



# BGU8004

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

Rev. 1 — 31 January 2014

Preliminary data sheet

## 1. Product profile

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### 1.1 General description

The BGU8004 is a Low Noise Amplifier (LNA) for GNSS receiver applications. It comes as extremely small and thin Wafer Level Chip Scale Package (WLCSP). The BGU8004 requires one external matching inductor.

The BGU8004 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 optimized performance when jamming signals from co-existing cellular transmitters are present. At low jamming power levels it delivers 17 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.

### 1.2 Features and benefits

- Covers full GNSS L1 band, from 1559 MHz to 1610 MHz
- Noise figure (NF) = 0.60 dB
- Gain 17.0 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 3.4 mA supply current
- Power-down mode current consumption  $< 1$   $\mu$ A
- Integrated temperature stabilized bias for easy design
- Requires only one input matching inductor
- 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**

$f = 1575 \text{ MHz}$ ;  $V_{CC} = 1.8 \text{ V}$ ;  $V_{I(ENABLE)} \geq 0.8 \text{ V}$ ;  $P_i < -40 \text{ dBm}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ ; input matched to  $50 \text{ } \Omega$  using a  $5.6 \text{ nH}$  inductor, see [Figure 1](#); unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{CC}$	supply voltage	RF input AC coupled	1.5	-	3.1	V
$I_{CC}$	supply current	$P_i < -40 \text{ dBm}$	-	3.4	-	mA
		$P_i = -20 \text{ dBm}$	-	7.5	-	mA
$G_p$	power gain	no jammer	-	17.0	-	dB
		$P_i = -20 \text{ dBm}$ ; $f_{jam} = 1850 \text{ MHz}$	-	19.0	-	dB
NF	noise figure	no jammer	[1]	0.60	-	dB
		no jammer	[2]	0.65	-	dB
$P_{i(1dB)}$	input power at 1 dB gain compression	$V_{CC} = 1.8 \text{ V}$	-	-10	-	dBm
		$V_{CC} = 2.85 \text{ V}$	-	-7.5	-	
IP3 <sub>i</sub>	input third-order intercept point	$V_{CC} = 1.8 \text{ V}$	[3]	4	-	dBm
		$V_{CC} = 2.85 \text{ V}$	[3]	6	-	dBm

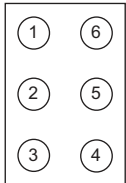
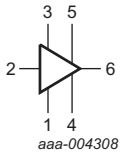
[1] PCB losses are subtracted.

[2] Including PCB losses.

[3]  $f_1 = 1713 \text{ MHz}$ ;  $f_2 = 1851 \text{ MHz}$ ;  $P_i = -20 \text{ dBm}$  at  $f_1$ ;  $P_i = -65 \text{ dBm}$  at  $f_2$ .

## 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		Version
	Name	Description	
BGU8004	WLCSP6	wafer level chip-size package; 6 balls; body $0.65 \times 0.44 \times 0.29 \text{ mm}$	BGU8004

## 4. Marking

**Table 4. Marking codes**

Type number	Marking code
BGU8004	single character, indicating assembly month. <sup>[1]</sup>

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

**Table 5. Calendar marking month code**

Double underscore indicate pin 1.

Year	[1] Month											
	J	F	M	A	M	J	J	A	S	O	N	D
2013	<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>
2014	<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>
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>

[1] Rotates every 3 years.

## 5. Limiting values

**Table 6. 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	[1] -0.5	+5.0	V
$V_{I(ENABLE)}$	input voltage on pin ENABLE	$V_{I(ENABLE)} < V_{CC} + 0.6$ V	[1][2] -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	[1][2][3] -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	[1][2][3] -0.5	+5.0	V
$P_i$	input power	$f = 1575$ MHz	[1] -	10	dBm
$P_{tot}$	total power dissipation	$T_{sp} \leq 130$ °C	-	55	mW
$T_{stg}$	storage temperature		-65	+150	°C
$T_j$	junction temperature		-	150	°C
$V_{ESD}$	electrostatic discharge voltage	Human Body Model (HBM) According to ANSI/ESDA/JEDEC standard JS-001	-	±2	kV
		Machine Model (MM) According to JEDEC standard JESD22-A115	-	±0.2	kV
		Charged Device Model (CDM) According to JEDEC standard JESD22-C101	-	±1	kV

[1] Stressed with pulses of 200 ms in duration, with application circuit as in [Figure 1](#).

[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	-	-	0.3	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 1](#); 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	-	3.4	-	mA	
		$P_i = -20$ dBm	-	7.5	-	mA	
		$V_{I(ENABLE)} \leq 0.3$ 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	
$RL_{in}$	input return loss	$P_i < -40$ dBm	-	10	-	dB	
		$P_i = -20$ dBm	-	15	-	dB	
$RL_{out}$	output return loss	$P_i < -40$ dBm	-	11	-	dB	
		$P_i = -20$ dBm	-	11	-	dB	
ISL	isolation		-	27	-	dB	
NF	noise figure	$P_i = -40$ dBm, no jammer	[1]	-	0.60	-	dB
		$P_i = -40$ dBm, no jammer	[2]	-	0.65	-	dB
		$P_{jam} = -20$ dBm; $f_{jam} = 850$ MHz	[2]	-	1.0	-	dB
		$P_{jam} = -20$ dBm; $f_{jam} = 1850$ MHz	[2]	-	1.0	-	dB
$P_{i(1dB)}$	input power at 1 dB gain compression		-	-10	-	dBm	

**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  $50\ \Omega$  using a  $5.6\text{ nH}$  inductor, see [Figure 1](#); unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
IP <sub>3i</sub>	input third-order intercept point		[3]	-	4	- dBm
t <sub>on</sub>	turn-on time	time from V <sub>I(ENABLE)</sub> ON, to 90 % of the gain	-	-	2	μs
t <sub>off</sub>	turn-off time	time from V <sub>I(ENABLE)</sub> OFF, to 10 % of the gain	-	-	1	μs

[1] PCB losses are subtracted

[2] Including PCB losses

[3]  $f_1 = 1713\text{ MHz}$ ;  $f_2 = 1851\text{ MHz}$ ;  $P_i = -20\text{ dBm}$  at  $f_1$ ;  $P_i = -65\text{ dBm}$  at  $f_2$ .

