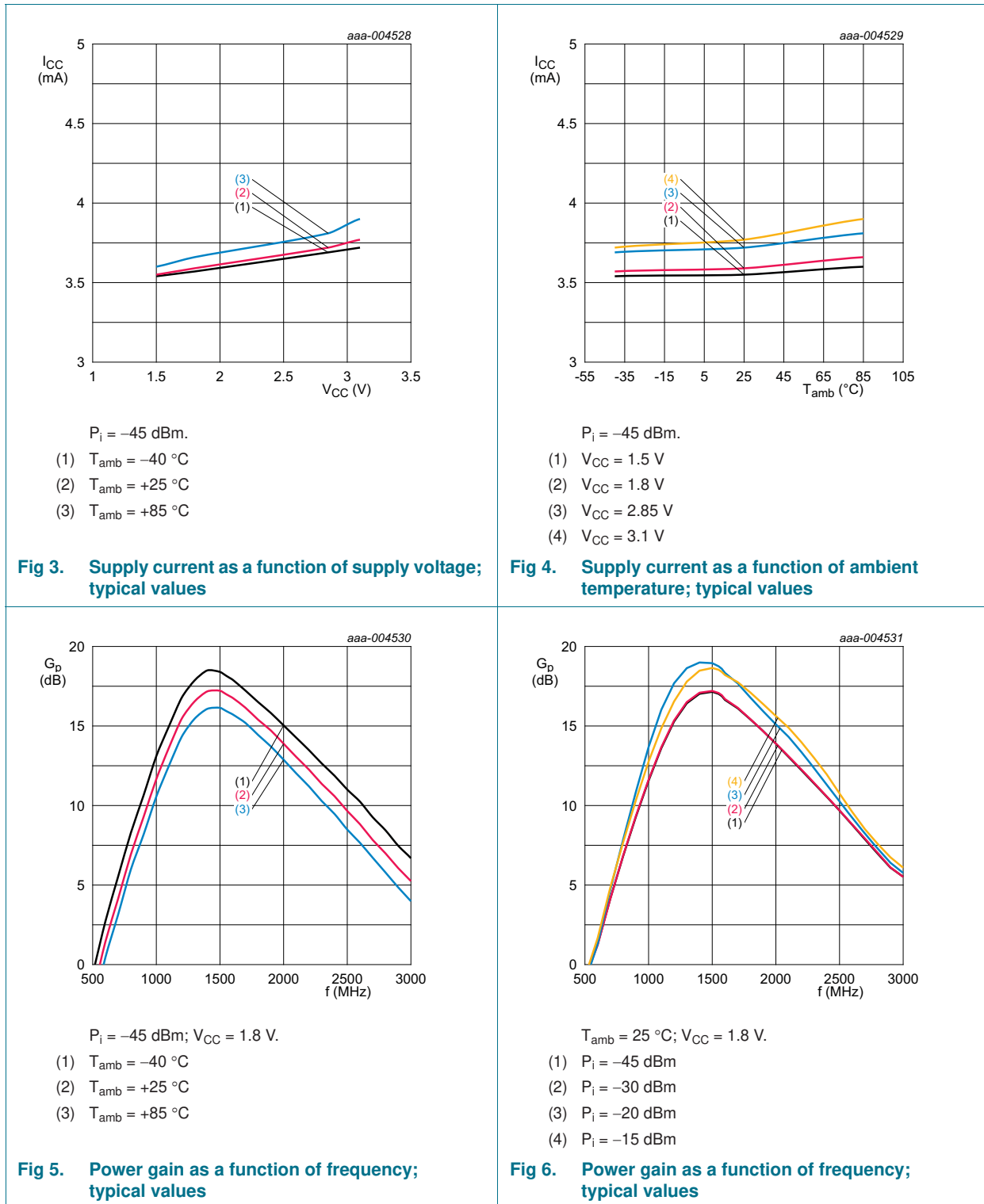


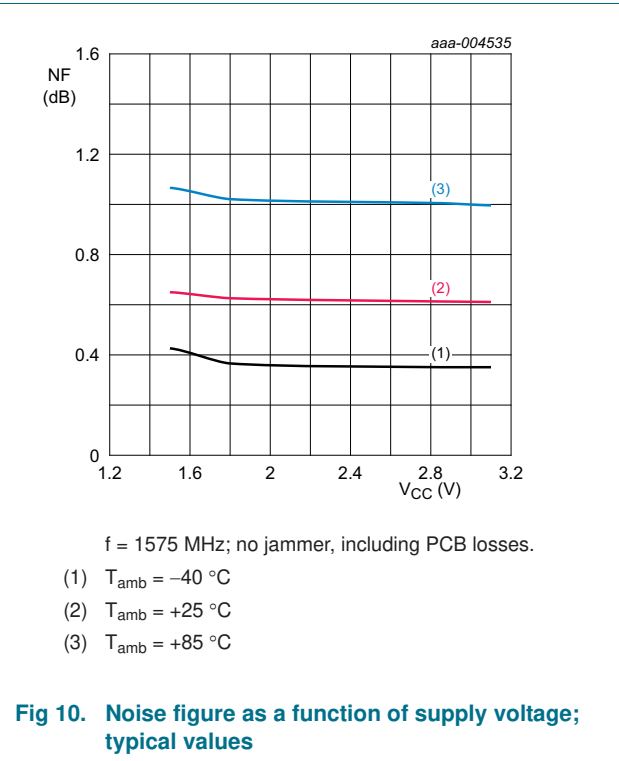
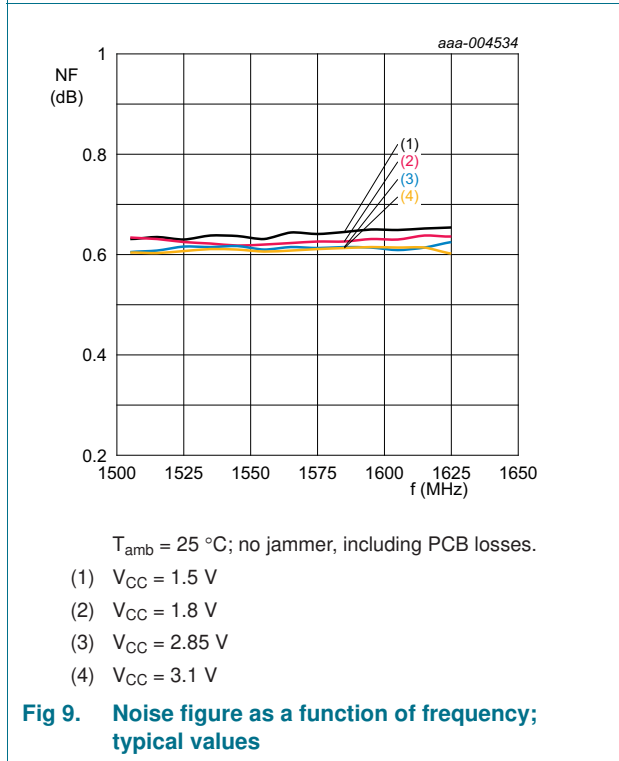
