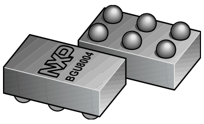


BGU8004

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

Rev. 1 — 31 January 2014 **Preliminary data sheet**

1. Product profile

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 μA
- 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 × 0.44 × 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} = 1.8 V; $V_{I(ENABLE)} \geq$ 0.8 V; P_i < –40 dBm; T_{amb} = 25 °C; input matched to 50 Ω using a 5.6 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 dBm		-	3.4	-	mA
		P_i = –20 dBm		-	7.5	-	mA
G_p	power gain	no jammer		-	17.0	-	dB
		P_i = –20 dBm; f_{jam} = 1850 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 V		-	–10	-	dBm
		V_{CC} = 2.85 V		-	–7.5	-	
$IP3_i$	input third-order intercept point	V_{CC} = 1.8 V	[3]	-	4	-	dBm
		V_{CC} = 2.85 V	[3]	-	6	-	dBm

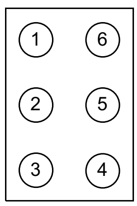
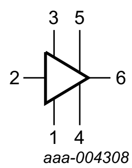
[1] PCB losses are subtracted.

[2] Including PCB losses.

[3] f_1 = 1713 MHz; f_2 = 1851 MHz; P_i = –20 dBm at f_1; P_i = –65 dBm at f_2.

2. Pinning information

Table 2. Pinning

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

3. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
BGU8004	WLCSP6	wafer level chip-size package; 6 balls; body 0.65 × 0.44 × 0.29 mm	BGU8004

4. Marking

Table 4. Marking codes

Type number	Marking code
BGU8004	single character, indicating assembly month.[1]

[1] Month code see Table 5.

Table 5. Calender marking month code

Double underscore indicate pin 1.

Year [1]	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
2013	M	N	O	P	Q	R	S	T	U	V	W	X
2014	Y	Z	b	d	f	h	3	4	5	6	7	9
2015	A	B	C	D	E	F	G	H	I	J	K	L

[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 Ω 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	µA
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 V *…continued*

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 Ω using a 5.6 nH inductor, see Figure 1; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$IP3_i$	input third-order intercept point		[3]	-	4	-	dBm
t_{on}	turn-on time	time from $V_{I(ENABLE)}$ ON, to 90 % of the gain		-	-	2	µs
t_{off}	turn-off time	time from $V_{I(ENABLE)}$ OFF, to 10 % of the gain		-	-	1	µs

[1] PCB losses are subtracted

[2] Including PCB losses

[3] f_1 = 1713 MHz; f_2 = 1851 MHz; P_i = −20 dBm at f_1; P_i = −65 dBm at f_2.

Table 10. Characteristics at V_{cc} = 2.85 V

f = 1575 MHz; V_{CC} = 2.85 V; $V_{I(ENABLE)} \geq 0.8$ V; $P_i < -40$ dBm; T_{amb} = 25 °C; input matched to 50 Ω 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		-	3.6	-	mA
		$P_i = -20$ dBm		-	7.5	-	mA
		$V_{I(ENABLE)} \leq 0.3$ V		-	-	1	µA
G_p	power gain	no jammer		-	17.0	-	dB
		$P_{jam} = -20$ dBm; f_{jam} = 850 MHz		-	18.0	-	dB
		$P_{jam} = -20$ dBm; f_{jam} = 1850 MHz		-	19.0	-	dB
RL_{in}	input return loss	$P_i < -40$ dBm		-	11	-	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			-	−7.5	-	dBm
$IP3_i$	input third-order intercept point		[3]	-	6	-	dBm
t_{on}	turn-on time	time from $V_{I(ENABLE)}$ ON, to 90 % of the gain		-	-	2	µs
t_{off}	turn-off time	time from $V_{I(ENABLE)}$ OFF, to 10 % of the gain		-	-	1	µs

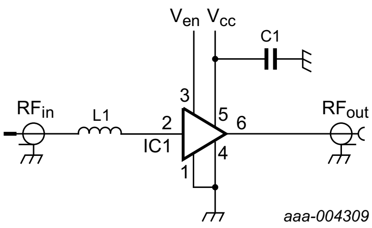
[1] PCB losses are subtracted

[2] Including PCB losses

[3] f_1 = 1713 MHz; f_2 = 1851 MHz; P_i = −20 dBm at f_1; P_i = −65 dBm at f_2.

9. Application information

9.1 GNSS LNA



For a list of components see Table 11.

