

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 \times 8 mm \times 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 IP_{3i} 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; $V_{CC1} = 5\text{ V}$; $V_{CC2} = 5\text{ V}$; $f = 1750\text{ MHz}$; $T_{amb} = 25\text{ }^\circ\text{C}$; input and output $50\ \Omega$; 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	$G_p = \text{max}; V_{ctrl(Gp)} = 0\text{ V}$	-	0.80	-	dB
		$G_p = 35\text{ dB}$	-	1	1.2	dB
IP3 _i	input third-order intercept point	$G_p = 35\text{ dB}$	0	1.5	-	dBm
$P_{1(dB)}$	input power at 1 dB gain compression	$G_p = 35\text{ dB}$	-13.5	-11.3	-	dBm

5. Ordering information

Table 2. Ordering information

Type number	Package		Version
	Name	Description	
BGU7078	HLQFN16R	plastic thermal enhanced low profile quad flat package; no leads; 16 terminals; body $8 \times 8 \times 1.3\text{ mm}$	SOT1301-1

6. Functional diagram

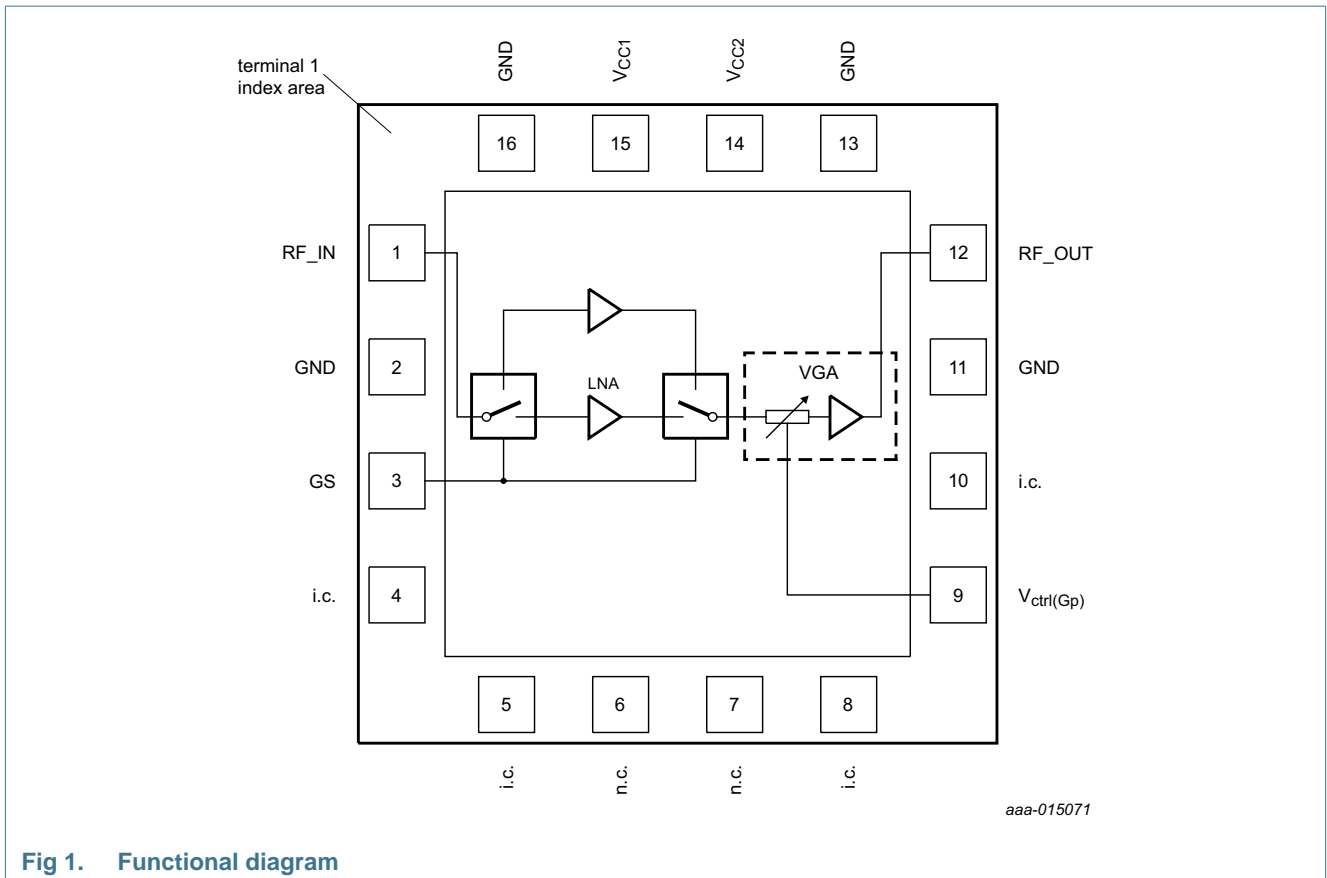


Fig 1. Functional diagram

7. Pinning information

7.1 Pinning

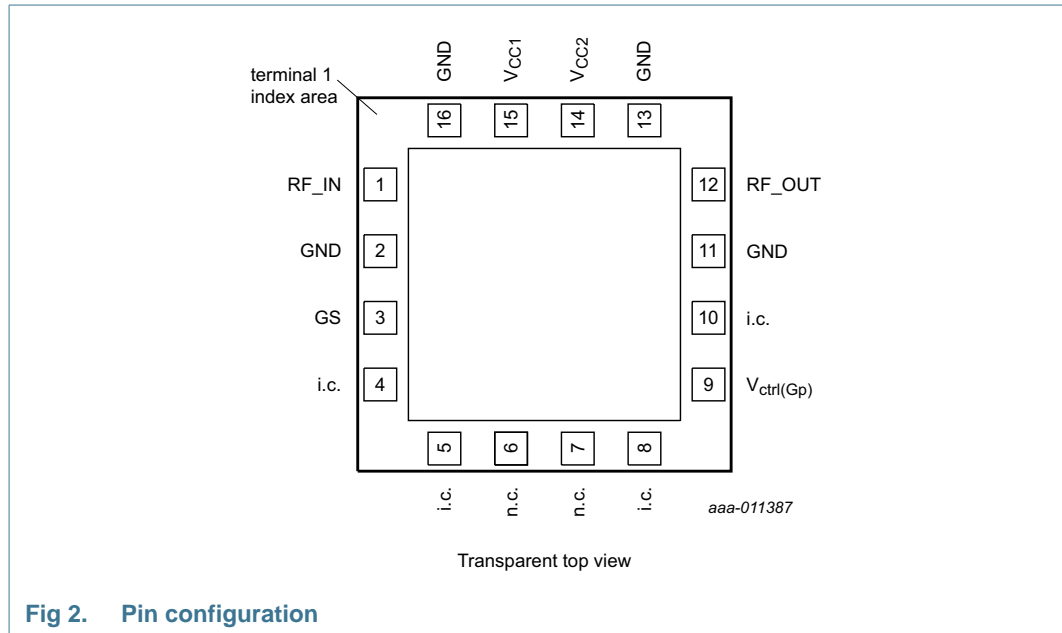


Fig 2. Pin configuration

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