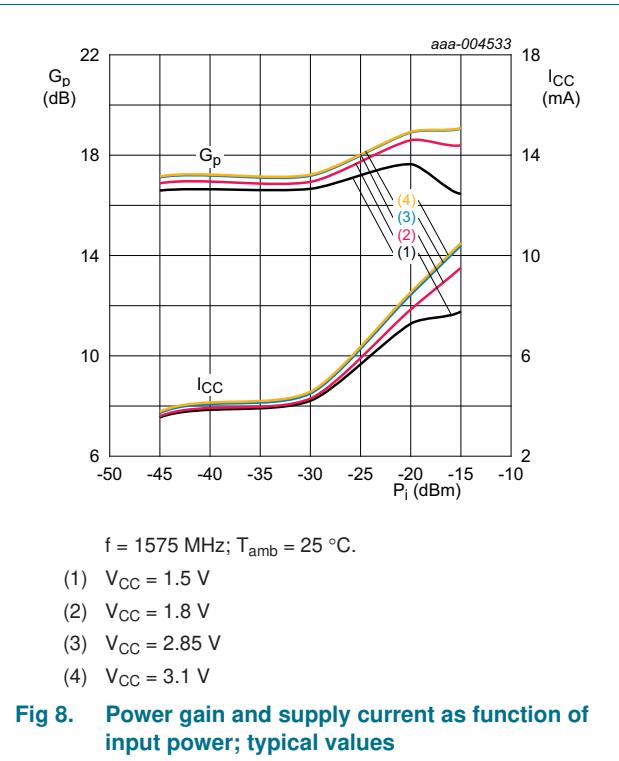
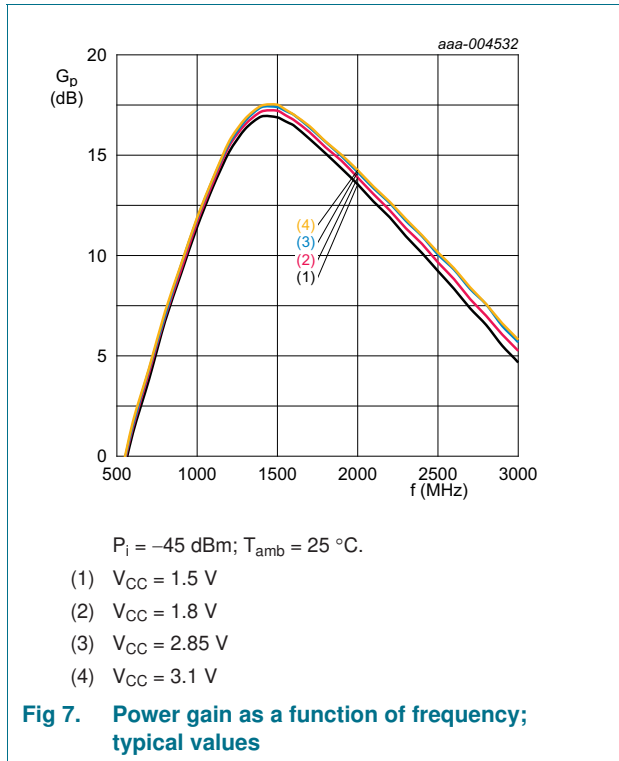
**Table 11. List of components**

For schematics see [Figure 2](#).