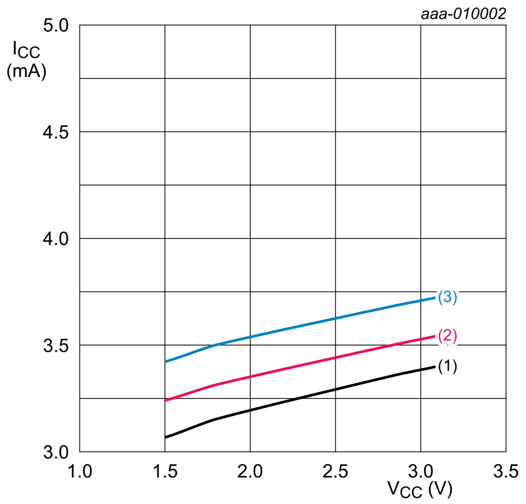
Fig 1. Schematics GNSS LNA evaluation board

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



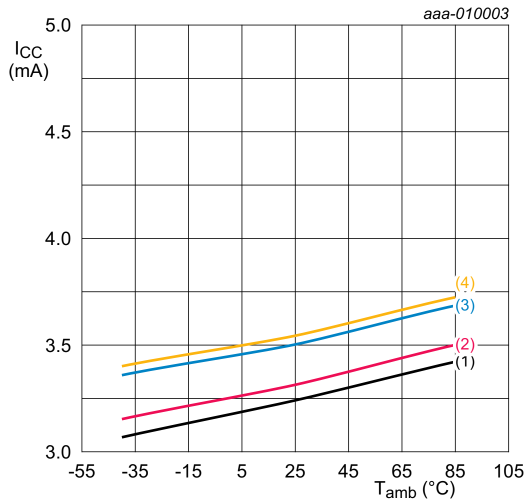
P_i = –45 dBm.

(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.

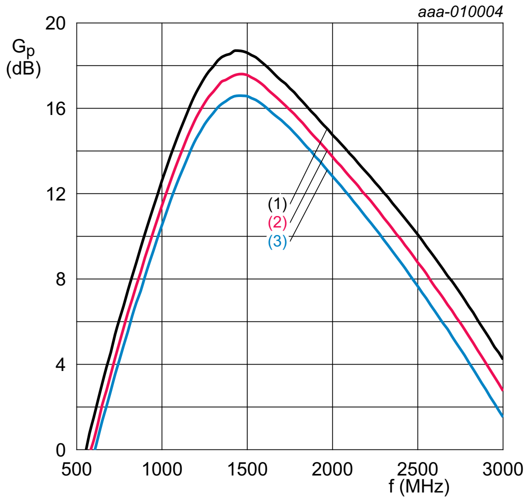
(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

(4) V_{CC} = 3.1 V

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



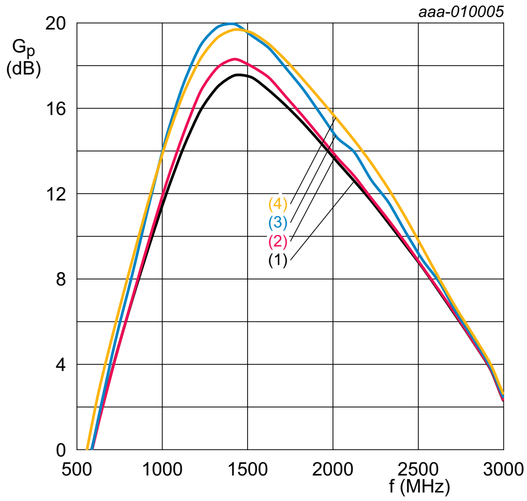
P_i = –45 dBm; V_{CC} = 1.8 V.

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

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



T_{amb} = 25 °C; V_{CC} = 1.8 V.

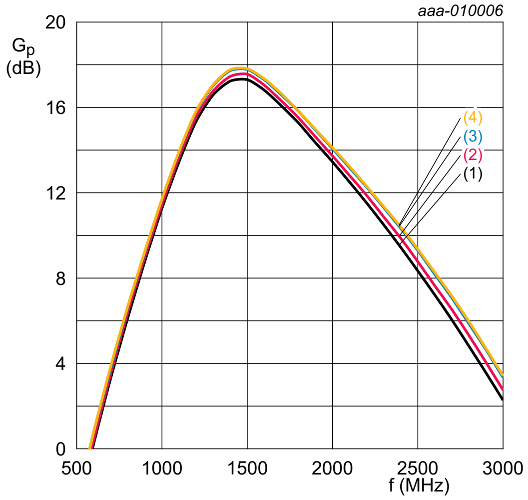
(1) P_i = –45 dBm

(2) P_i = –30 dBm

(3) P_i = –20 dBm

(4) P_i = –15 dBm

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



P_i = –45 dBm; T_{amb} = 25 °C.