**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  $50\ \Omega$  using a  $5.6\text{ nH}$  inductor, see [Figure 1](#); 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	
		$P_i = -20\text{ dBm}$	-	7.5	-	mA	
		$V_{I(ENABLE)} \leq 0.3\text{ V}$	-	-	1	μA	
G <sub>p</sub>	power gain	no jammer	-	17.0	-	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	$P_i < -40\text{ dBm}$	-	11	-	dB	
		$P_i = -20\text{ dBm}$	-	15	-	dB	
RL <sub>out</sub>	output return loss	$P_i < -40\text{ dBm}$	-	11	-	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]	-	1.0	-	dB
		$P_{jam} = -20\text{ dBm}$ ; $f_{jam} = 1850\text{ MHz}$	[2]	-	1.0	-	dB
P <sub>i(1dB)</sub>	input power at 1 dB gain compression		-	-7.5	-	dBm	
IP <sub>3i</sub>	input third-order intercept point		[3]	-	6	- dBm	
t <sub>on</sub>	turn-on time	time from V <sub>I(ENABLE)</sub> ON, to 90 % of the gain	-	-	2	μs	
t <sub>off</sub>	turn-off time	time from V <sub>I(ENABLE)</sub> OFF, to 10 % of the gain	-	-	1	μs	

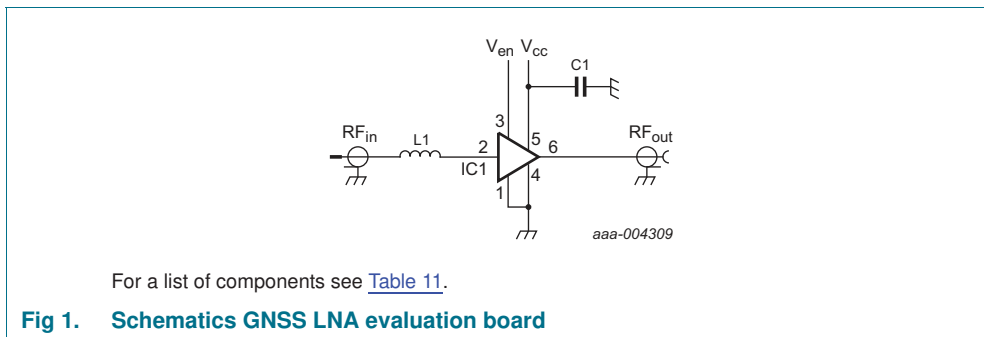
[1] PCB losses are subtracted

[2] Including PCB losses

[3]  $f_1 = 1713\text{ MHz}$ ;  $f_2 = 1851\text{ MHz}$ ;  $P_i = -20\text{ dBm}$  at  $f_1$ ;  $P_i = -65\text{ dBm}$  at  $f_2$ .