$R_{th(j-case)}$	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; $V_{CC1} = 5\text{ V}$; $V_{CC2} = 5\text{ V}$; $f = 1750\text{ MHz}$; $T_{amb} = 25\text{ °C}$; input and output $50\text{ }\Omega$; 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
$G_{p(\text{flat})}$	power gain flatness	$1710\text{ MHz} \leq f \leq 1785\text{ MHz}$; $18\text{ dB} \leq G_p \leq 35\text{ dB}$	-	0.4	-	dB
NF	noise figure	$G_p = \text{max}$; $V_{\text{ctrl}(G_p)} = 0\text{ V}$	-	0.80	-	dB
		$G_p = 35\text{ dB}$	-	1	1.2	dB
		$G_p = 18\text{ dB}$	-	6.1	-	dB
IP _{3i}	input third-order intercept point	2-tone; tone-spacing = 1.0 MHz				
		$G_p = 35\text{ dB}$	0	1.5	-	dBm
		$G_p = 30\text{ dB}$	-	4.4	-	dBm
		$G_p = 29\text{ dB}$	-	4.7	-	dBm
		$G_p = 18\text{ dB}$	-	5.5	-	dBm
P _{i(1dB)}	input power at 1 dB gain compression	$G_p = 35\text{ dB}$	-13.5	-11.3	-	dBm
		$G_p = 30\text{ dB}$	-	-7.5	-	dBm
		$G_p = 29\text{ dB}$	-	-7.0	-	dBm
		$G_p = 18\text{ dB}$	-	-5.7	-	dBm
RL _{in}	input return loss	$G_p = \text{max}$; $V_{\text{ctrl}(G_p)} = 0\text{ V}$	-	22.3	-	dB
		$G_p = 35\text{ dB}$	-	25.7	-	dB
RL _{out}	output return loss	$G_p = \text{max}$; $V_{\text{ctrl}(G_p)} = 0\text{ V}$	-	15.6	-	dB