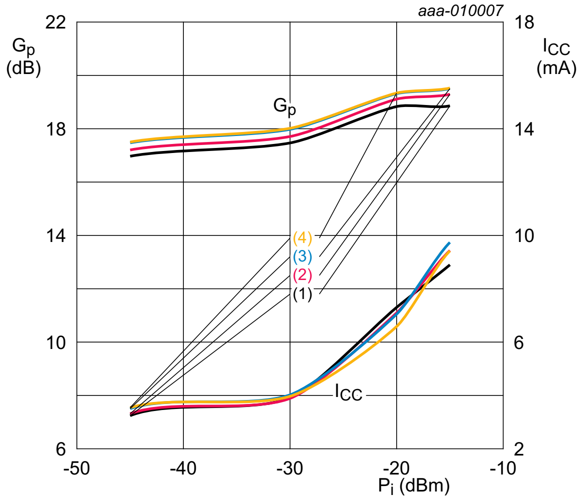
(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

(4) V_{CC} = 3.1 V

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



f = 1575 MHz; T_{amb} = 25 °C.

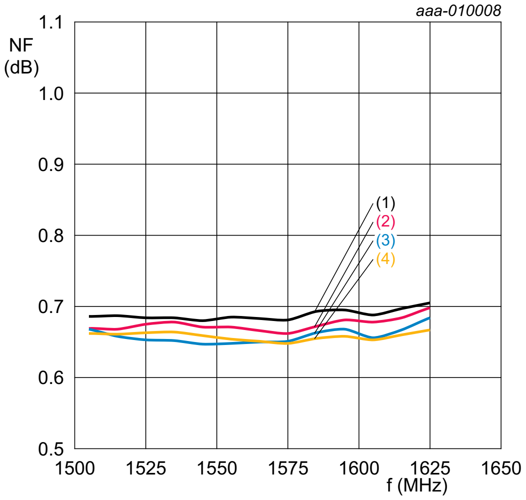
(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

(4) V_{CC} = 3.1 V

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



T_{amb} = 25 °C; no jammer, including PCB losses.

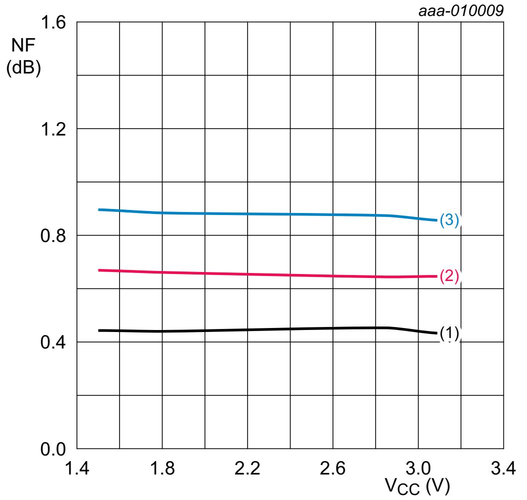
(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

(4) V_{CC} = 3.1 V

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



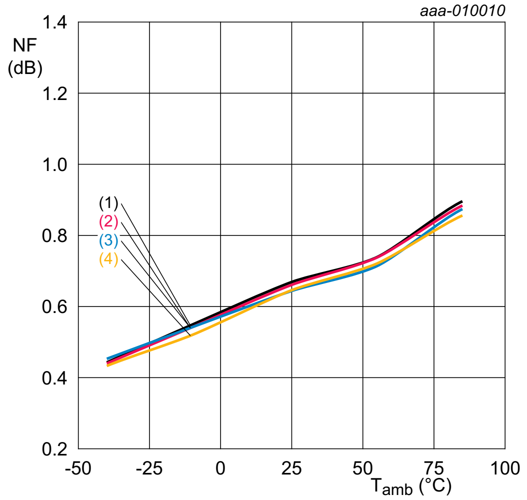
f = 1575 MHz; no jammer, including PCB losses.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

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



f = 1575 MHz; no jammer, including PCB losses.

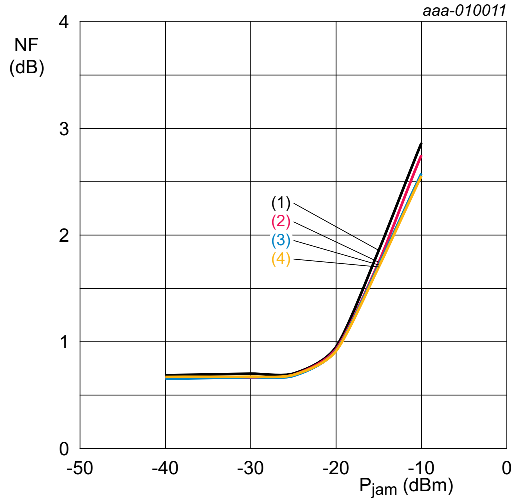
(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

