

# BGU8309

## SiGe:C low-noise amplifier MMIC for GPS, GLONASS, Galileo and COMPASS

Rev. 4 — 18 January 2017 Product data sheet

## 1. General description

The BGU8309 is, also known as the GPS1401M, a low current Low Noise-Amplifier (LNA) for GNSS receiver applications. The BGU8309 is available in a small plastic 5-pin extremely thin leadless package. The BGU8309 requires only one external matching inductor and is optimized for higher $IP3_i$ performance.

The BGU8309 adapts itself to the changing environment resulting from co-habitation of different radio systems in modern cellular handsets. It has been designed for ultra low power consumption and optimal 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 0.65 dB and a supply current of 3.6 mA. During high jamming power levels, resulting for example from a cellular transmit burst, it temporarily increases its bias current to improve sensitivity.

## 2. Features and benefits

- Out of band $IP3_i$ of 5 dBm
- Optimized performance at a low supply current of 3.6 mA
- Covers full GNSS L1 band, from 1559 MHz to 1610 MHz
- Noise figure = 0.7 dB
- Gain 17 dB
- Input 1 dB compression point of −9 dBm
- Supply voltage 1.5 V to 3.1 V
- Integrated supply decoupling capacitor
- Power-down mode current consumption < 1 μA
- Integrated temperature stabilized bias for easy design
- Requires only one input matching inductor
- RF input and RF output are AC coupled through internal DC blocking caps
- ESD protection on all pins (HBM > 2 kV)
- Integrated matching for the output
- Available in a 5-pins leadless package 0.8 mm × 0.8 mm × 0.35 mm: SOT1226-2
- 180 GHz transit frequency - SiGe:C technology
- Moisture sensitivity level 1

## 3. Applications

- LNA for GPS, GLONASS
- Galileo and Compass (BeiDou) in smart phones
- Feature phones
- Tablet PCs
- Digital still cameras
- Digital video cameras
- RF front-end modules
- Complete GNSS modules
- Wearable applications

## 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 6.8 nH inductor, see Figure 3. Unless otherwise specified.*

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{CC}$ | supply voltage | | | 1.5 | - | 3.1 | V |
| $I_{CC}$ | supply current | $P_i$ < –40 dBm | | 1.6 | 3.6 | 5.6 | mA |
| $G_p$ | power gain | no jammer | | 15 | 17 | 19 | dB |
| NF | noise figure | $P_i$ = –40 dBm; no jammer | [1][2] | - | 0.7 | 1.25 | dB |
| $P_{i(1dB)}$ | input power at 1 dB gain compression | | [2] | –14 | –9 | - | dBm |
| $IP3_i$ | input third-order intercept point | | [2][3] | –1 | 5 | - | dBm |

[1] PCB losses are subtracted.

[2] Guaranteed by device design, but not tested in production.

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

## 5. Ordering information

**Table 2. Ordering information**

| Type number | Package | | |
|---|---|---|---|
| | Name | Description | Version |
| BGU8309 | X2SON5 | plastic thermal enhanced extremely thin small outline package; no leads; 5 terminals; body 0.8 × 0.8 × 0.35 mm | SOT1226-2 |
| OM17017 | EVB | BGU8309; evaluation board, MMIC only | - |

## 6. Marking

**Table 3. Marking codes**

| Type number | Marking code |
|---|---|
| BGU8309 | A |


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# 7. Block diagram

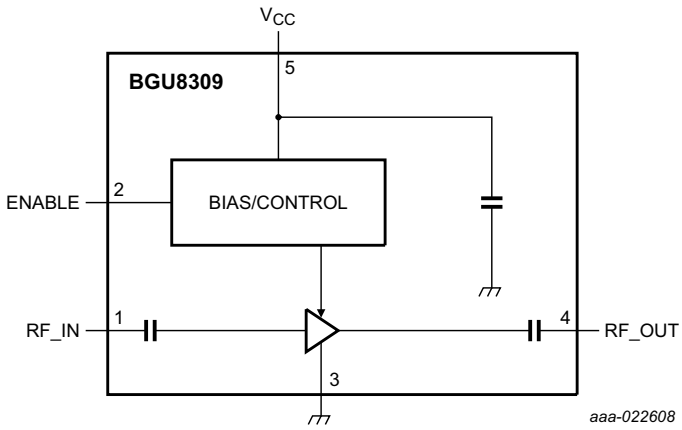
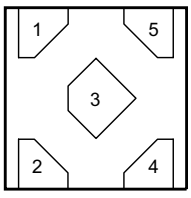