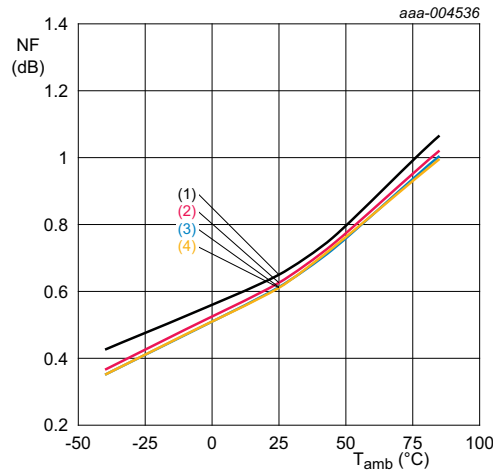
Component	Description	Value	Remarks
C1	decoupling capacitor	1 nF	
IC1	BGU8006	-	NXP
L1	high quality matching inductor	5.6 nH	Murata LQW15A

9.2 Graphs





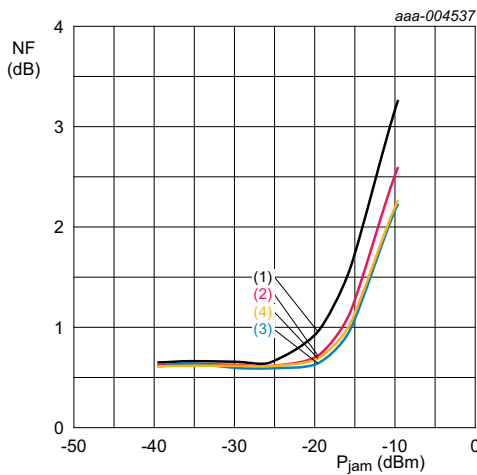




$f = 1575 \text{ MHz}$ ; no jammer, including PCB losses.

- (1)  $V_{CC} = 1.5 \text{ V}$
- (2)  $V_{CC} = 1.8 \text{ V}$
- (3)  $V_{CC} = 2.85 \text{ V}$
- (4)  $V_{CC} = 3.1 \text{ V}$

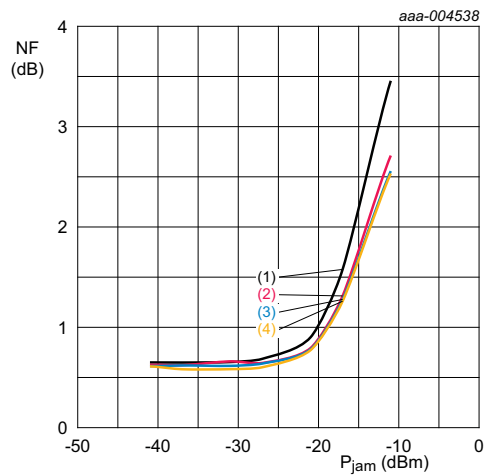
**Fig 11. Noise figure as a function of ambient temperature; typical values**



$f_{jam} = 850 \text{ MHz}$ ;  $T_{amb} = 25 \text{ °C}$ ;  $f = 1575 \text{ MHz}$ ; including PCB losses.

- (1)  $V_{CC} = 1.5 \text{ V}$
- (2)  $V_{CC} = 1.8 \text{ V}$
- (3)  $V_{CC} = 2.85 \text{ V}$
- (4)  $V_{CC} = 3.1 \text{ V}$

**Fig 12. Noise figure as a function of jamming power; typical values**



$f_{jam} = 1850 \text{ MHz}$ ;  $T_{amb} = 25 \text{ °C}$ ;  $f = 1575 \text{ MHz}$ ; including PCB losses.

- (1)  $V_{CC} = 1.5 \text{ V}$
- (2)  $V_{CC} = 1.8 \text{ V}$
- (3)  $V_{CC} = 2.85 \text{ V}$
- (4)  $V_{CC} = 3.1 \text{ V}$