(4) V_{CC} = 3.1 V

Fig 10. Noise figure as a function of ambient temperature; typical values



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

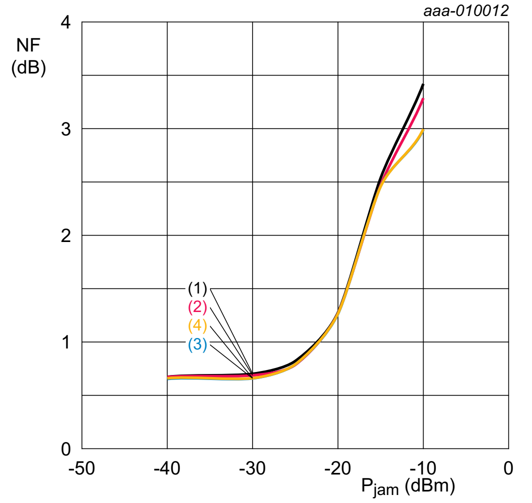
(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

(4) V_{CC} = 3.1 V

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



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

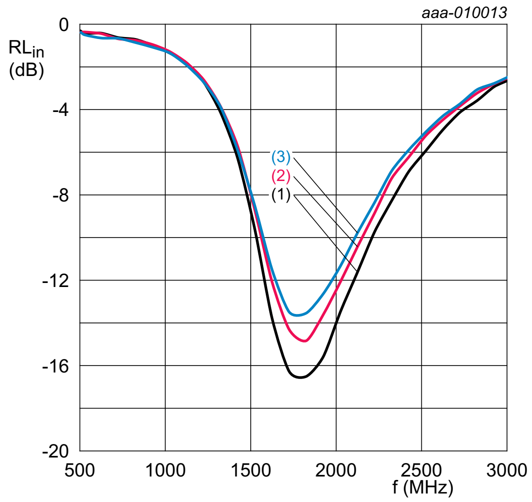
(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

(4) V_{CC} = 3.1 V

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



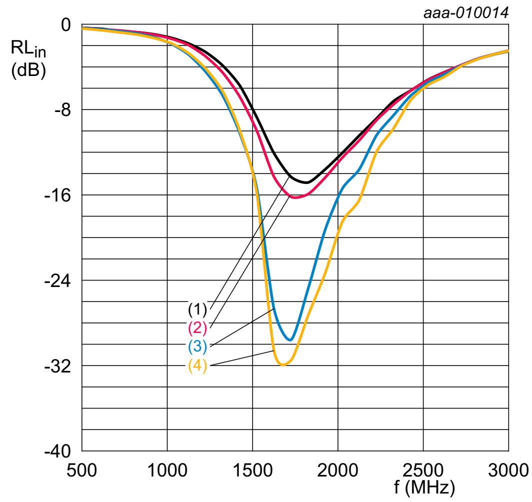
P_i = –45 dBm; V_{CC} = 1.8 V.

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

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



T_{amb} = 25 °C; V_{CC} = 1.8 V.

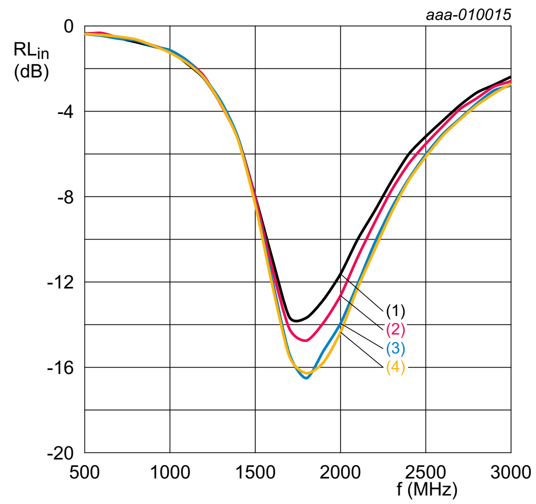
(1) P_i = –45 dBm

(2) P_i = –30 dBm

(3) P_i = –20 dBm

(4) P_i = –15 dBm

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



P_i = –45 dBm; T_{amb} = 25 °C.

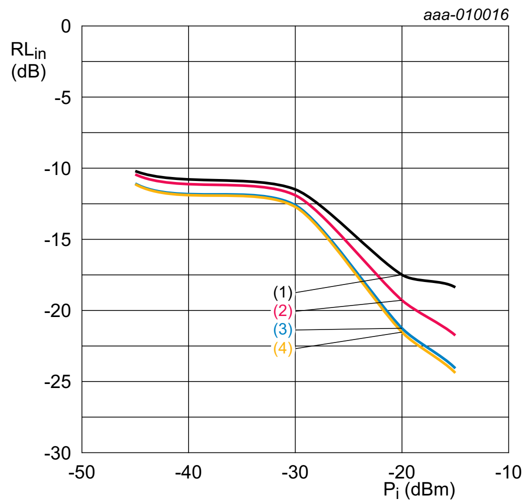
(1) V_{CC} = 1.5 V

(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.