**Fig 1. Block diagram**

# 8. Pinning information

## 8.1 Pinning




Transparent top view

**Fig 2. Pin configuration**

## 8.2 Pin description

**Table 4. Pin description**

| Symbol | Pin | Description |
|---|---|---|
| RF_IN | 1 | RF input |
| ENABLE | 2 | enable |
| GND | 3 | ground |
| RF_OUT | 4 | RF output |
| $V_{CC}$ | 5 | supply voltage |


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# 9. Limiting values

**Table 5. Limiting values**

*In accordance with the Absolute Maximum Rating System (IEC 60134).*
*See Section 18.3 "Disclaimers", paragraph "Limiting values".*

| Symbol | Parameter | Conditions | Min | Max | Unit |
|---|---|---|---|---|---|
| $V_{CC}$ | supply voltage | [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 | [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 JEDEC standard JS-001-2010 | - | ±2 | kV |
| | | Charged Device Model (CDM) according to JEDEC standard JESD22-C101C | - | ±1 | kV |

[1] Stressed with pulses of 200 ms in duration, with application circuit as in Figure 3.

[2] Warning: Due to internal ESD diode protection, to avoid excess current, the applied DC voltage must not exceed $V_{CC}$ + 0.6 V or 5.0 V.

[3] The RF input and RF output are AC coupled through internal DC blocking capacitors.

# 10. Recommended operating conditions

**Table 6. 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 |

# 11. Thermal characteristics

**Table 7. Thermal characteristics**

| Symbol | Parameter | Conditions | Typ | Unit |
|---|---|---|---|---|
| $R_{th(j\text{-}bop)}$ | thermal resistance from junction to bottom of package | in free air [1] | 192 | K/W |
| $R_{th(j\text{-}pcb)}$ | thermal resistance from junction to printed-circuit board | in free air [2] | 330 | K/W |
| $\Psi_{j\text{-}pcb}$ | thermal characterization parameter from junction to printed-circuit board | in free air [2] | 177 | K/W |

[1] Simulated using finite element method resembling device on NXP application board.

[2] Measured with device mounted on NXP application board.


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# 12. Characteristics

**Table 8. Characteristics at $V_{CC}$ = 1.8 V**

*f = 1575 MHz; $V_{I(ENABLE)} \geq 0.8$ V; $P_i < -40$ dBm; $T_{amb}$ = 25 °C; input matched to 50 Ω using a 6.8 nH inductor, see Figure 3, 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 | 1.6 | 3.6 | 5.6 | mA |
| | | $P_i = -20$ dBm | - | 4.6 | - | mA |
| | | $V_{I(ENABLE)} \leq 0.3$ V | - | - | 1 | µA |
| $G_p$ | power gain | no jammer | 15 | 17 | 19 | dB |
| | | $P_{jam} = -20$ dBm; $f_{jam}$ = 850 MHz | - | 17 | - | dB |
| | | $P_{jam} = -20$ dBm; $f_{jam}$ = 1850 MHz | - | 17 | - | dB |
| $RL_{in}$ | input return loss | $P_i < -40$ dBm | - | 12 | - | dB |
| | | $P_i = -20$ dBm | - | 12 | - | dB |
| $RL_{out}$ | output return loss | $P_i < -40$ dBm | - | 10 | - | dB |
| | | $P_i = -20$ dBm | - | 10 | - | dB |
| ISL | isolation | | - | 22 | - | dB |
| NF | noise figure | $P_i = -40$ dBm; no jammer [1][2] | - | 0.7 | 1.25 | dB |
| | | $P_i = -40$ dBm; no jammer [2][3] | - | 0.8 | 1.35 | dB |
| | | $P_{jam} = -20$ dBm; $f_{jam}$ = 850 MHz [3] | - | 1.0 | - | dB |
| | | $P_{jam} = -20$ dBm; $f_{jam}$ = 1850 MHz [3] | - | 1.4 | - | dB |
| $P_{i(1dB)}$ | input power at 1 dB gain compression | [2] | −14 | −9 | - | dBm |
| $IP3_i$ | input third-order intercept point | [2][4] | −1 | 5 | - | dBm |
| IMD3 | third-order intermodulation distortion | input [4] | - | −98 | - | dBm |
| K | Rollett stability factor | | - | >1 | - | - |
| $t_{on}$ | 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] Guaranteed by device design, but not tested in production.