## 9. Application information

### 9.1 GNSS LNA

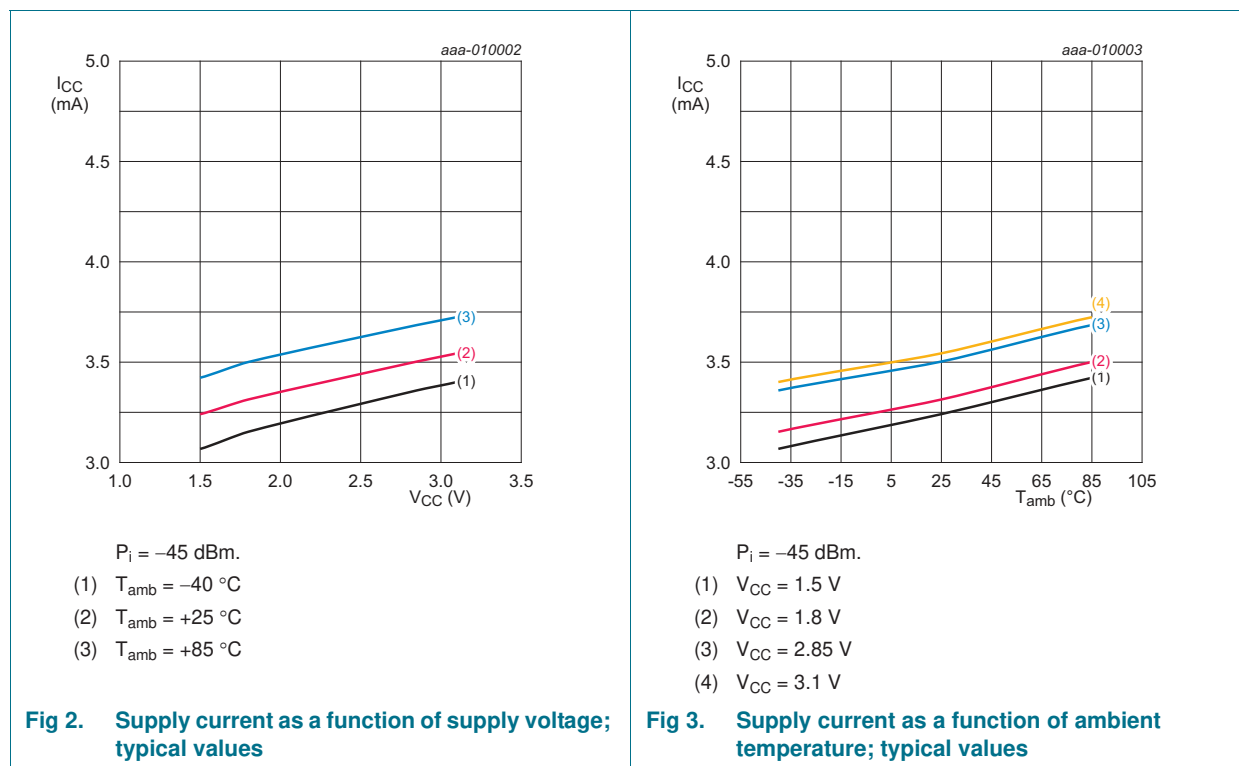


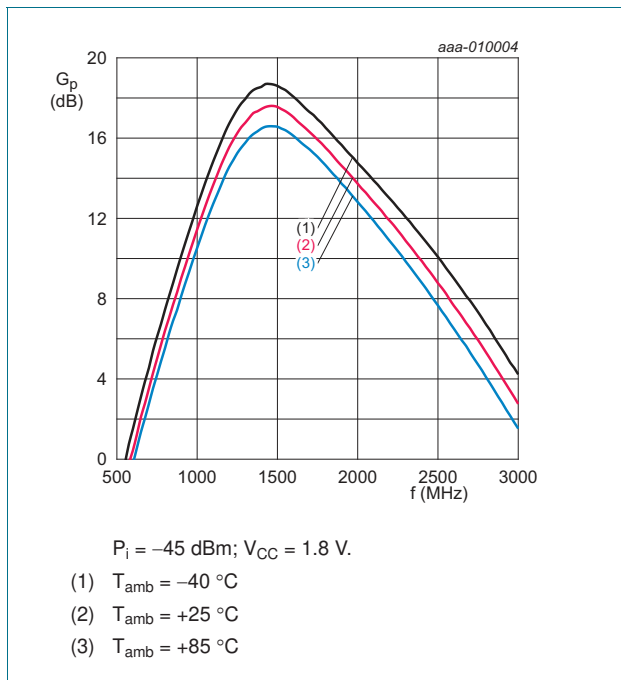
**Table 11. List of components**

For schematics see [Figure 1](#).

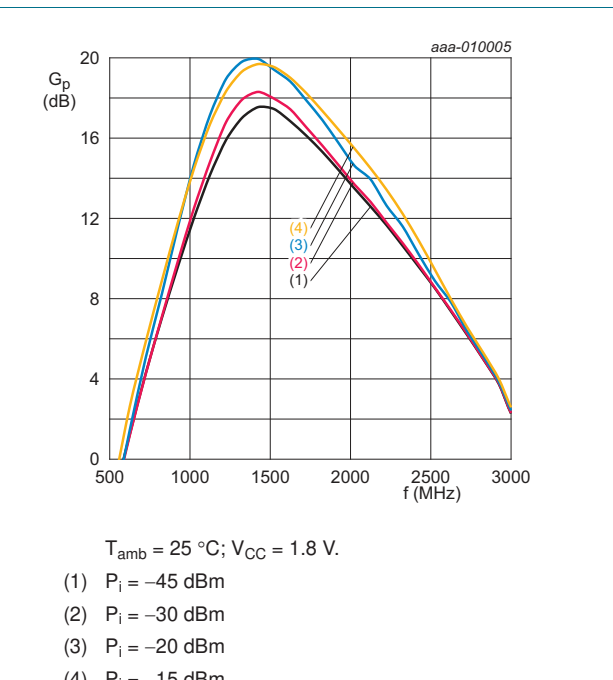
Component	Description	Value	Remarks
C1	decoupling capacitor	1 nF	optional component
IC1	BGU8004	-	NXP
L1	high quality matching inductor	6.8 nH	Murata LQW15A

### 9.2 Graphs

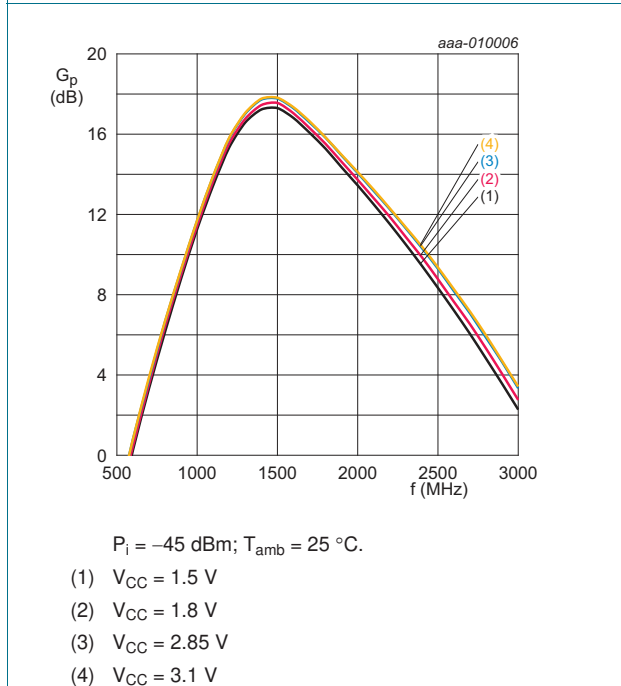




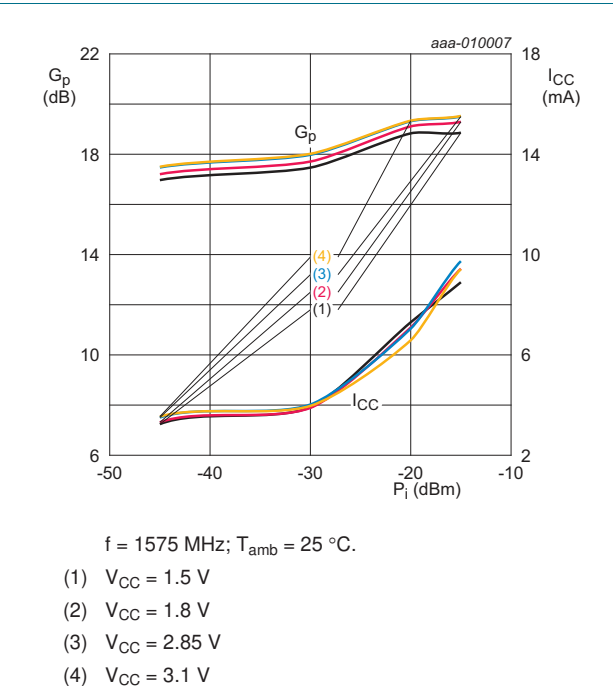
**Fig 4. Power gain as a function of frequency; typical values**