**Fig 13. Noise figure as a function of jamming power; typical values**

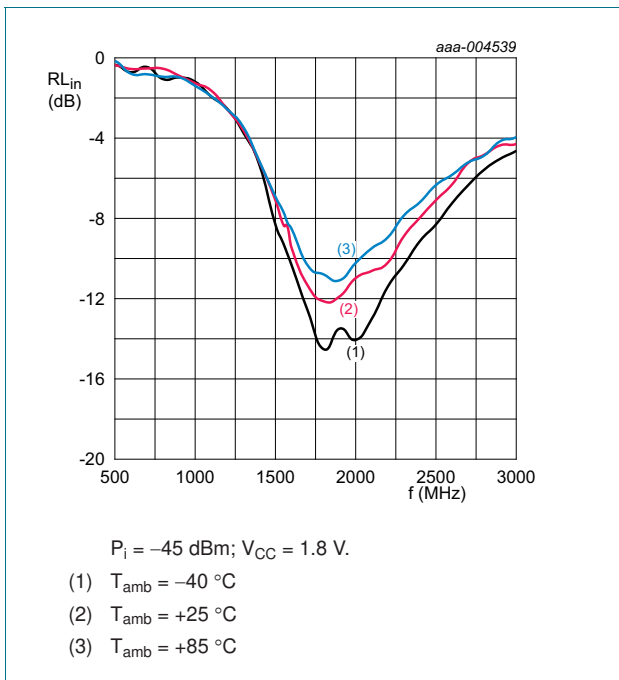


Fig 14. Input return loss as a function of frequency; typical values

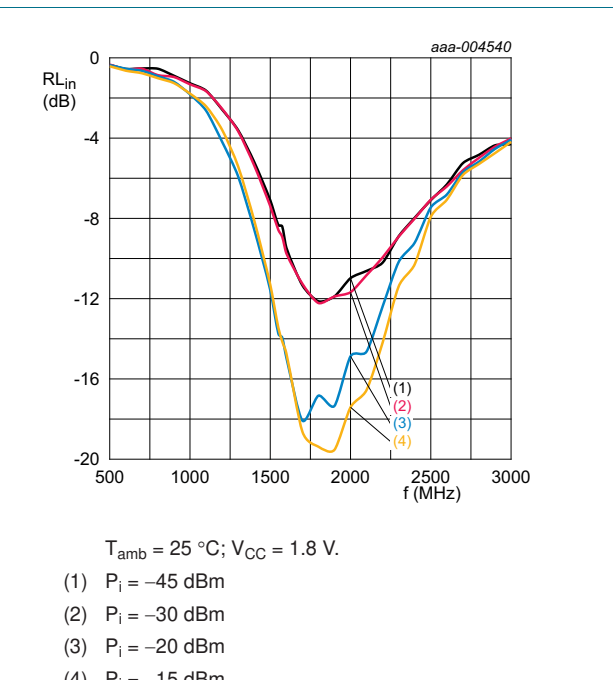


Fig 15. Input return loss as a function of frequency; typical values

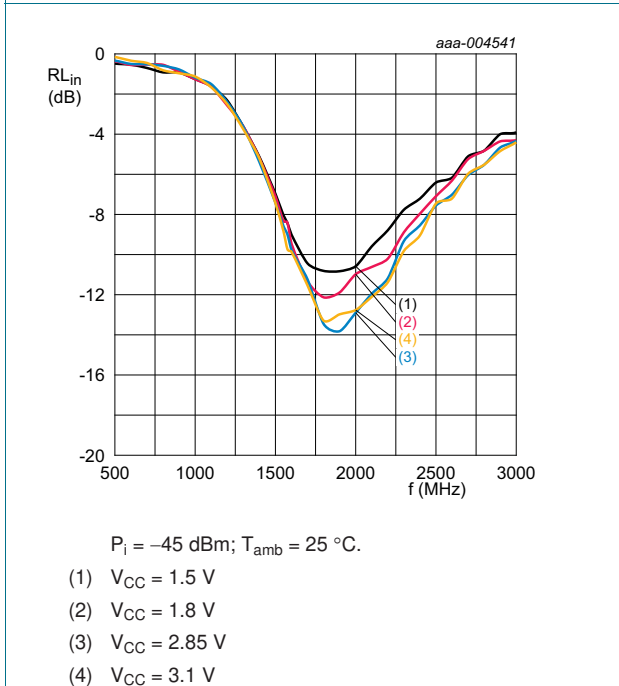


Fig 16. Input return loss as a function of frequency; typical values

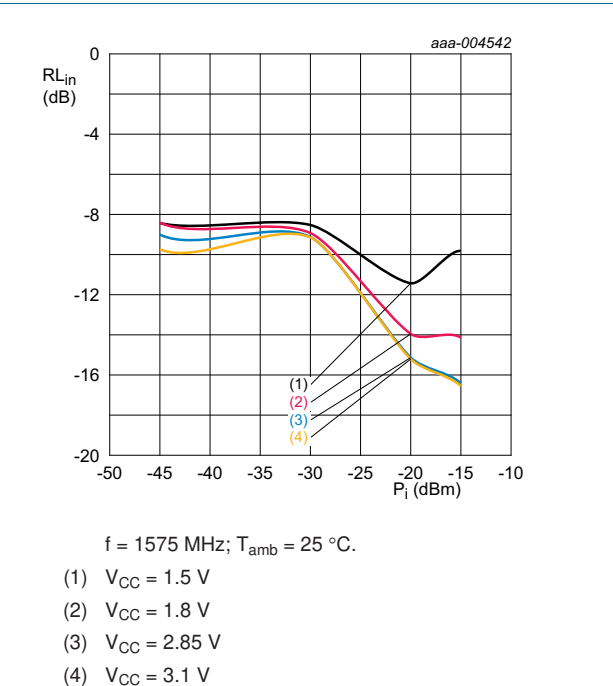


Fig 17. Input return loss as a function of input power; typical values

