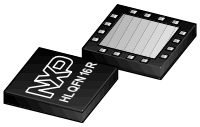


# BGU7078

## Analog high linearity low noise variable gain amplifier

Rev. 3 — 15 February 2017 Product data sheet

## 1. General description

The BGU7078 is a fully integrated analog-controlled variable gain amplifier module. Its low noise and high linearity performance makes it ideal for sensitive receivers in cellular base station applications. The BGU7078 is designed for the 1710 MHz to 1785 MHz frequency range. It has a gain control range of more than 35 dB. At maximum gain, the noise figure is 0.8 dB. The gain is analog-controlled having maximum gain at 3.3 V. The LNA can be bypassed extending the dynamic range. The BGU7078 is internally matched to 50 Ω meaning no external matching is required, enabling ease of use. It is housed in a 16 pins 8 mm × 8 mm × 1.3 mm leadless HLQFN16R package SOT1301.

## 2. Features and benefits

- Input and output internally matched to 50 Ω
- Low noise figure of 0.8 dB
- High input $IP3_i$ of 1.9 dBm
- High $P_{i(1dB)}$ of −11.3 dBm
- Bypass mode of LNA giving high dynamic gain range
- Gain control range of 0 dB to 35 dB
- Single 5 V supply
- Single analog gain control of 0 V to 3.3 V
- Unconditionally stable up to 12.75 GHz
- Moisture sensitivity level 3
- ESD protection at all pins

## 3. Applications

- Cellular base stations, remote radio heads
- 3G, LTE infrastructure
- Low noise applications with variable gain and high linearity requirements
- Active antenna

## 4. Quick reference data

**Table 1. Quick reference data**

*GS = LOW; see Table 9; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; f = 1750 MHz; $T_{amb}$ = 25 °C; input and output 50 Ω; unless otherwise specified. All RF parameters have been characterized at the device RF input and RF output terminals.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{CC(tot)}$ | total supply current | | 210 | 245 | 280 | mA |
| NF | noise figure | $G_p$ = max; $V_{ctrl(Gp)}$ = 0 V | - | 0.80 | - | dB |
| | | $G_p$ = 35 dB | - | 1 | 1.2 | dB |
| $IP3_i$ | input third-order intercept point | $G_p$ = 35 dB | 0 | 1.5 | - | dBm |
| $P_{i(1dB)}$ | input power at 1 dB gain compression | $G_p$ = 35 dB | –13.5 | –11.3 | - | dBm |

## 5. Ordering information

**Table 2. Ordering information**

| Type number | Package | | |
|---|---|---|---|
| | Name | Description | Version |
| BGU7078 | HLQFN16R | plastic thermal enhanced low profile quad flat package; no leads; 16 terminals; body 8 × 8 × 1.3 mm | SOT1301-1 |