[3] Including PCB losses.

[4] $f_1$ = 1713 MHz; $f_2$ = 1851 MHz; $P_i = -20$ dBm at $f_1$; $P_i = -65$ dBm at $f_2$.

**Table 9. Characteristics at $V_{CC}$ = 2.85 V**

*f = 1575 MHz; $V_{I(ENABLE)} \geq 0.8$ V; $P_i < -40$ dBm; $T_{amb}$ = 25 °C; input matched to 50 Ω using a 6.8 nH inductor, see Figure 3; 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 | 1.6 | 3.6 | 5.6 | mA |
| | | $P_i = -20$ dBm | - | 4.6 | - | mA |
| | | $V_{I(ENABLE)} \leq 0.3$ V | - | - | 1 | µA |


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**Table 9. Characteristics at $V_{CC}$ = 2.85 V** *…continued*

*f = 1575 MHz; $V_{I(ENABLE)} \geq 0.8$ V; $P_i < -40$ dBm; $T_{amb}$ = 25 °C; input matched to 50 Ω using a 6.8 nH inductor, see Figure 3; unless otherwise specified.*

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $G_p$ | power gain | no jammer | | 15 | 17 | 19 | dB |
| | | $P_{jam}$ = –20 dBm; $f_{jam}$ = 850 MHz | | - | 17 | - | dB |
| | | $P_{jam}$ = –20 dBm; $f_{jam}$ = 1850 MHz | | - | 17 | - | dB |
| $RL_{in}$ | input return loss | $P_i < -40$ dBm | | - | 12 | - | dB |
| | | $P_i$ = –20 dBm | | - | 12 | - | dB |
| $RL_{out}$ | output return loss | $P_i < -40$ dBm | | - | 10 | - | dB |
| | | $P_i$ = –20 dBm | | - | 10 | - | dB |
| ISL | isolation | | | - | 22 | - | dB |
| NF | noise figure | $P_i$ = –40 dBm; no jammer | [1][2] | - | 0.7 | 1.25 | dB |
| | | $P_i$ = –40 dBm; no jammer | [2][3] | - | 0.8 | 1.35 | dB |
| | | $P_{jam}$ = –20 dBm; $f_{jam}$ = 850 MHz | [3] | - | 1.0 | - | dB |
| | | $P_{jam}$ = –20 dBm; $f_{jam}$ = 1850 MHz | [3] | - | 1.4 | - | dB |
| $P_{i(1dB)}$ | input power at 1 dB gain compression | | [2] | –14 | –9 | - | dBm |
| $IP3_i$ | input third-order intercept point | | [2][4] | –1 | 5 | - | dBm |
| IMD3 | third-order intermodulation distortion | input | [4] | - | –98 | - | dBm |
| K | Rollett stability factor | | | - | >1 | - | - |
| $t_{on}$ | 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] Guaranteed by device design, but not tested in production.

[3] Including PCB losses.

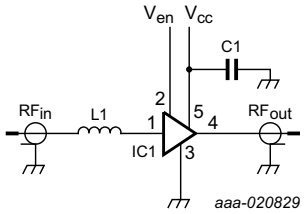
[4] $f_1$ = 1713 MHz; $f_2$ = 1851 MHz; $P_i$ = –20 dBm at $f_1$; $P_i$ = –65 dBm at $f_2$.


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# 13. Application information

## 13.1 GNSS LNA




For a list of components, see Table 10.