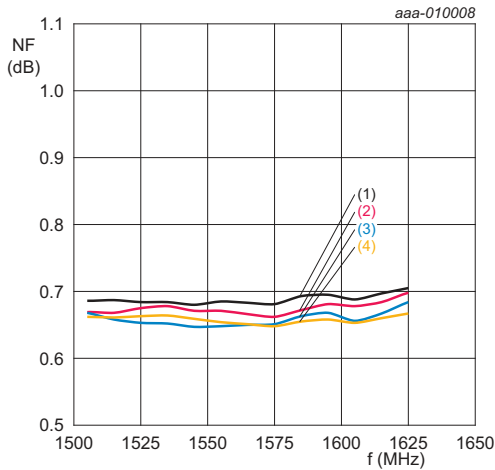
**Fig 5. Power gain as a function of frequency; typical values**



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

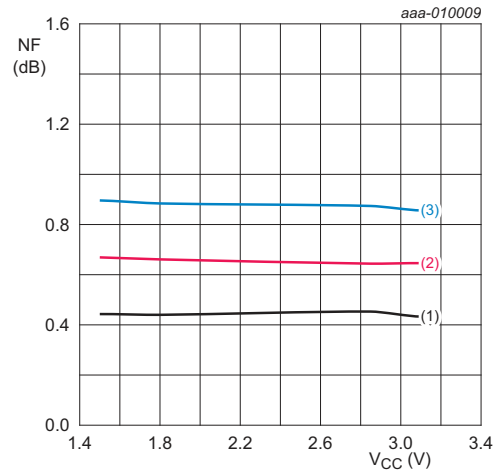


**Fig 7. Power gain and supply current as function of input power; typical values**



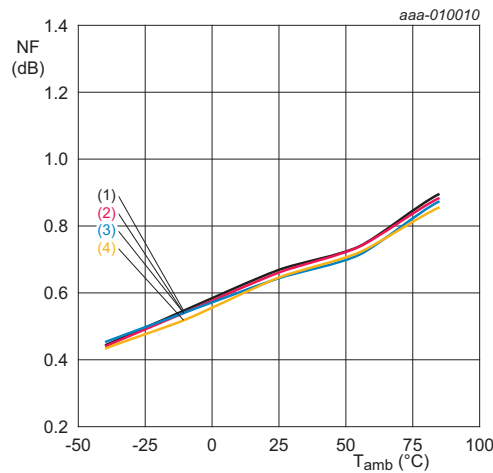
$T_{amb} = 25\text{ }^{\circ}\text{C}$ ; no jammer, including PCB losses.  
 (1)  $V_{CC} = 1.5\text{ V}$   
 (2)  $V_{CC} = 1.8\text{ V}$   
 (3)  $V_{CC} = 2.85\text{ V}$   
 (4)  $V_{CC} = 3.1\text{ V}$

**Fig 8. Noise figure as a function of frequency; typical values**



$f = 1575\text{ MHz}$ ; no jammer, including PCB losses.  
 (1)  $T_{amb} = -40\text{ }^{\circ}\text{C}$   
 (2)  $T_{amb} = +25\text{ }^{\circ}\text{C}$   
 (3)  $T_{amb} = +85\text{ }^{\circ}\text{C}$

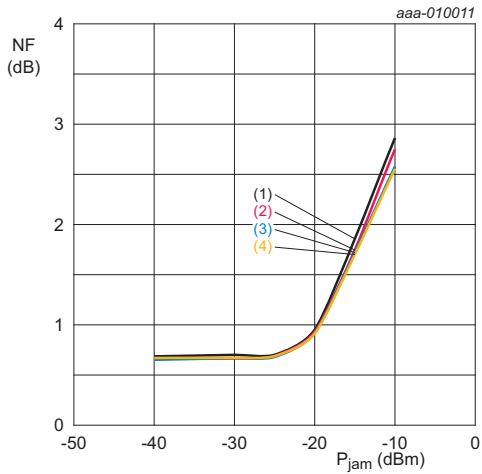
**Fig 9. Noise figure as a function of supply voltage; typical values**



$f = 1575\text{ MHz}$ ; 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 10. Noise figure as a function of ambient temperature; typical values**

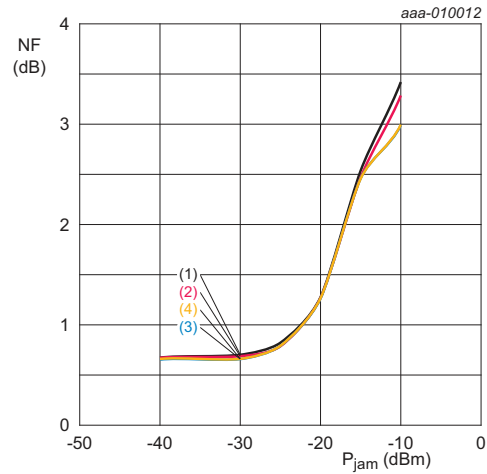




$f_{jam} = 850 \text{ MHz}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ ;  $f = 1575 \text{ MHz}$ ;  
including PCB losses.

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

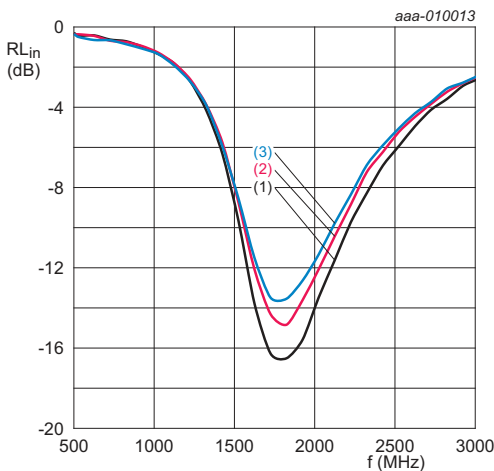
**Fig 11. Noise figure as a function of jamming power; typical values**



$f_{jam} = 1850 \text{ MHz}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ ;  $f = 1575 \text{ MHz}$ ;  
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)  $V_{CC} = 3.1 \text{ V}$