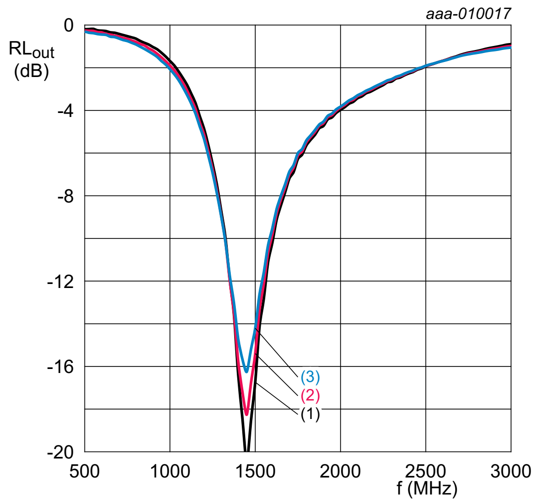
(1) V_{CC} = 1.5 V

(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



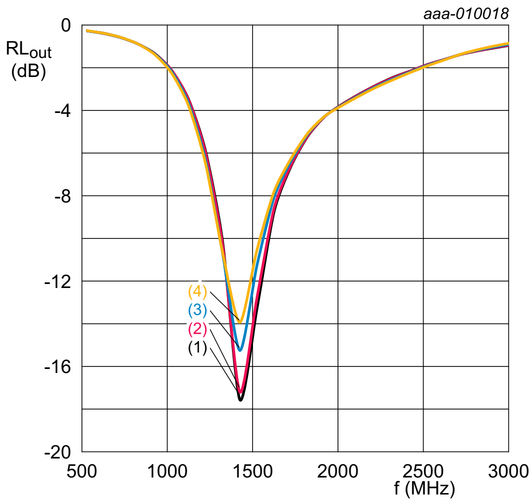
P_i = –45 dBm; V_{CC} = 1.8 V.

(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.

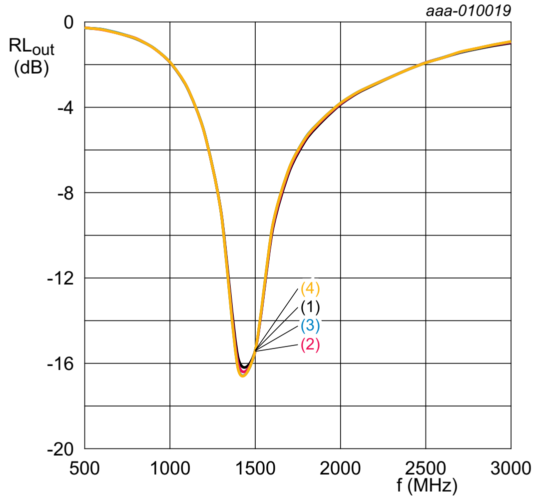
(1) P_i = –45 dBm

(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.

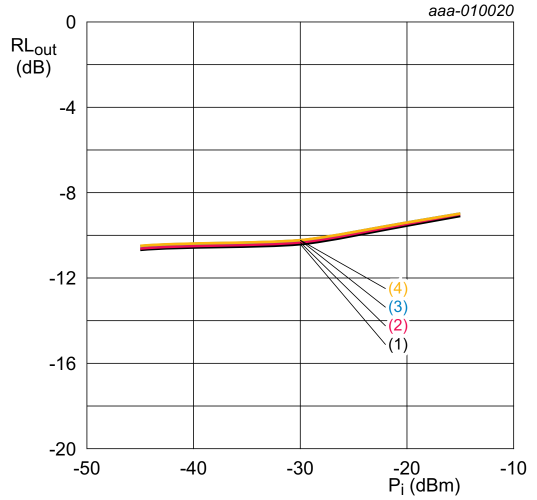
(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

(4) V_{CC} = 3.1 V

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



f = 1575 MHz; T_{amb} = 25 °C.

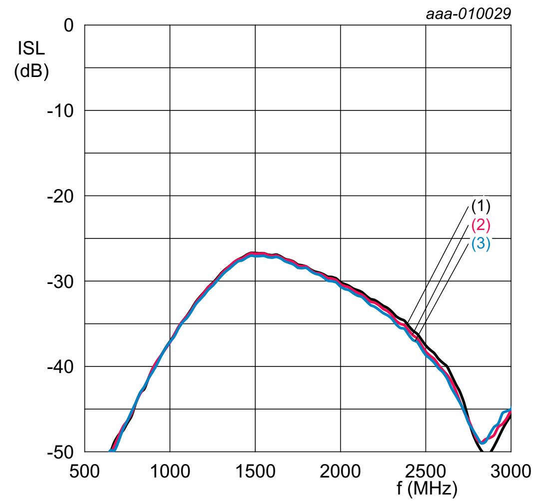
(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