## 6. Functional diagram

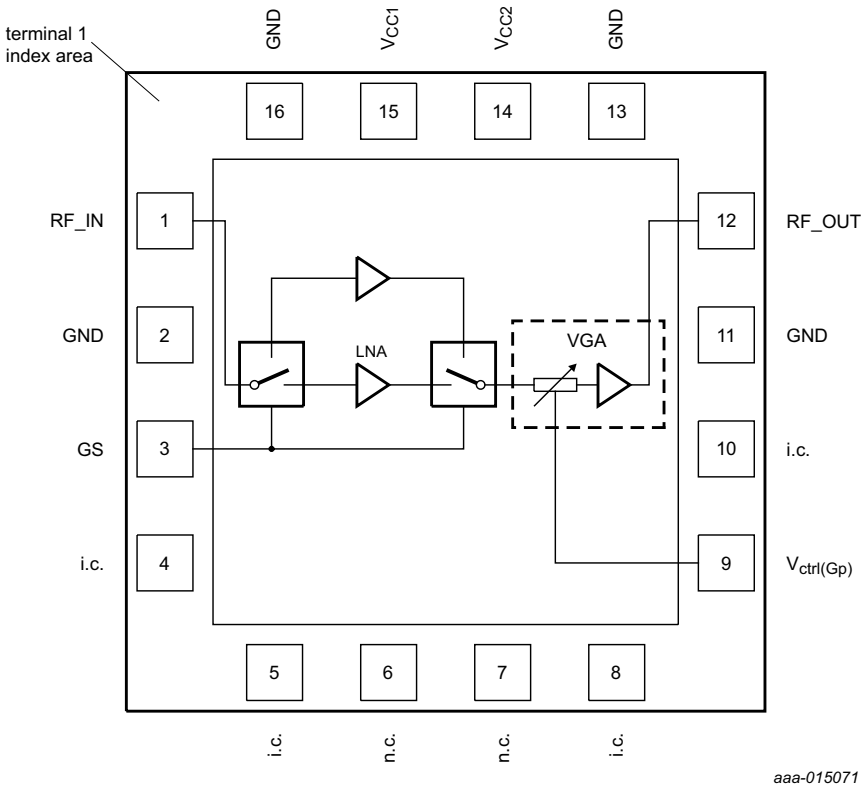



**Fig 1. Functional diagram**

# 7. Pinning information

## 7.1 Pinning

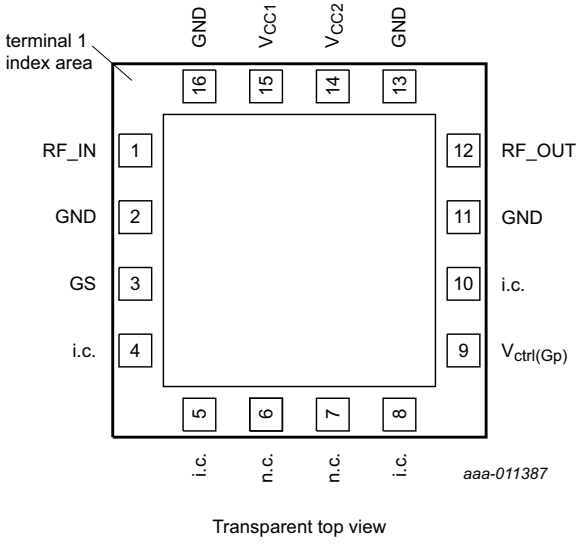



**Fig 2. Pin configuration**

## 7.2 Pin description

**Table 3. Pin description**

| Symbol | Pin | Description |
|---|---|---|
| RF_IN | 1 | RF input |
| GND | 2, 11, 13, 16 | ground |
| GS | 3 | gain switch control |
| i.c. | 4, 5, 10 | internally connected; can either be left open or grounded |
| n.c. | 6, 7 | not connected; internally left open |
| i.c. | 8 | internally connected to ground |
| $V_{ctrl(Gp)}$ | 9 | power gain control voltage |
| RF_OUT | 12 | RF output |
| $V_{CC2}$ | 14 | supply voltage 2 |
| $V_{CC1}$ | 15 | supply voltage 1 |

# 8. Limiting values

**Table 4. Limiting values**

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

| Symbol | Parameter | Conditions | Min | Max | Unit |
|---|---|---|---|---|---|
| $V_{CC}$ | supply voltage | | 0 | 6 | V |
| $V_{ctrl(Gp)}$ | power gain control voltage | | –1 | +3.6 | V |
| $V_{I(GS)}$ | input voltage on pin GS | | –1 | +3.6 | V |
| $P_{i(RF)CW}$ | continuous waveform RF input power | high gain mode; $V_{ctrl(Gp)}$ = 0 V | - | 10 | dBm |
| | | low gain mode; $V_{ctrl(Gp)}$ = 0 V | - | 10 | dBm |
| $T_j$ | junction temperature | | - | 150 | °C |
| $T_{stg}$ | storage temperature | | –40 | +150 | °C |
| $V_{ESD}$ | electrostatic discharge voltage | Human Body Model (HBM) according to ANSI/ESDA/JEDEC standard JS-001-2010 | - | ±2 | kV |
| | | Charged Device Model (CDM) according to JEDEC standard JESD22-C101 | - | ±750 | V |

# 9. Recommended operating conditions

**Table 5. Operating conditions**

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{CC1}$ | supply voltage 1 | | 4.75 | 5 | 5.25 | V |
| $V_{CC2}$ | supply voltage 2 | | 4.75 | 5 | 5.25 | V |
| $V_{ctrl(Gp)}$ | power gain control voltage | | 0 | - | 3.3 | V |
| $V_{I(GS)}$ | input voltage on pin GS | | 0 | - | 3.3 | V |
| $Z_0$ | characteristic impedance | | - | 50 | - | Ω |
| $T_{case}$ | case temperature | | –40 | - | +85 | °C |

# 10. Thermal characteristics

**Table 6. Thermal characteristics**

| Symbol | Parameter | Conditions | Typ | Unit |
|---|---|---|---|---|
| $R_{th(j\text{-}case)}$ | thermal resistance from junction to case | [1] | 43 | K/W |

[1] The case temperature is measured at the ground solder pad.

# 11. Characteristics

**Table 7. Characteristics high gain mode**

*GS = LOW; see Table 9; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; f = 1750 MHz; $T_{amb}$ = 25 °C; input and output 50 Ω; unless otherwise specified. All RF parameters have been characterized at the device RF input and RF output terminals.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{CC(tot)}$ | total supply current | | 210 | 245 | 280 | mA |
| $G_{p(min)}$ | minimum power gain | $V_{ctrl(Gp)}$ = 3.3 V | - | 8.6 | - | dB |
| $G_{p(max)}$ | maximum power gain | $V_{ctrl(Gp)}$ = 0 V | - | 37.2 | - | dB |