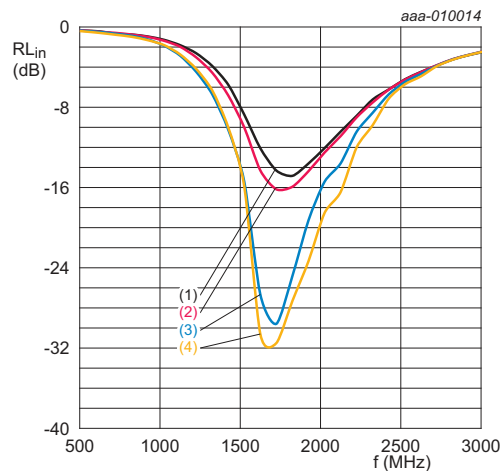
**Fig 12. Noise figure as a function of jamming power; typical values**



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

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

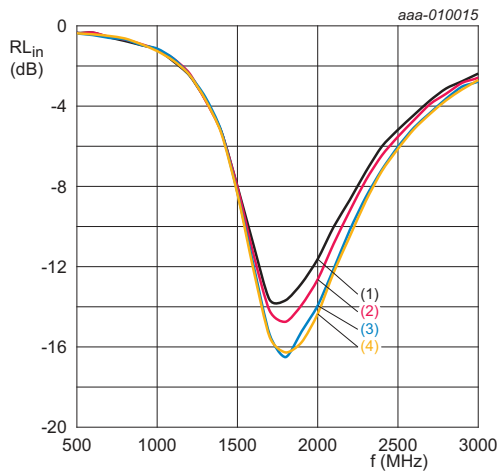
**Fig 13. Input return loss as a function of frequency; typical values**



$T_{amb} = 25 \text{ }^\circ\text{C}$ ;  $V_{CC} = 1.8 \text{ V}$ .

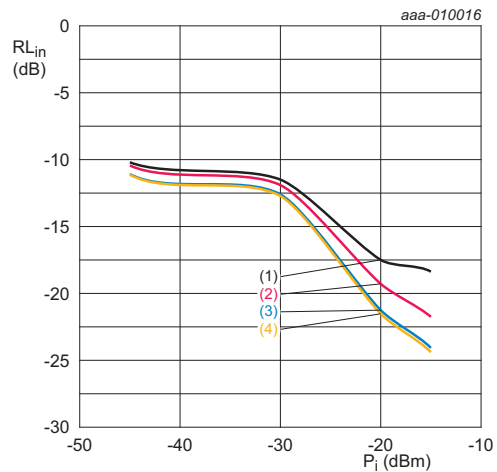
- (1)  $P_i = -45 \text{ dBm}$
- (2)  $P_i = -30 \text{ dBm}$
- (3)  $P_i = -20 \text{ dBm}$
- (4)  $P_i = -15 \text{ dBm}$

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



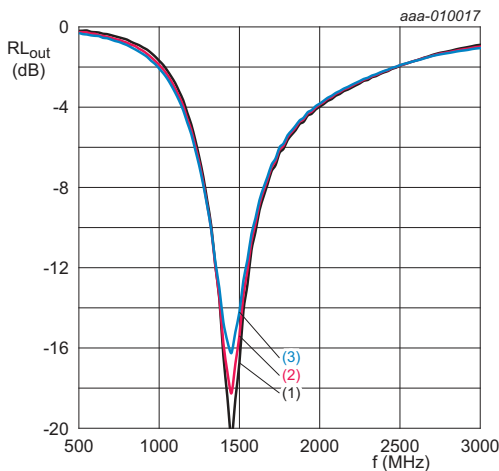
$P_i = -45$  dBm;  $T_{amb} = 25$  °C.  
 (1)  $V_{CC} = 1.5$  V  
 (2)  $V_{CC} = 1.8$  V  
 (3)  $V_{CC} = 2.85$  V  
 (4)  $V_{CC} = 3.1$  V

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



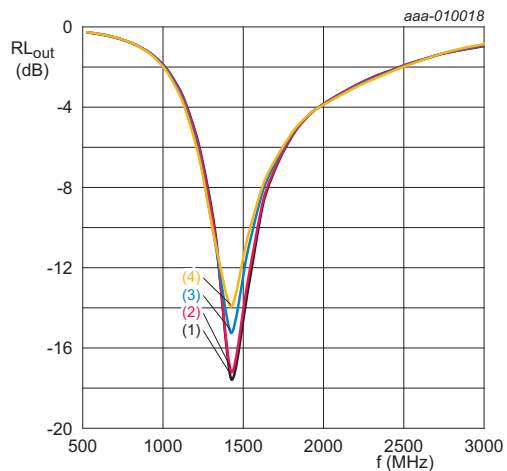
$f = 1575$  MHz;  $T_{amb} = 25$  °C.  
 (1)  $V_{CC} = 1.5$  V  
 (2)  $V_{CC} = 1.8$  V  
 (3)  $V_{CC} = 2.85$  V  
 (4)  $V_{CC} = 3.1$  V