K	Rollett stability factor	$0\text{ GHz} \leq f \leq 12.75\text{ GHz}$	1	-	-	-

Table 8. Characteristics low gain mode

GS = HIGH; see Table 9; $V_{CC1} = 5\text{ V}$; $V_{CC2} = 5\text{ V}$; $f = 1750\text{ MHz}$; $T_{amb} = 25\text{ °C}$; input and output $50\text{ }\Omega$; 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
$G_{p(\text{min})}$	minimum power gain	$V_{\text{ctrl}(G_p)} = 3.3\text{ V}$	-	-8.8	-	dB
$G_{p(\text{max})}$	maximum power gain	$V_{\text{ctrl}(G_p)} = 0\text{ V}$	-	19.3	-	dB
$G_{p(\text{flat})}$	power gain flatness	$1710\text{ MHz} \leq f \leq 1785\text{ MHz}$; $3\text{ dB} \leq G_p \leq 17\text{ dB}$	-	0.0	-	dB
NF	noise figure	$G_p = 17\text{ dB}$	-	10.1	-	dB
		$G_p = 3\text{ dB}$	-	20.5	-	dB
IP _{3i}	input third-order intercept point	2-tone; tone-spacing = 1.0 MHz				
		$G_p = 17\text{ dB}$	-	19.3	-	dBm
		$G_p = 12\text{ dB}$	-	21.5	-	dBm
		$G_p = 11\text{ dB}$	-	21.8	-	dBm
		$G_p = 3\text{ dB}$	-	23	-	dBm
P _{i(1dB)}	input power at 1 dB gain compression	$G_p = 17\text{ dB}$	-	6.3	-	dBm
		$G_p = 12\text{ dB}$	-	9.7	-	dBm
		$G_p = 11\text{ dB}$	-	10	-	dBm
		$G_p = 3\text{ dB}$	-	10.9	-	dBm