**Fig 3. Schematics GNSS LNA evaluation board**

**Table 10. List of components**

*For schematics, see Figure 3.*

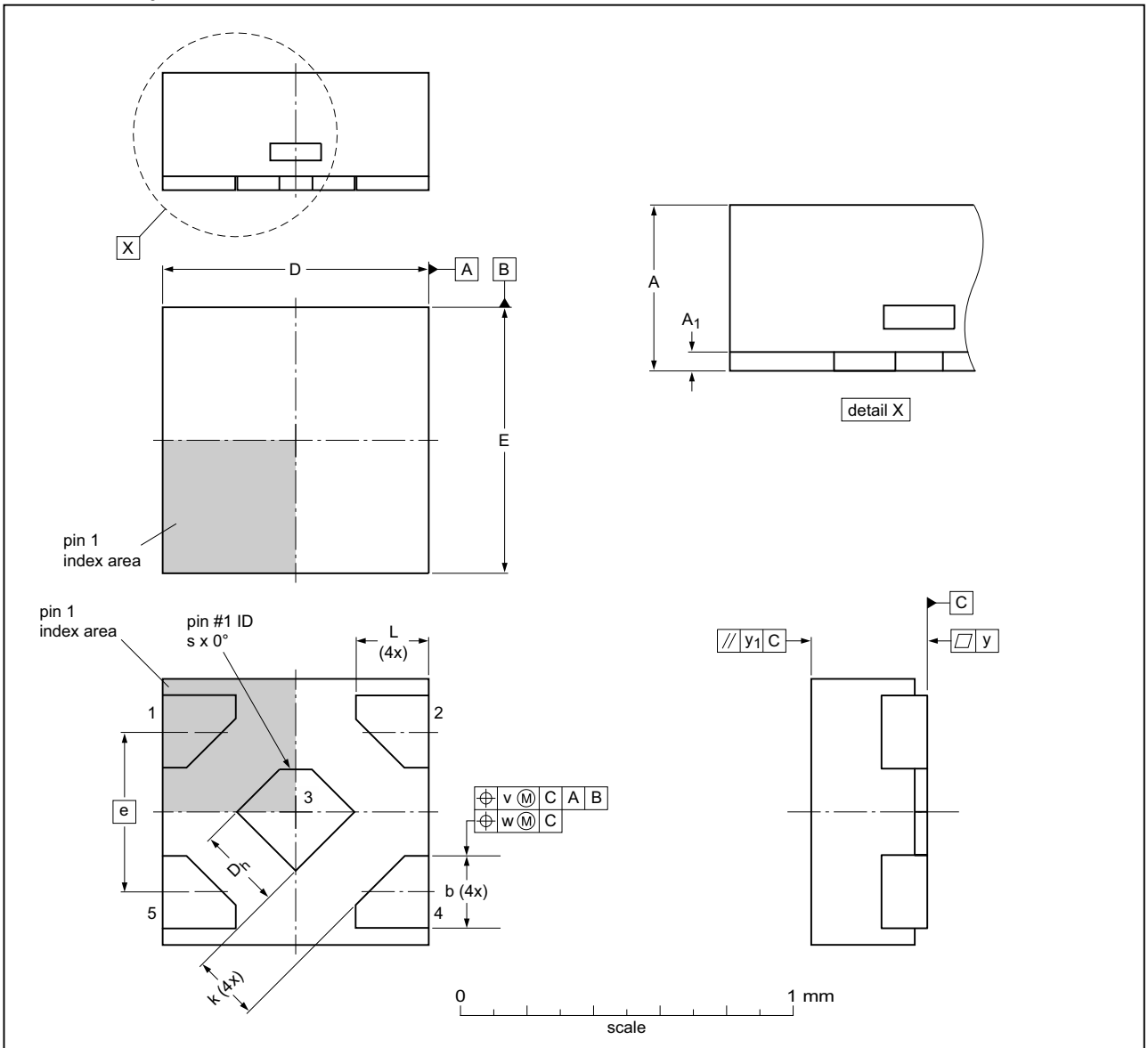
| Component | Description | Value | Remarks |
|---|---|---|---|
| C1 | decoupling capacitor | 1 nF | to suppress power supply noise |
| IC1 | BGU8309 | - | NXP Semiconductors |
| L1 | high-quality matching inductor | 6.8 nH | Murata LQW15A |