**Table 7. Characteristics high gain mode** *...continued*

*GS = LOW; see Table 9; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; f = 1750 MHz; $T_{amb}$ = 25 °C; input and output 50 Ω; unless otherwise specified. All RF parameters have been characterized at the device RF input and RF output terminals.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $G_{p(flat)}$ | power gain flatness | 1710 MHz ≤ f ≤ 1785 MHz; 18 dB ≤ $G_p$ ≤ 35 dB | - | 0.4 | - | dB |
| NF | noise figure | $G_p$ = max; $V_{ctrl(Gp)}$ = 0 V | - | 0.80 | - | dB |
| | | $G_p$ = 35 dB | - | 1 | 1.2 | dB |
| | | $G_p$ = 18 dB | - | 6.1 | - | dB |
| $IP3_i$ | input third-order intercept point | 2-tone; tone-spacing = 1.0 MHz | | | | |
| | | $G_p$ = 35 dB | 0 | 1.5 | - | dBm |
| | | $G_p$ = 30 dB | - | 4.4 | - | dBm |
| | | $G_p$ = 29 dB | - | 4.7 | - | dBm |
| | | $G_p$ = 18 dB | - | 5.5 | - | dBm |
| $P_{i(1dB)}$ | input power at 1 dB gain compression | $G_p$ = 35 dB | −13.5 | −11.3 | - | dBm |
| | | $G_p$ = 30 dB | - | −7.5 | - | dBm |
| | | $G_p$ = 29 dB | - | −7.0 | - | dBm |
| | | $G_p$ = 18 dB | - | −5.7 | - | dBm |
| $RL_{in}$ | input return loss | $G_p$ = max; $V_{ctrl(Gp)}$ = 0 V | - | 22.3 | - | dB |
| | | $G_p$ = 35 dB | - | 25.7 | - | dB |
| $RL_{out}$ | output return loss | $G_p$ = max; $V_{ctrl(Gp)}$ = 0 V | - | 15.6 | - | dB |
| K | Rollett stability factor | 0 GHz ≤ f ≤ 12.75 GHz | 1 | - | - | - |

**Table 8. Characteristics low gain mode**

*GS = HIGH; see Table 9; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; f = 1750 MHz; $T_{amb}$ = 25 °C; input and output 50 Ω; unless otherwise specified. All RF parameters have been characterized at the device RF input and RF output terminals.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{CC(tot)}$ | total supply current | | 210 | 245 | 280 | mA |
| $G_{p(min)}$ | minimum power gain | $V_{ctrl(Gp)}$ = 3.3 V | - | −8.8 | - | dB |
| $G_{p(max)}$ | maximum power gain | $V_{ctrl(Gp)}$ = 0 V | - | 19.3 | - | dB |
| $G_{p(flat)}$ | power gain flatness | 1710 MHz ≤ f ≤ 1785 MHz; 3 dB ≤ $G_p$ ≤ 17 dB | - | 0.0 | - | dB |
| NF | noise figure | $G_p$ = 17 dB | - | 10.1 | - | dB |
| | | $G_p$ = 3 dB | - | 20.5 | - | dB |
| $IP3_i$ | input third-order intercept point | 2-tone; tone-spacing = 1.0 MHz | | | | |
| | | $G_p$ = 17 dB | - | 19.3 | - | dBm |
| | | $G_p$ = 12 dB | - | 21.5 | - | dBm |
| | | $G_p$ = 11 dB | - | 21.8 | - | dBm |
| | | $G_p$ = 3 dB | - | 23 | - | dBm |
| $P_{i(1dB)}$ | input power at 1 dB gain compression | $G_p$ = 17 dB | - | 6.3 | - | dBm |
| | | $G_p$ = 12 dB | - | 9.7 | - | dBm |
| | | $G_p$ = 11 dB | - | 10 | - | dBm |
| | | $G_p$ = 3 dB | - | 10.9 | - | dBm |

**Table 8. Characteristics low gain mode** *...continued*

*GS = HIGH; see Table 9; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; f = 1750 MHz; $T_{amb}$ = 25 °C; input and output 50 Ω; unless otherwise specified. All RF parameters have been characterized at the device RF input and RF output terminals.*

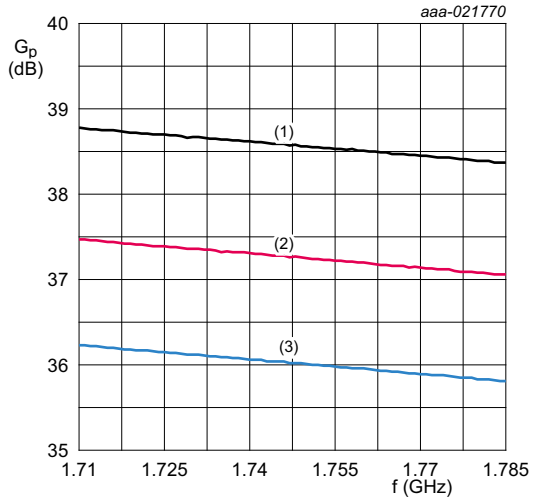
| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $RL_{in}$ | input return loss | $G_p$ = max; $V_{ctrl(Gp)}$ = 0 V | - | 30 | - | dB |
| | | $G_p$ = 17 dB | - | 33 | - | dB |
| $RL_{out}$ | output return loss | $G_p$ = max; $V_{ctrl(Gp)}$ = 0 V | - | 12.8 | - | dB |
| K | Rollett stability factor | 0 GHz ≤ f ≤ 12.75 GHz | 1 | - | - | - |

**Table 9. Gain switch truth table**

*$V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $T_{amb}$ = 25 °C.*

| Gain mode | GS | |
|---|---|---|
| | Logic | $V_{I(GS)}$ |
| High gain mode | LOW | 0 V to 0.5 V |
| Low gain mode | HIGH | 2 V to 3.3 V |