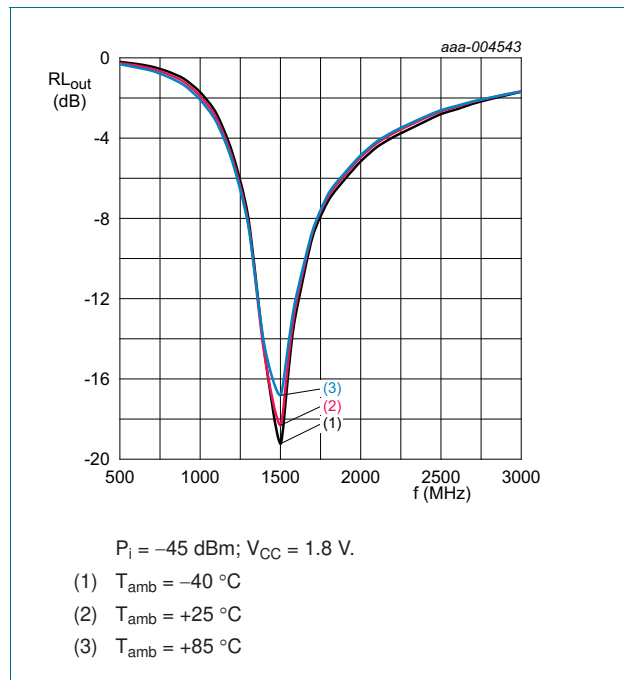


Fig 18. Output return loss as a function of frequency; typical values

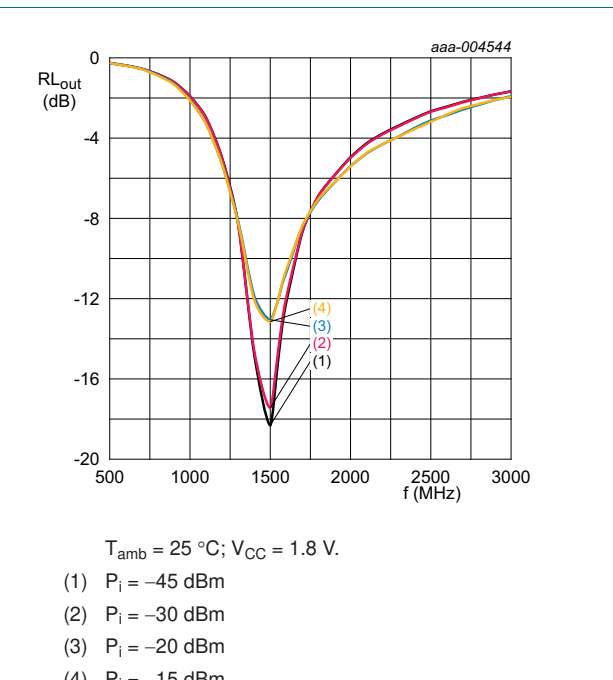


Fig 19. Output return loss as a function of frequency; typical values

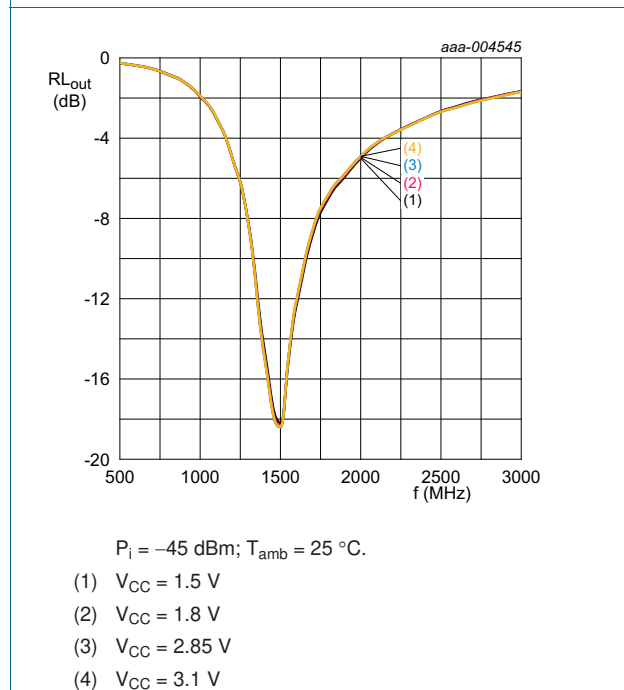


Fig 20. Output return loss as a function of frequency; typical values

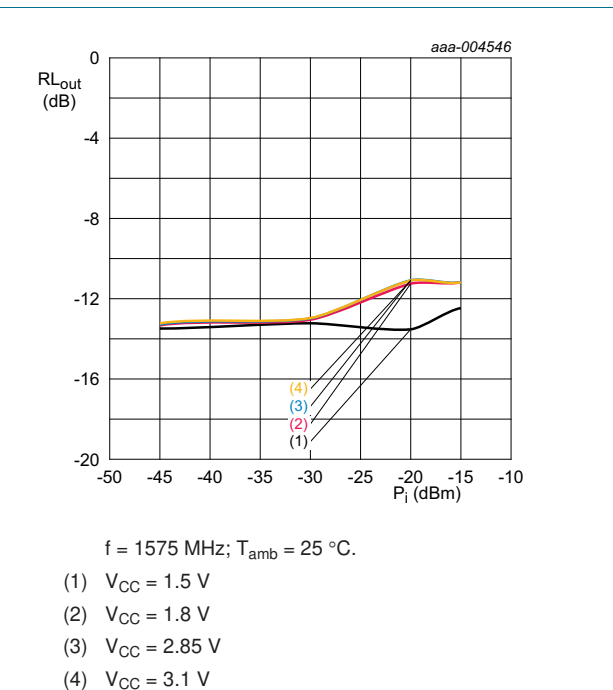
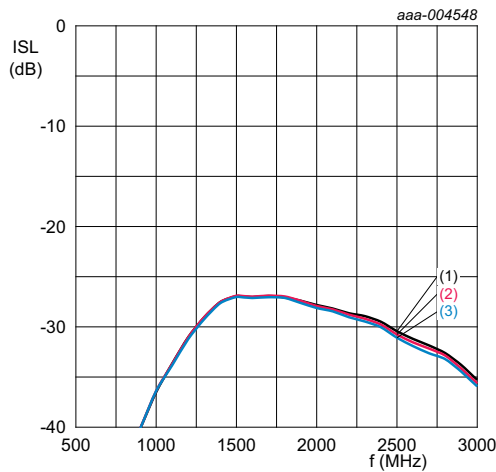
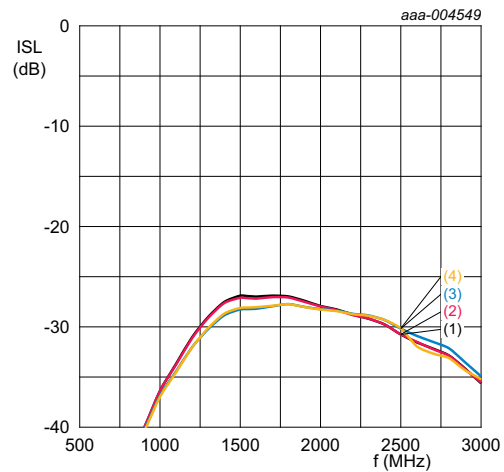