(4) V_{CC} = 3.1 V

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



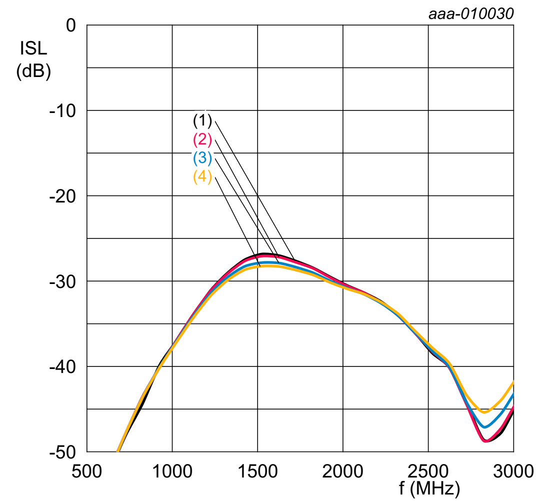
P_i = –45 dBm; V_{CC} = 1.8 V.

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

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



T_{amb} = 25 °C; V_{CC} = 1.8 V.

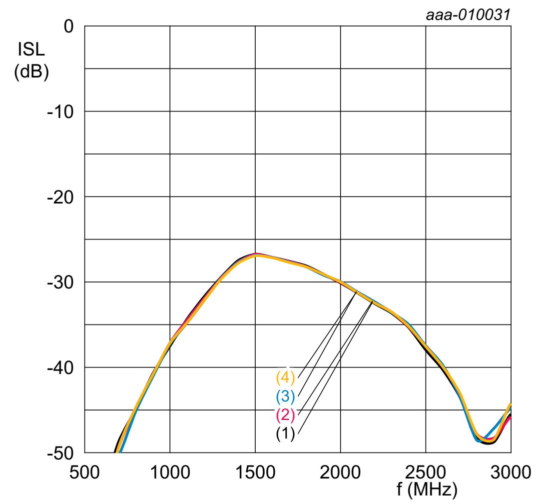
(1) P_i = –45 dBm

(2) P_i = –30 dBm

(3) P_i = –20 dBm

(4) P_i = –15 dBm

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



P_i = –45 dBm; T_{amb} = 25 °C.

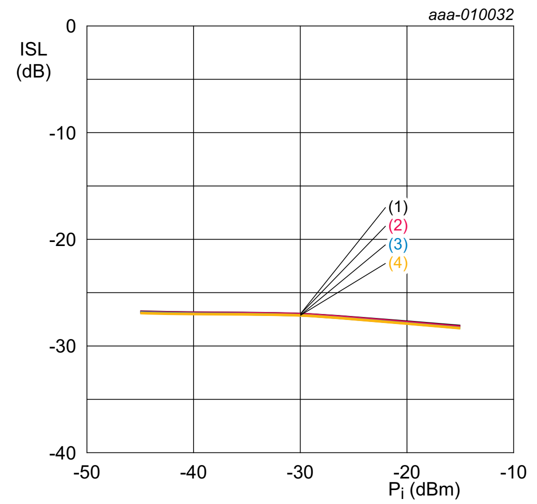
(1) V_{CC} = 1.5 V

(2) V_{CC} = 1.8 V

(3) V_{CC} = 2.85 V

(4) V_{CC} = 3.1 V

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



f = 1575 MHz; T_{amb} = 25 °C.