## 11.1 Graphs



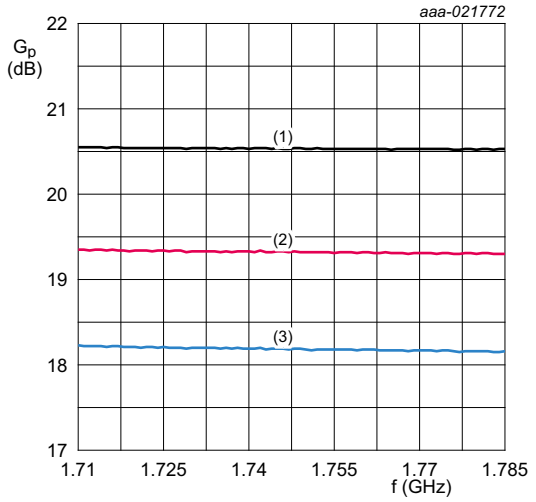

GS = LOW; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V

(1) $T_{amb}$ = −40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

**Fig 3. Power gain as a function of frequency in high gain mode; typical values**



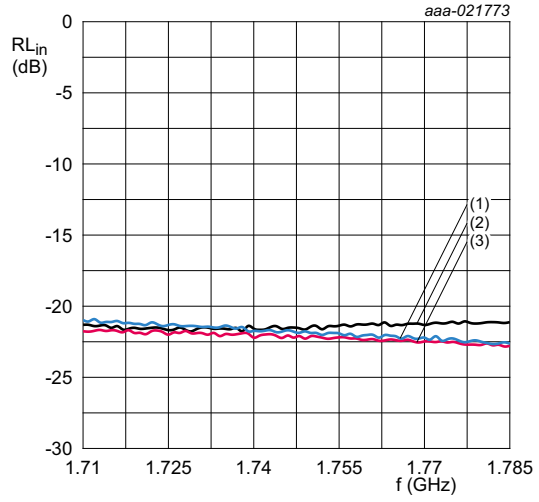

GS = HIGH; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V

(1) $T_{amb}$ = −40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

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



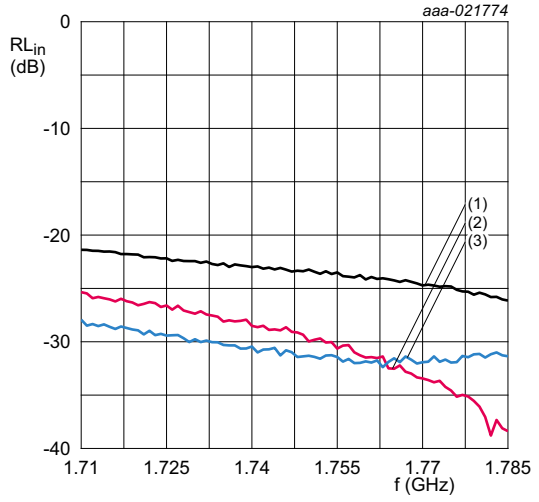

GS = LOW; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V

(1) $T_{amb}$ = –40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

**Fig 5. Input return loss as a function of frequency in high gain mode; typical values**



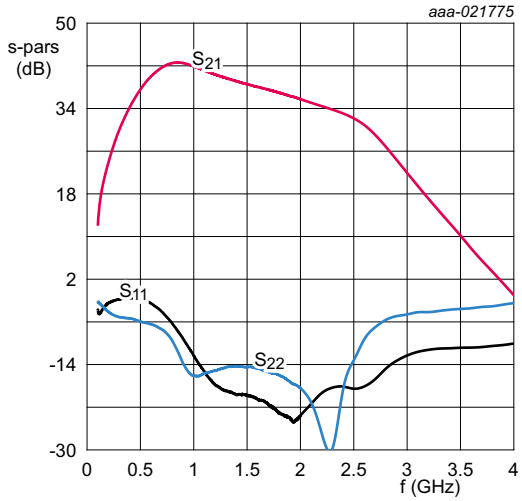

GS = HIGH; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V

(1) $T_{amb}$ = –40 °C

(2) $T_{amb}$ = +25 °C

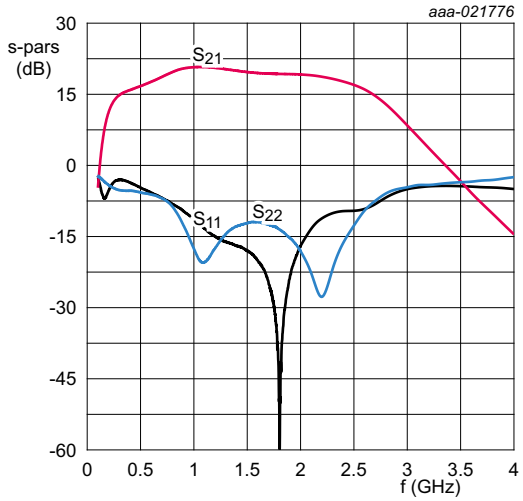
(3) $T_{amb}$ = +85 °C

**Fig 6. Input return loss as a function of frequency in low gain mode; typical values**



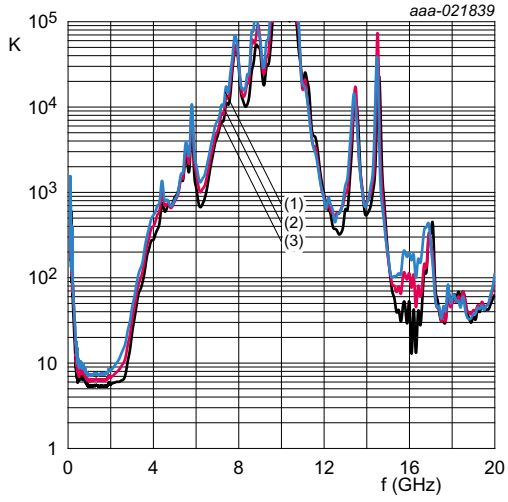