Fig 21. Output return loss as a function of input power; typical values



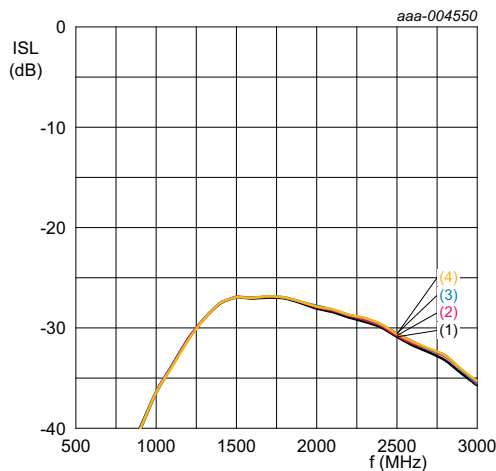
$P_i = -45 \text{ dBm}; V_{CC} = 1.8 \text{ V}.$   
 (1)  $T_{amb} = -40 \text{ }^\circ\text{C}$   
 (2)  $T_{amb} = +25 \text{ }^\circ\text{C}$   
 (3)  $T_{amb} = +85 \text{ }^\circ\text{C}$

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



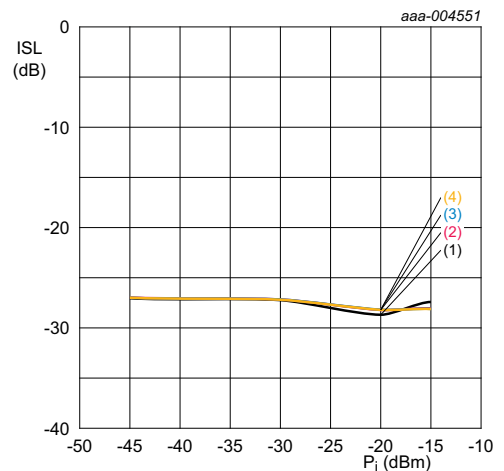
$T_{amb} = 25 \text{ }^\circ\text{C}; V_{CC} = 1.8 \text{ V}.$   
 (1)  $P_i = -45 \text{ dBm}$   
 (2)  $P_i = -30 \text{ dBm}$   
 (3)  $P_i = -20 \text{ dBm}$   
 (4)  $P_i = -15 \text{ dBm}$

**Fig 23. Isolation as a function of frequency; typical values**



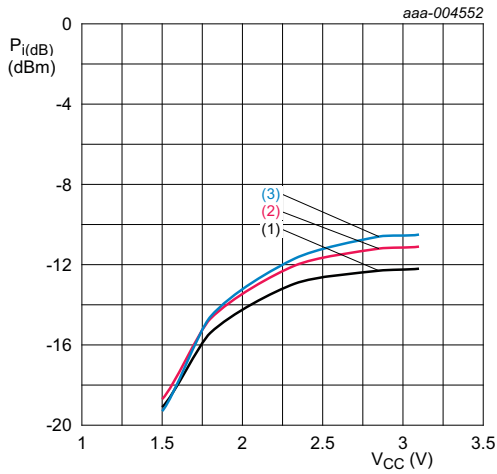
$P_i = -45 \text{ dBm}; T_{amb} = 25 \text{ }^\circ\text{C}.$   
 (1)  $V_{CC} = 1.5 \text{ V}$   
 (2)  $V_{CC} = 1.8 \text{ V}$   
 (3)  $V_{CC} = 2.85 \text{ V}$   
 (4)  $V_{CC} = 3.1 \text{ V}$

**Fig 24. Isolation as a function of frequency; typical values**



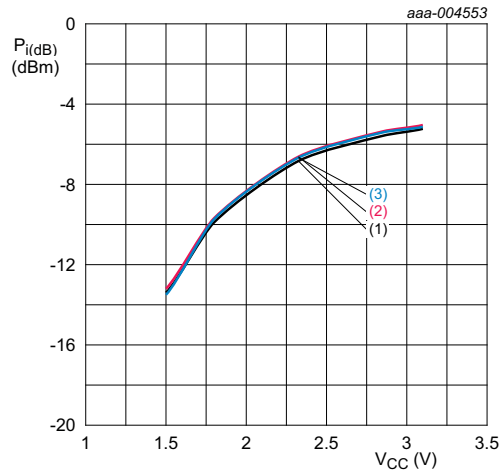
$f = 1575 \text{ MHz}; T_{amb} = 25 \text{ }^\circ\text{C}.$   
 (1)  $V_{CC} = 1.5 \text{ V}$   
 (2)  $V_{CC} = 1.8 \text{ V}$   
 (3)  $V_{CC} = 2.85 \text{ V}$   
 (4)  $V_{CC} = 3.1 \text{ V}$

**Fig 25. Isolation as a function of input power; typical values**



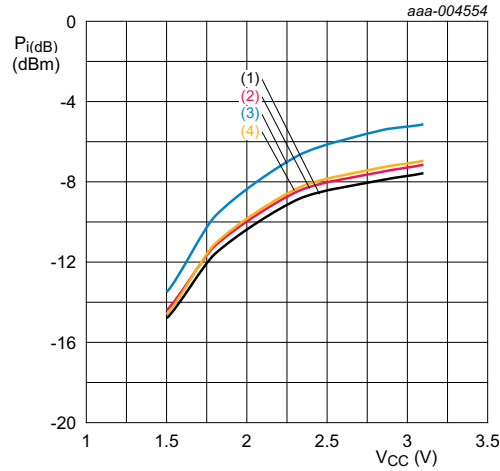
$f = 850$  MHz.  
 (1)  $T_{amb} = -40$  °C  
 (2)  $T_{amb} = +25$  °C  
 (3)  $T_{amb} = +85$  °C