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# 14. Package outline

**X2SON5: plastic thermal enhanced extremely thin small outline package; no leads; 5 terminals; body 0.8 x 0.8 x 0.32 mm** **SOT1226-2**




Dimensions (mm are the original dimensions)

| Unit | | A | $A_1$ | D | $D_h$ | E | b | e | K | L | s | v | w | y | $y_1$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | max | 0.35 | 0.04 | 0.85 | 0.30 | 0.85 | 0.27 | | | 0.27 | | | | | |
| | nom | 0.32 | 0.02 | 0.80 | 0.25 | 0.80 | 0.22 | 0.48 | | 0.22 | 0.1 | 0.1 | 0.05 | 0.05 | 0.05 |
| | min | 0.30 | 0.00 | 0.75 | 0.20 | 0.75 | 0.17 | | 0.20 | 0.17 | (ref) | | | | |

*sot1226-2_po*

| Outline version | References | | | | European projection | Issue date |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | EIAJ | | | |
| SOT1226-2 | | - - - | | | | ~~16-03-31~~ 16-04-05 |

**Fig 4. Package outline SOT1226-2(X2SON5)**


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## 15. 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.

## 16. Abbreviations

**Table 11. Abbreviations**

| Acronym | Description |
|---|---|
| ESD | ElectroStatic Discharge |
| HBM | Human Body Model |
| GLONASS | Globalnaya Navigazionnaya Sputnikovaya Sistema |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| LNA | Low-Noise Amplifier |
| RF | Radio Frequency |
| TDD | Time-Division Duplexing |


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# 17. Revision history

**Table 12. Revision history**

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| BGU8309 v.4 | 20170118 | Product data sheet | - | BGU8309 v.3 |
| Modifications: | Section 1: added GPS1401M according to our new naming convention | | | |
| BGU8309 v.3 | 20161102 | Product data sheet | - | BGU8309 v.2 |
| Modification: | • Table 8 on page 5: the minimum value for $I_{CC}$, $P_i$ < –40 dBm has been changed to 1.6<br>• Table 8 on page 5; the maximum value for $I_{CC}$, $P_i$ < –40 dBm has been changed to 5.6<br>• Table 8 on page 5: the minimum value for $G_p$, no jammer has been changed to 15<br>• Table 8 on page 5: the maximum value for $G_p$, no jammer has been changed to 19<br>• Table 8 on page 5: the maximum value for NF, $P_i$ = –40 dBm; no jammer has been changed to 1.25<br>• Table 8 on page 5: the maximum value for NF, $P_i$ = –40 dBm; no jammer has been changed to 1.35<br>• Table 8 on page 5: the minimum value for $P_{i(1dB)}$ has been changed to –14<br>• Table 8 on page 5: the minimum value for $IP3_i$ has been changed to –1<br>• Table 9 on page 5: the minimum value for $I_{CC}$, $P_i$ < –40 dBm has been changed to 1.6<br>• Table 9 on page 5; the maximum value for $I_{CC}$, $P_i$ < –40 dBm has been changed to 5.6<br>• Table 9 on page 5: the minimum value for $G_p$, no jammer has been changed to 15<br>• Table 9 on page 5: the maximum value for $G_p$, no jammer has been changed to 19<br>• Table 9 on page 5: the maximum value for NF, $P_i$ = –40 dBm; no jammer has been changed to 1.25<br>• Table 9 on page 5: the maximum value for NF, $P_i$ = –40 dBm; no jammer has been changed to 1.35<br>• Table 9 on page 5: the minimum value for $P_{i(1dB)}$ has been changed to –14<br>• Table 9 on page 5: the minimum value for $IP3_i$ has been changed to –1 | | | |
| BGU8309 v.2 | 20160808 | Product data sheet | - | BGU8309 v.1 |
| Modification: | • Status changed from objective to product. | | | |
| BGU8309 v.1 | 20160718 | Objective data sheet | - | - |


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# 18. Legal information

## 18.1 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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