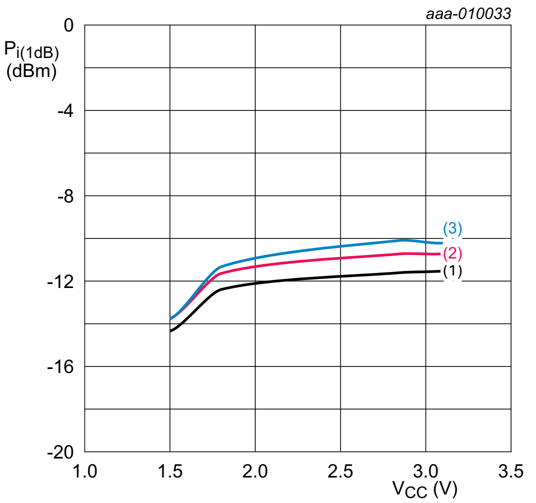
(1) V_{CC} = 1.5 V

(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



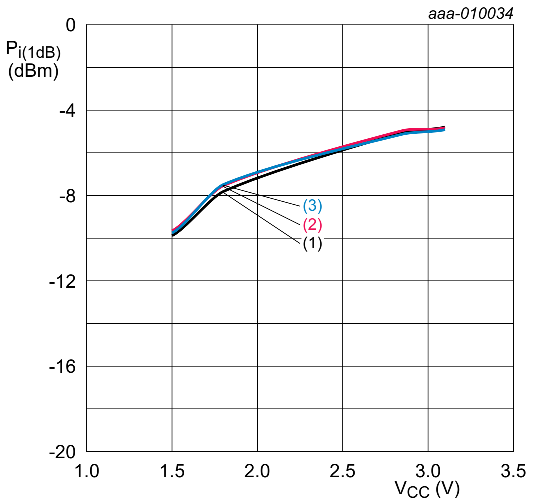
f = 850 MHz.

(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



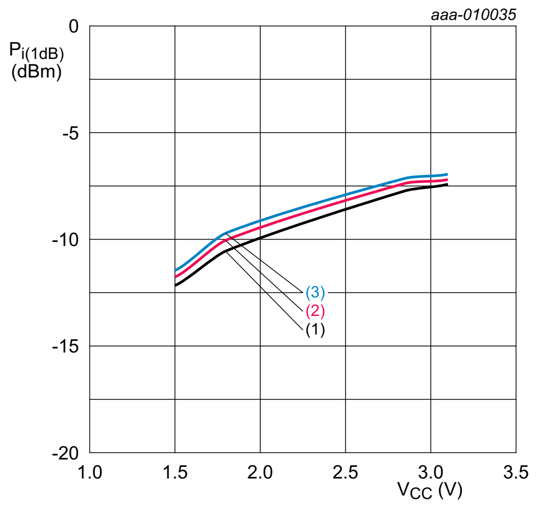
f = 1850 MHz.

(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



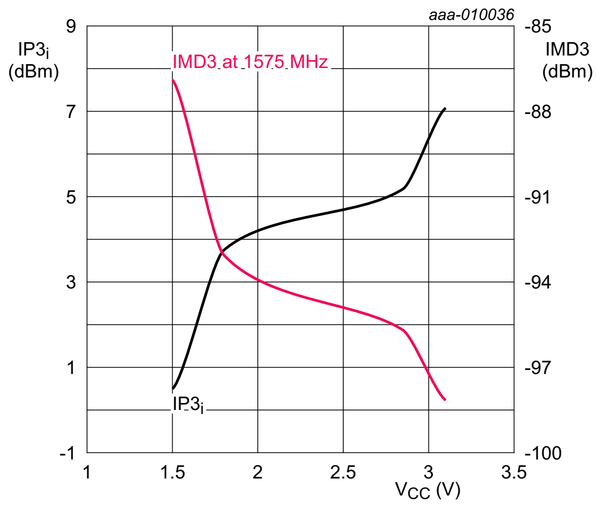
f = 1575 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

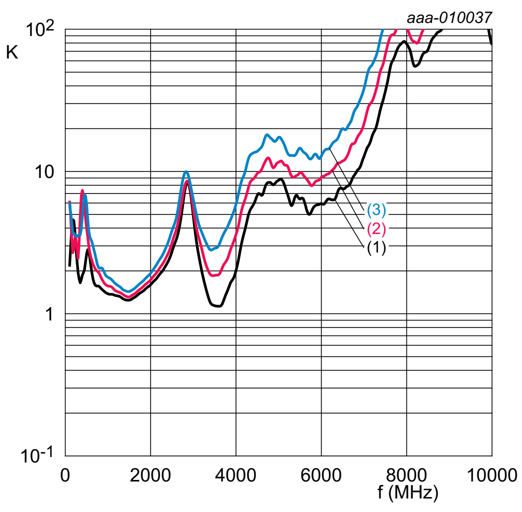
(3) T_{amb} = +85 °C

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



f_1 = 1713 MHz; f_2 = 1851 MHz; P_i = −20 dBm at f_1; P_i = −65 dBm at f_2; T_{amb} = 25 °C.

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



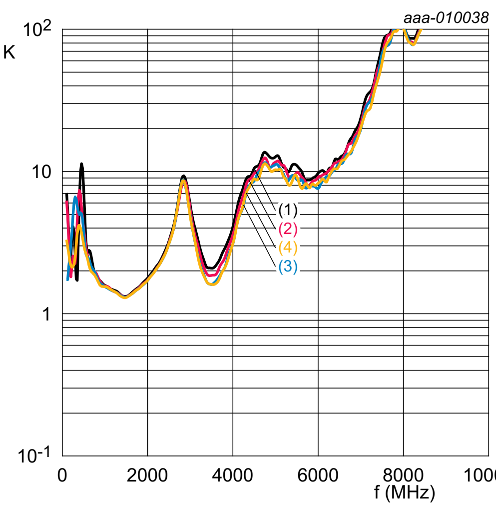
P_i = −45 dBm; V_{CC} = 1.8 V.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 29. Rollett stability factor 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