GS = LOW; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V

**Fig 7. S-parameters as a function of frequency in high gain mode; typical values**




GS = HIGH; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V

**Fig 8. S-parameters as a function of frequency in low gain mode; typical values**



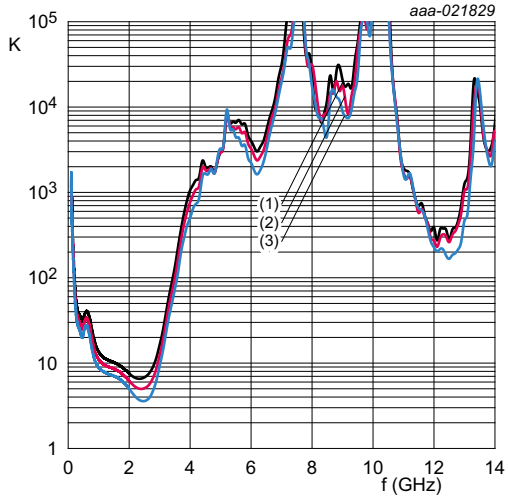

GS = LOW; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V

(1) $T_{amb}$ = −40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

**Fig 9. Rollett stability factor as a function of frequency in high gain mode; typical values**



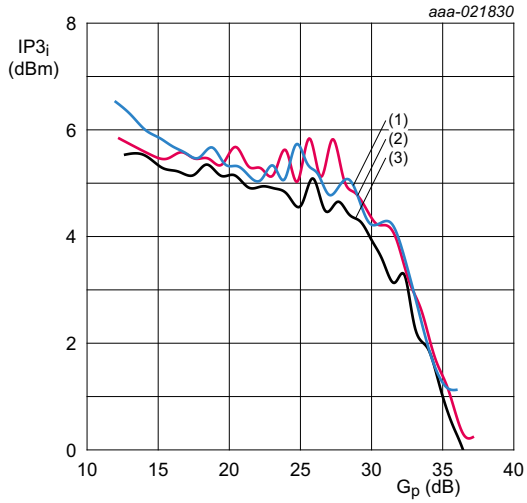

GS = HIGH; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V

(1) $T_{amb}$ = −40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

**Fig 10. Rollett stability factor as a function of frequency in low gain mode; typical values**



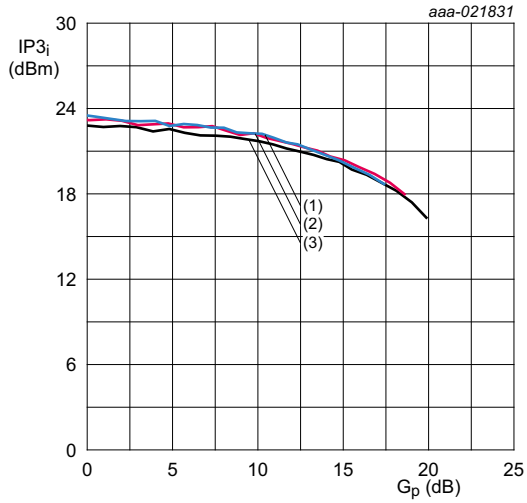

GS = LOW; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; f = 1750 MHz

(1) $T_{amb}$ = −40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

**Fig 11. Input third-order intercept point as a function of power gain in high gain mode; typical values**



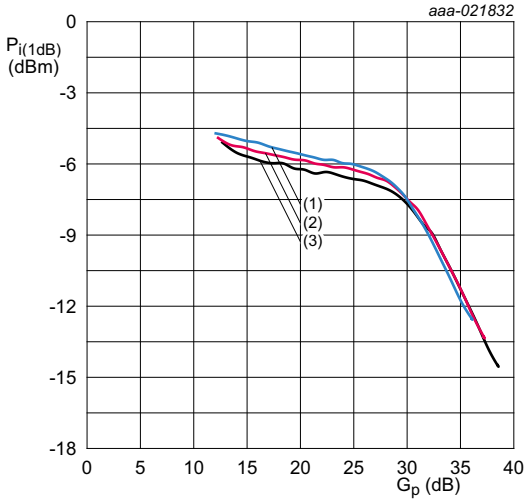