**Fig 16. Input return loss as a function of input power; typical values**



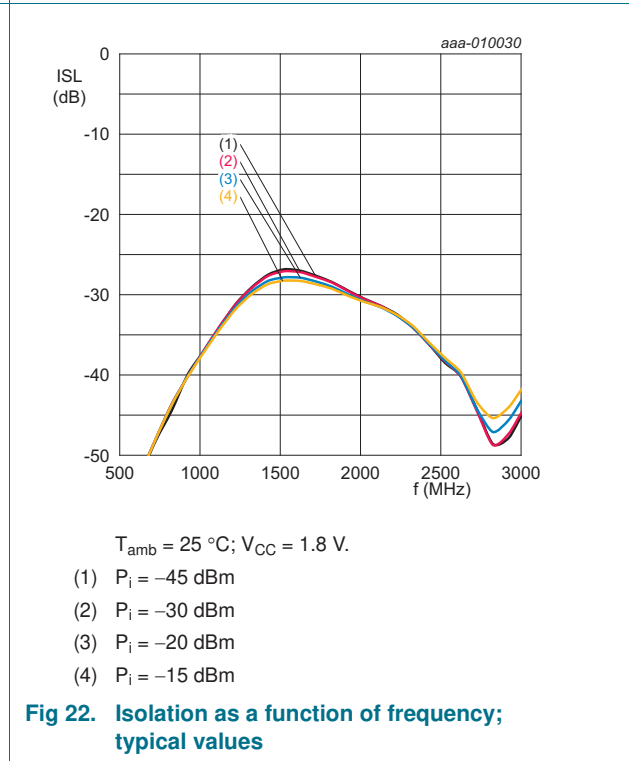
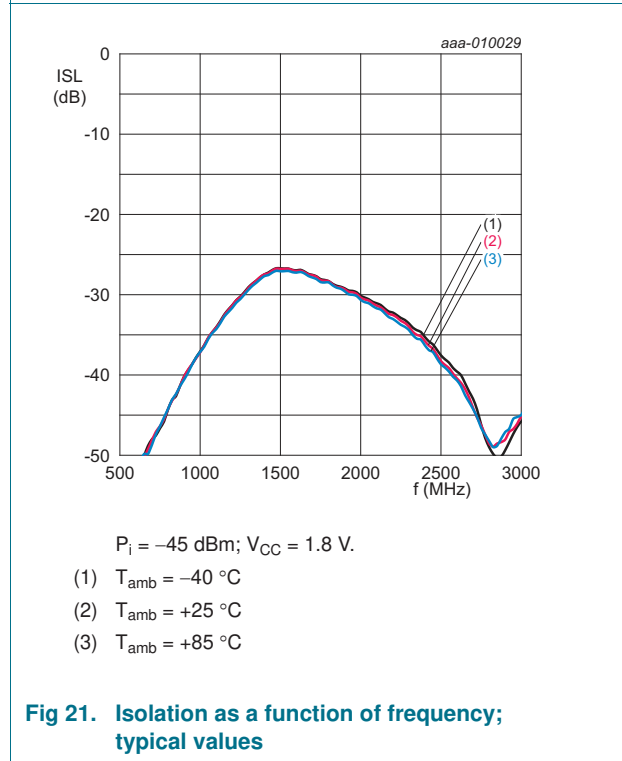
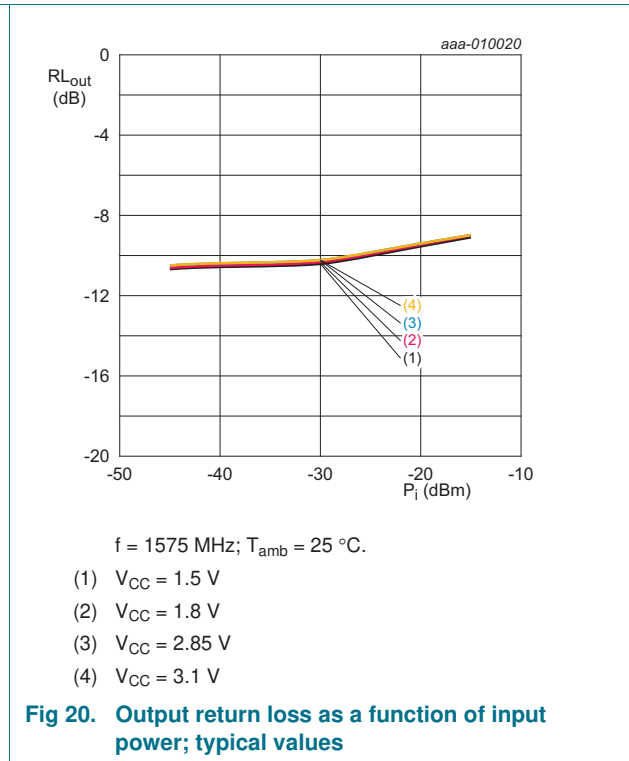
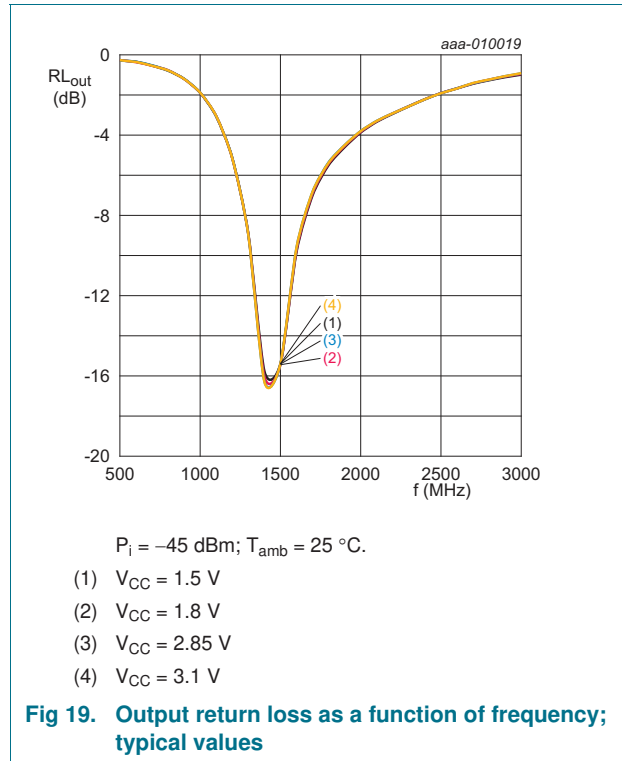
$P_i = -45$  dBm;  $V_{CC} = 1.8$  V.  
 (1)  $T_{amb} = -40$  °C  
 (2)  $T_{amb} = +25$  °C  
 (3)  $T_{amb} = +85$  °C