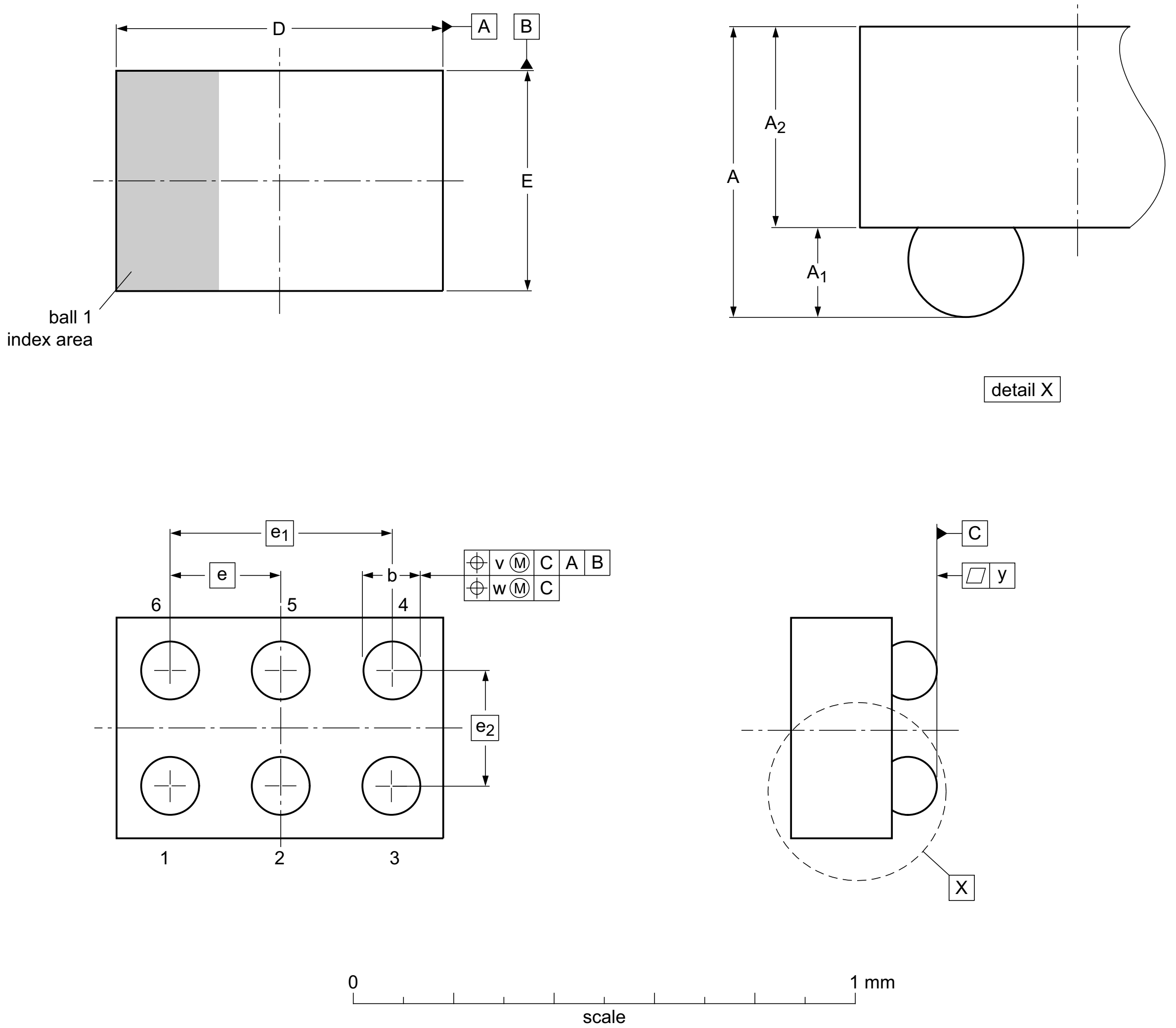
(3) V_{CC} = 2.85 V

(4) V_{CC} = 3.1 V

Fig 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**



Dimensions (mm are the original dimensions)

Unit		A	A_1	A_2	b	D	E	e	e_1	e_2	v	w	y
mm	max	0.32	0.105	0.215	0.131	0.68	0.47						
	nom	0.29	0.090	0.200	0.116	0.65	0.44	0.22	0.44	0.23	0.05	0.05	0.01
	min	0.26	0.075	0.185	0.101	0.62	0.41						

wlcsp6_bgu8004_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
BGU8004						~~13-10-09~~ 13-11-04

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[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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For sales office addresses, please send an email to: **salesaddresses@nxp.com**

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