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



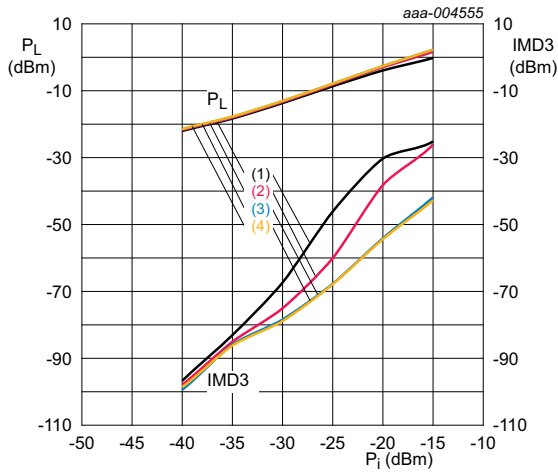
$f = 1850$  MHz.  
 (1)  $T_{amb} = -40$  °C  
 (2)  $T_{amb} = +25$  °C  
 (3)  $T_{amb} = +85$  °C

**Fig 27. 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

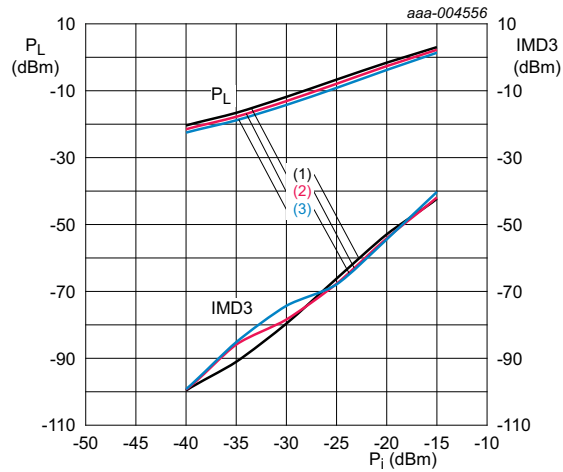
**Fig 28. Input power at 1 dB gain compression as a function of supply voltage; typical values**



$T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $f = 1575\text{ MHz}$ ;  $f_1 = 1713\text{ MHz}$ ;  
 $f_2 = 1851\text{ MHz}$ ;  $P_i$  per carrier.

- (1)  $V_{CC} = 1.5\text{ V}$
- (2)  $V_{CC} = 1.8\text{ V}$
- (3)  $V_{CC} = 2.85\text{ V}$
- (4)  $V_{CC} = 3.1\text{ V}$

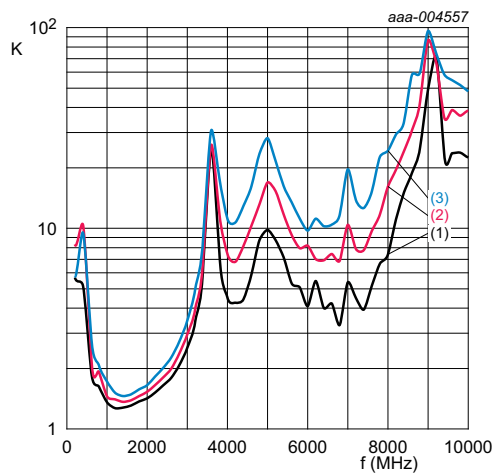
**Fig 29. Output power and third order intermodulation distortion as function of input power; typical values**



$V_{CC} = 2.85\text{ V}$ ;  $f = 1575\text{ MHz}$ ;  $f_1 = 1713\text{ MHz}$ ;  
 $f_2 = 1851\text{ MHz}$ ;  $P_i$  per carrier.

- (1)  $T_{amb} = -40\text{ }^{\circ}\text{C}$
- (2)  $T_{amb} = +25\text{ }^{\circ}\text{C}$
- (3)  $T_{amb} = +85\text{ }^{\circ}\text{C}$

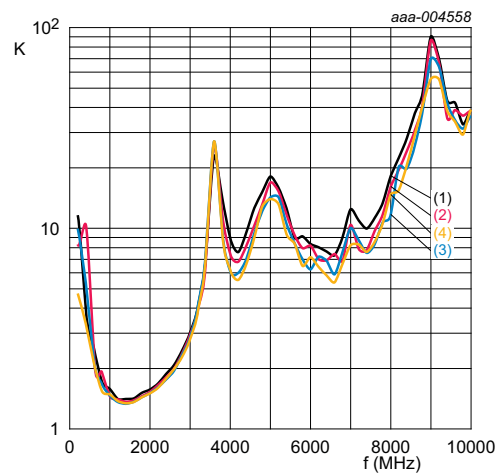
**Fig 30. Output power and third order intermodulation distortion as function of input power; typical values**



$V_{CC} = 1.8\text{ V}$ ;  $P_i = -45\text{ dBm}$ .

- (1)  $T_{amb} = -40\text{ }^{\circ}\text{C}$
- (2)  $T_{amb} = +25\text{ }^{\circ}\text{C}$
- (3)  $T_{amb} = +85\text{ }^{\circ}\text{C}$

**Fig 31. Rollett stability factor as a function of frequency; typical values**



$T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $P_i = -45\text{ dBm}$ .