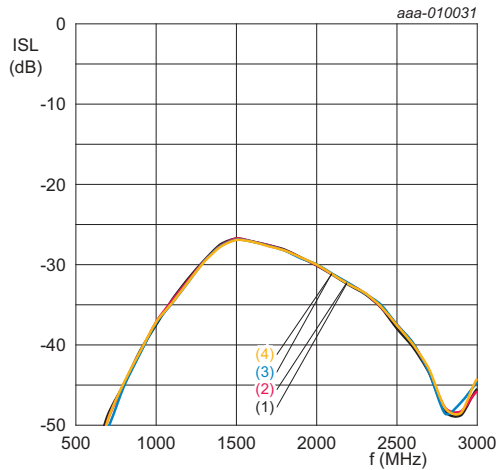
**Fig 17. Output return loss as a function of frequency; typical values**



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

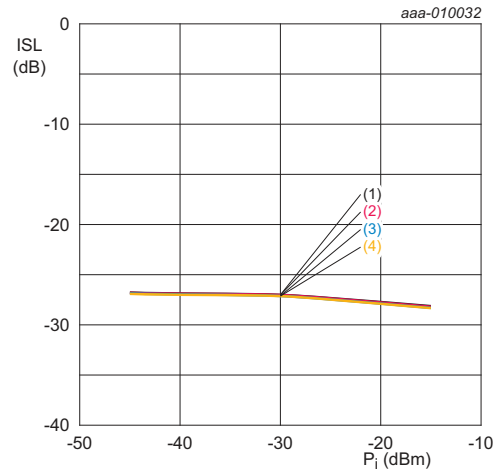
**Fig 18. Output return loss as a function of frequency; typical values**





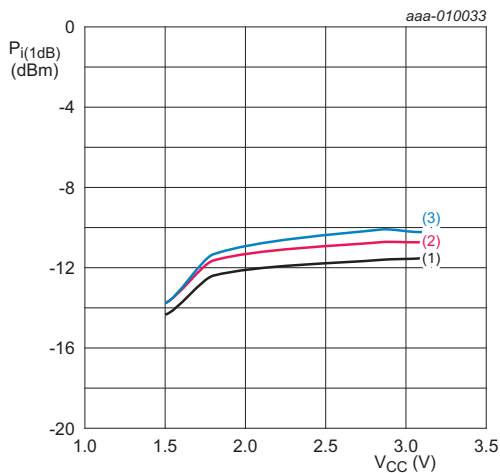
$P_i = -45$  dBm;  $T_{amb} = 25$  °C.  
 (1)  $V_{CC} = 1.5$  V  
 (2)  $V_{CC} = 1.8$  V  
 (3)  $V_{CC} = 2.85$  V  
 (4)  $V_{CC} = 3.1$  V

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



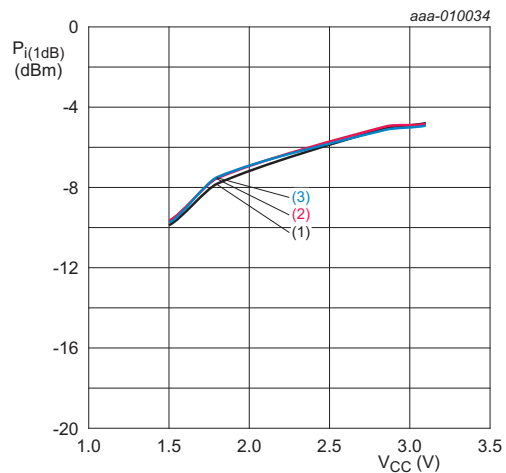
$f = 1575$  MHz;  $T_{amb} = 25$  °C.  
 (1)  $V_{CC} = 1.5$  V  
 (2)  $V_{CC} = 1.8$  V  
 (3)  $V_{CC} = 2.85$  V  
 (4)  $V_{CC} = 3.1$  V

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



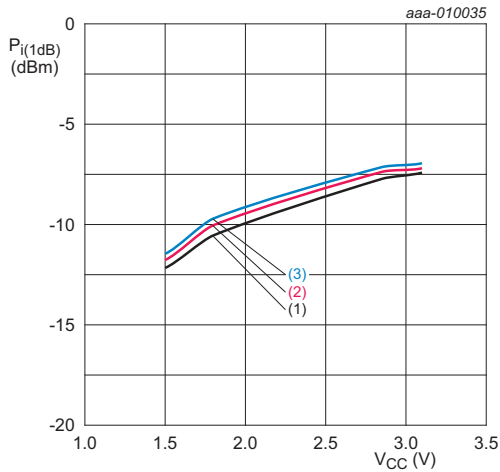
$f = 850$  MHz.  
 (1)  $T_{amb} = -40$  °C  
 (2)  $T_{amb} = +25$  °C  
 (3)  $T_{amb} = +85$  °C

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



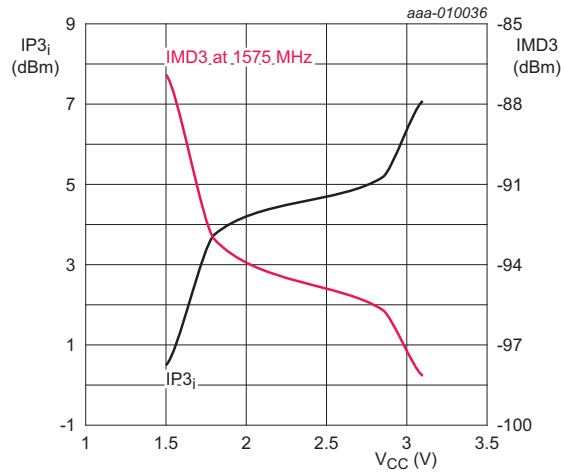
$f = 1850$  MHz.  
 (1)  $T_{amb} = -40$  °C  
 (2)  $T_{amb} = +25$  °C  
 (3)  $T_{amb} = +85$  °C

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



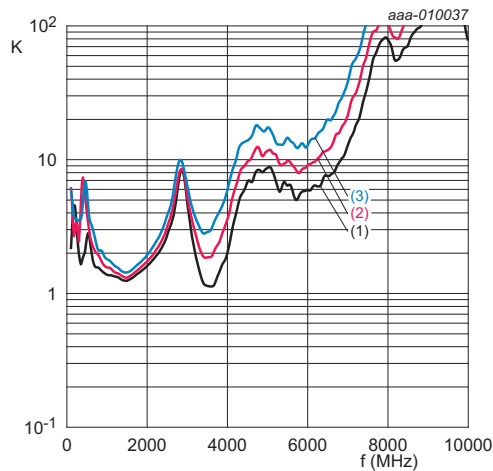
$f = 1575\text{ MHz}$ .  
 (1)  $T_{amb} = -40^\circ\text{C}$   
 (2)  $T_{amb} = +25^\circ\text{C}$   
 (3)  $T_{amb} = +85^\circ\text{C}$