GS = HIGH; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; f = 1750 MHz

(1) $T_{amb}$ = −40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

**Fig 12. Input third-order intercept point as a function of power gain in low gain mode; typical values**



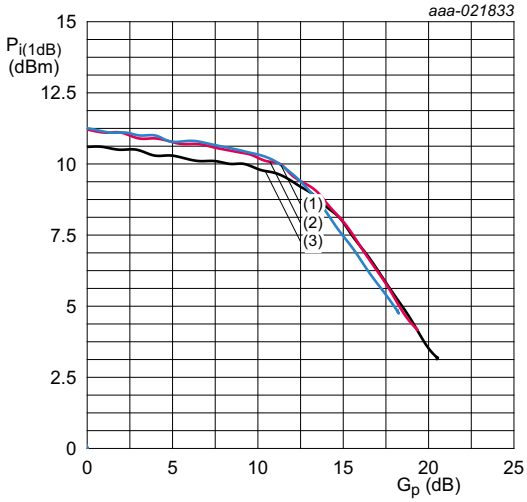

GS = LOW; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V; f = 1750 MHz

(1) $T_{amb}$ = −40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

**Fig 13. Input power at 1 dB gain compression as a function of power gain in high gain mode; typical values**



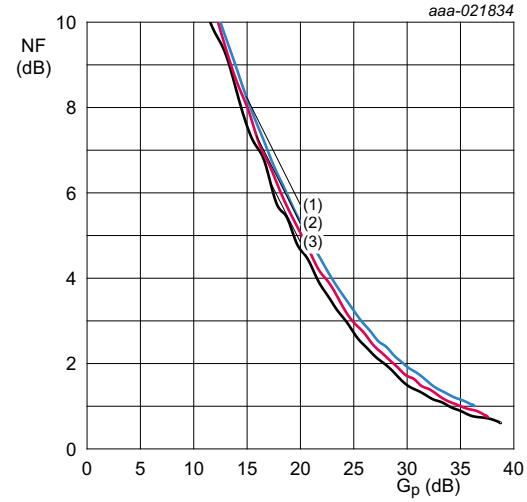

GS = HIGH; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V; f = 1750 MHz

(1) $T_{amb}$ = −40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

**Fig 14. Input power at 1 dB gain compression as a function of power gain in low gain mode; typical values**



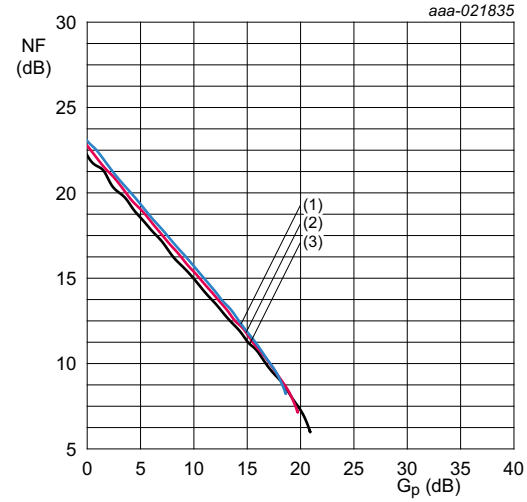

GS = LOW; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V; f = 1750 MHz

(1) $T_{amb}$ = −40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

**Fig 15. Noise figure as a function of power gain in high gain mode; typical values**



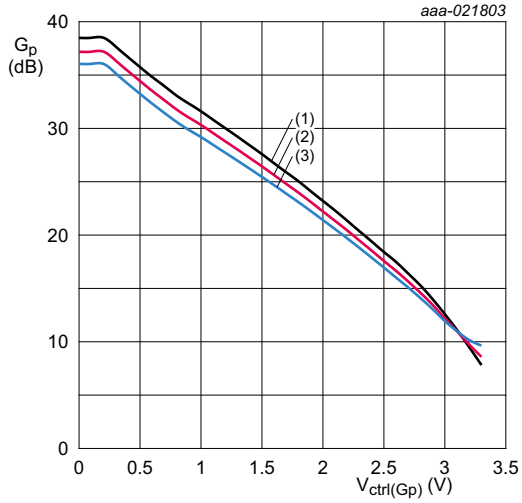