- (1)  $V_{CC} = 1.5\text{ V}$
- (2)  $V_{CC} = 1.8\text{ V}$
- (3)  $V_{CC} = 2.85\text{ V}$
- (4)  $V_{CC} = 3.1\text{ V}$

**Fig 32. Rollett stability factor as a function of frequency; typical values**

### 10. Package outline

WLCSP6: wafer level chip-size package; 6 balls; 0.65 x 0.44 x 0.29 mm

BGU8006

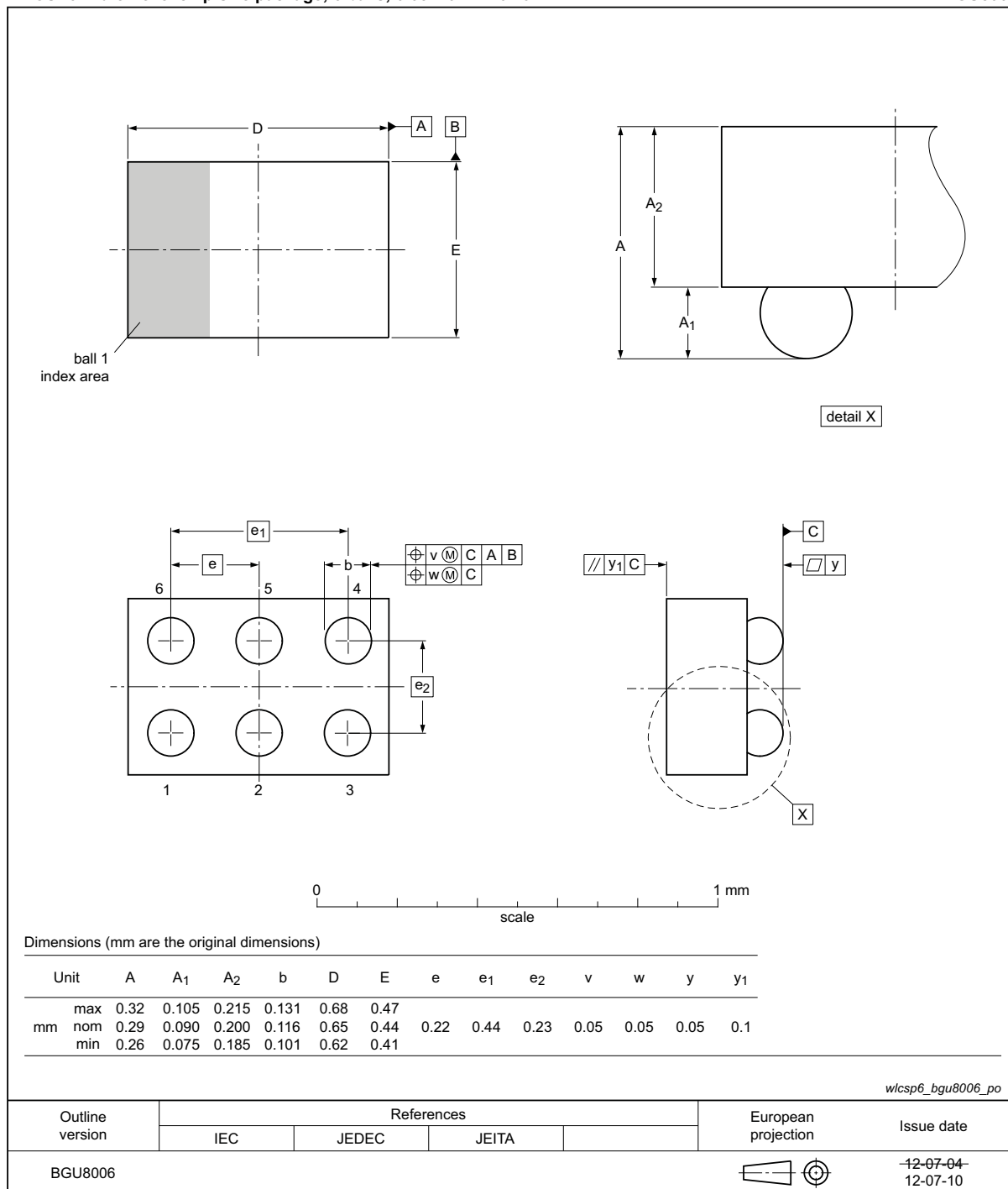


Fig 33. Package outline BGU8006 (WLCSP6)

## 11. Abbreviations

**Table 12. Abbreviations**

Acronym	Description
GLONASS	GLObal NAVigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HBM	Human Body Model
MMIC	Monolithic Microwave Integrated Circuit
PCB	Printed Circuit Board
SiGe:C	Silicon Germanium Carbon

## 12. Revision history

**Table 13. Revision history**

Document ID	Release date	Data sheet status	Change notice	Supersedes
BGU8006 v.3	20161117	Product data sheet	-	BGU8006 v.2
Modifications:	<ul style="list-style-type: none"> <li>• <a href="#">Table 5 on page 3</a>: several changes have been made.</li> <li>• <a href="#">Figure 1 on page 3</a>: figure has been added.</li> </ul>			
BGU8006 v.2	20121212	Product data sheet	-	BGU8006 v.1
Modifications:	<ul style="list-style-type: none"> <li>• <a href="#">Table 1 on page 2</a>: several changes have been made.</li> <li>• <a href="#">Table 4 on page 3</a>: removed 'code' in first row.</li> <li>• <a href="#">Table 6 on page 3</a>: several changes have been made.</li> <li>• <a href="#">Section 6 on page 4</a>: section has been added.</li> <li>• <a href="#">Table 9 on page 4</a>: several changes have been made.</li> <li>• <a href="#">Table 10 on page 5</a>: several changes have been made.</li> </ul>			
BGU8006 v.1	20120911	Preliminary data sheet	-	-



## 13. Legal information

### 13.1 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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