**Fig 27. Input power at 1 dB gain compression as a function of supply voltage; typical values**



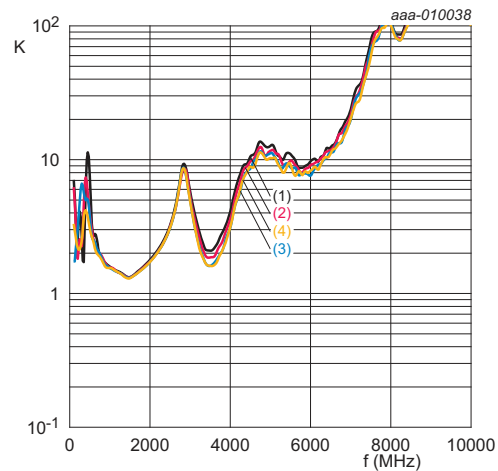
$f_1 = 1713\text{ MHz}$ ;  $f_2 = 1851\text{ MHz}$ ;  $P_i = -20\text{ dBm}$  at  $f_1$ ;  
 $P_i = -65\text{ dBm}$  at  $f_2$ ;  $T_{amb} = 25^\circ\text{C}$ .

**Fig 28. Input third order intercept point and third order intermodulation distortion as function of supply voltage; typical values**



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

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



$P_i = -45\text{ dBm}$ ;  $T_{amb} = 25^\circ\text{C}$ .  
 (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 30. 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

BGU8004

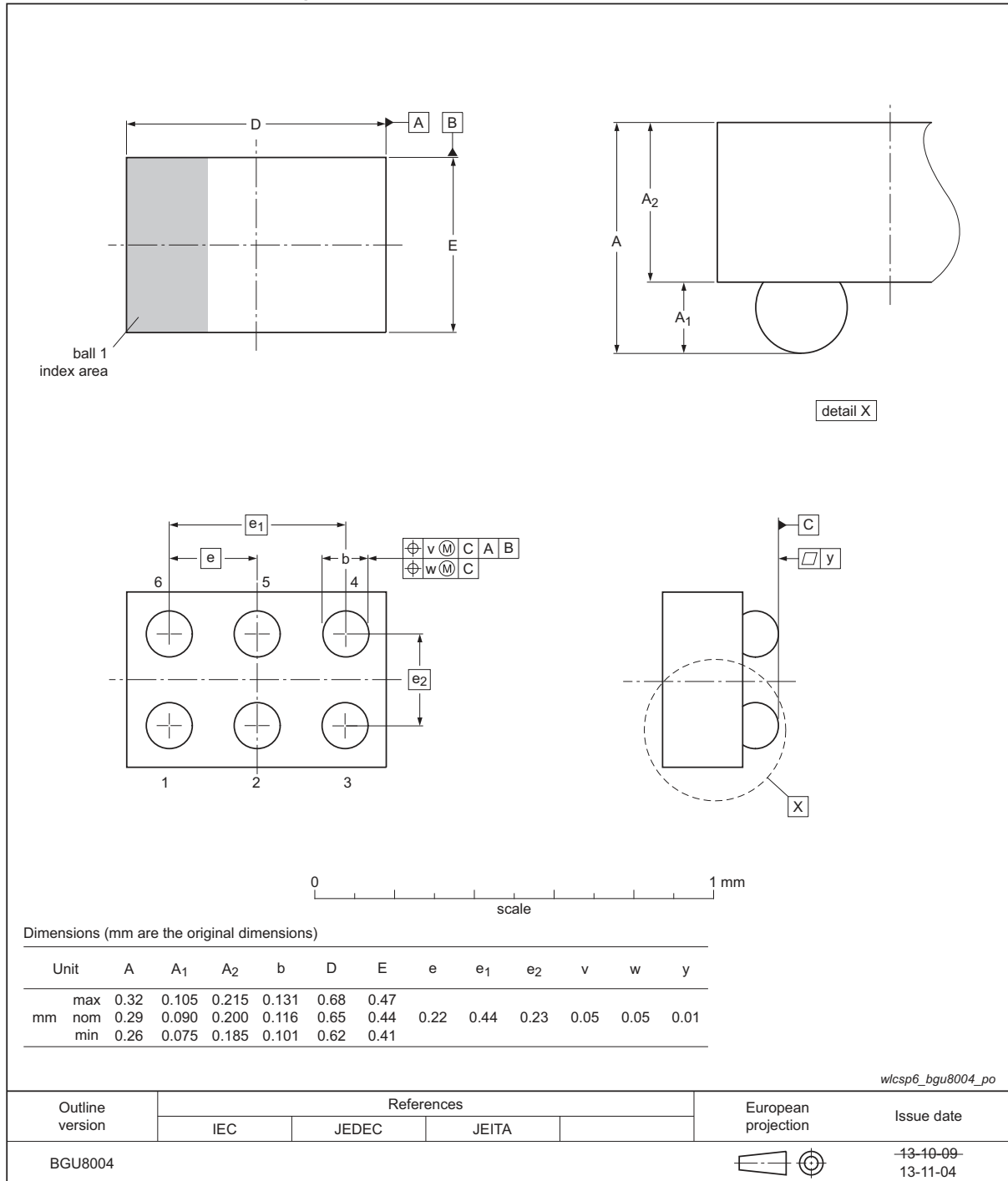


Fig 31. Package outline BGU8004 (WLCSP6)

## 11. 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.

## 12. 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

## 13. Revision history

**Table 13. Revision history**

Document ID	Release date	Data sheet status	Change notice	Supersedes
BGU8004 v.1	20140131	Preliminary data sheet	-	-

## 14. Legal information

### 14.1 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".

[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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