GS = HIGH; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V; f = 1750 MHz

(1) $T_{amb}$ = −40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

**Fig 16. Noise figure as a function of power gain in low gain mode; typical values**



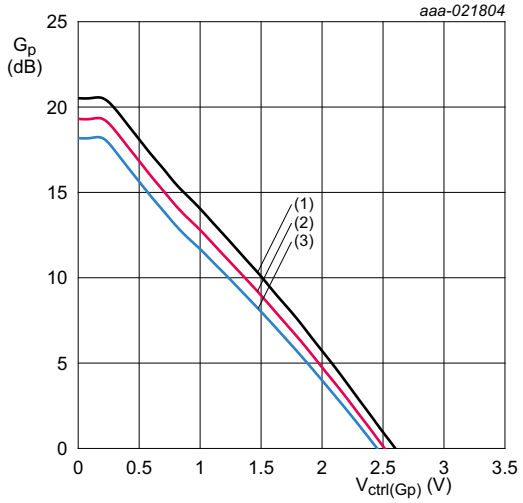

GS = LOW; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V; f = 1750 MHz

(1) $T_{amb}$ = −40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

**Fig 17. Power gain as a function of frequency in high gain mode; typical values**




GS = HIGH; $V_{CC1}$ = 5 V; $V_{CC2}$ = 5 V; $V_{ctrl(Gp)}$ = 0 V; f = 1750 MHz

(1) $T_{amb}$ = −40 °C

(2) $T_{amb}$ = +25 °C

(3) $T_{amb}$ = +85 °C

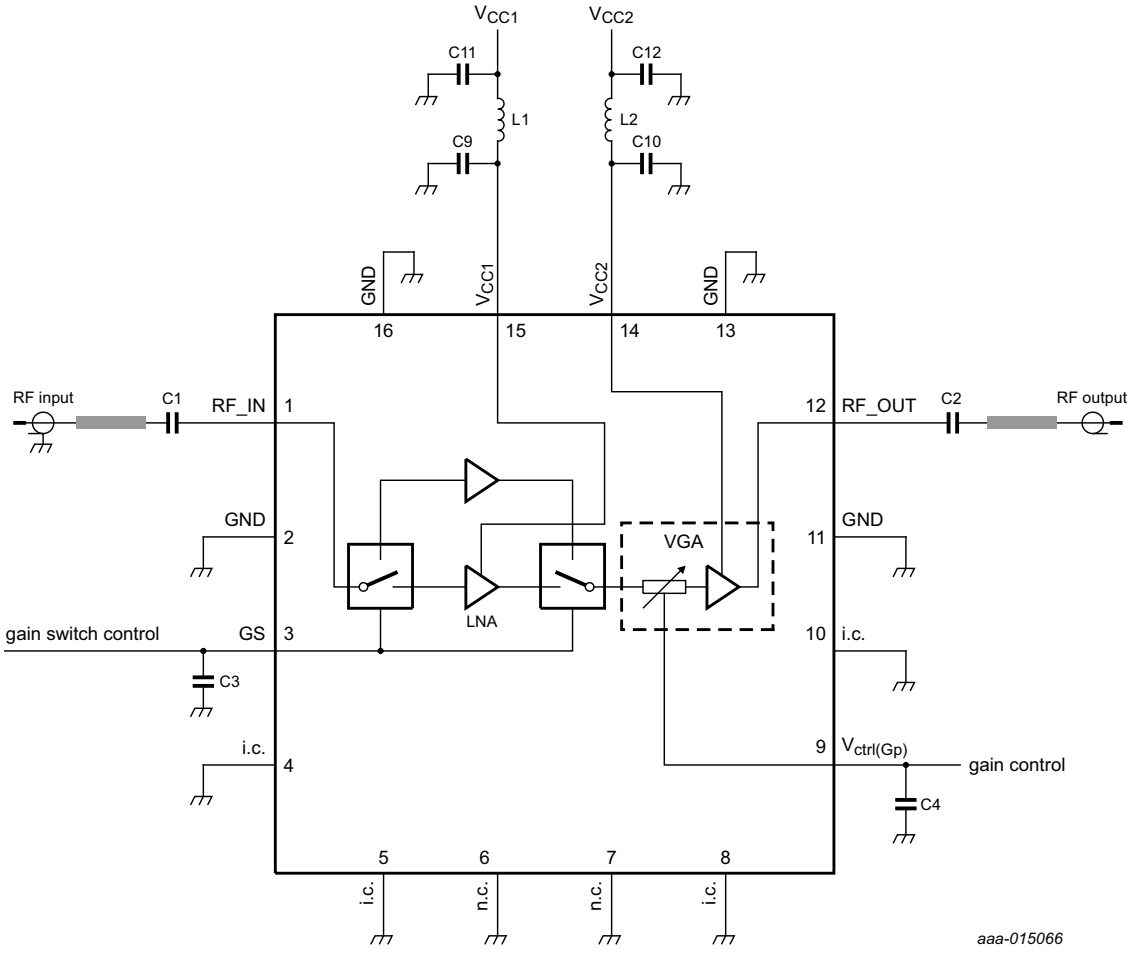
**Fig 18. Power gain as a function of frequency in low gain mode; typical values**

## 12. Application information

**Table 10. List of components**

*For application circuit, see Figure 19.*

| Component | Description | Value | Remarks |
|---|---|---|---|
| C1, C2 | capacitor | 1 nF | SMD 0402 |
| C3, C4, C9, C10 | capacitor | 100 pF | SMD 0402 |
| C11, C12 | capacitor | 100 nF | SMD 0402 |
| L1, L2 | inductor | 10 nH | SMD 0402 |

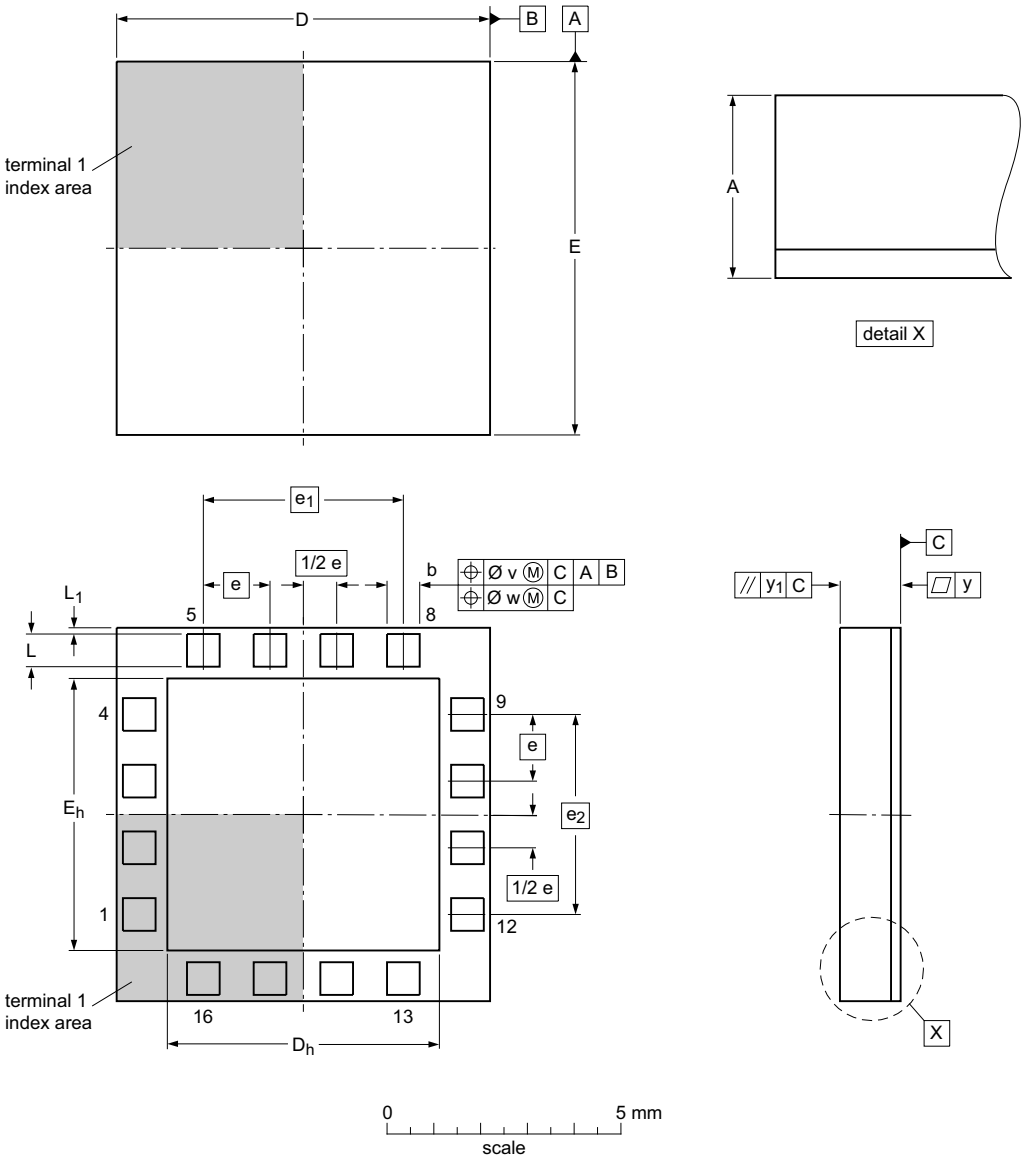



For a list of components, see Table 10.

**Fig 19. Schematic layout for application circuit**

## 13. Package outline

**HLQFN16R: plastic thermal enhanced low profile quad flat package; no leads; 16 terminals; body 8 x 8 x 1.3 mm** **SOT1301-1**




Dimensions

| Unit | | A | b | D | $D_h$ | E | $E_h$ | e | $e_1$ | $e_2$ | L | $L_1$ | v | w | y | $y_1$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | max | 1.40 | 0.75 | 8.1 | 5.85 | 8.1 | 5.85 | | | | 0.75 | 0.15 | | | | |
| mm | nom | 1.30 | 0.70 | 8.0 | 5.80 | 8.0 | 5.80 | 1.42 | 4.26 | 4.26 | 0.70 | 0.10 | 0.1 | 0.05 | 0.08 | 0.1 |
| | min | 1.25 | 0.65 | 7.9 | 5.75 | 7.9 | 5.75 | | | | 0.65 | 0.05 | | | | |

*sot1301-1_po*

| Outline version | References | | | | European projection | Issue date |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT1301-1 | | | | | | ~~11-08-23~~ 11-08-29 |

**Fig 20. Package outline SOT1301-1 (HLQFN16R)**

## 14. Abbreviations

**Table 11. Abbreviations**

| Acronym | Description |
|---|---|
| ESD | ElectroStatic Discharge |
| LNA | Low-Noise Amplifier |
| LTE | Long Term Evolution |

## 15. Revision history

**Table 12. Revision history**

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| BGU7078 v.3 | 20170215 | Product data sheet | - | BGU7078 v.2 |
| Modifications: | • Table 1 on page 2: updated the values for $I_{CC(tot)}$ | | | |
| | • Table 7 on page 4: updated the values for $I_{CC(tot)}$ | | | |
| | • Table 8 on page 5: updated the values for $I_{CC(tot)}$ | | | |
| BGU7078 v.2 | 20161215 | Product data sheet | - | BGU7078 v.1 |
| Modifications: | • Table 6 on page 4: The value for $R_{th(j\text{-}case)}$ has been updated. | | | |
| BGU7078 v.1 | 20160329 | Product data sheet | - | - |

# 16. Legal information

## 16.1 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".

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## 18. Contents





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