Table 8. Characteristics low gain mode ...continued

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

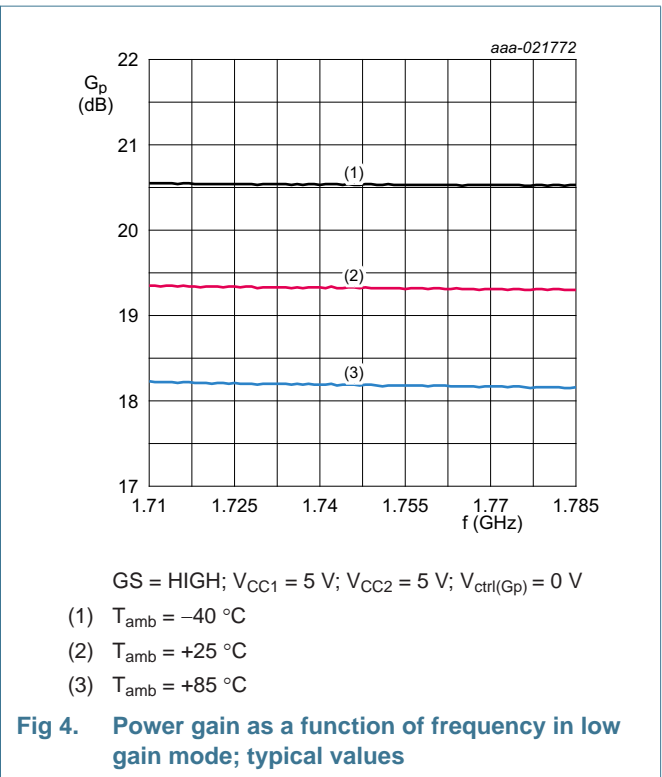
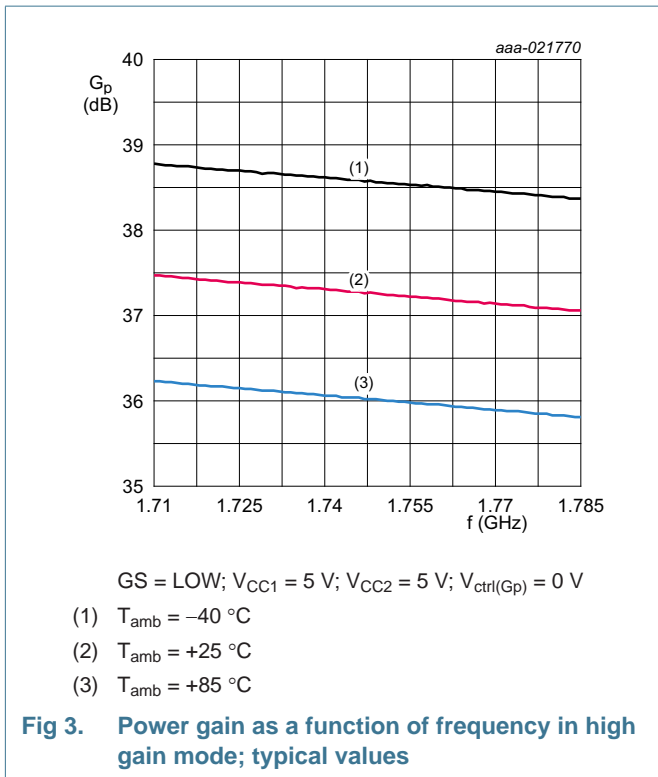
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
RL _{in}	input return loss	$G_p = \text{max}$; $V_{ctrl(Gp)} = 0\text{ V}$	-	30	-	dB
		$G_p = 17\text{ dB}$	-	33	-	dB
RL _{out}	output return loss	$G_p = \text{max}$; $V_{ctrl(Gp)} = 0\text{ V}$	-	12.8	-	dB
K	Rollett stability factor	$0\text{ GHz} \leq f \leq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

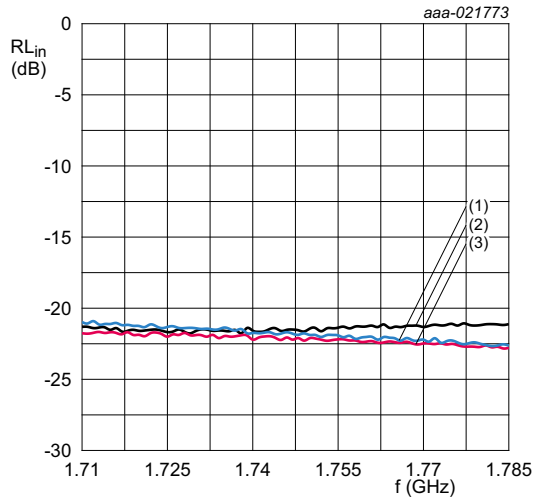
Table 9. Gain switch truth table

$V_{CC1} = 5\text{ V}$; $V_{CC2} = 5\text{ V}$; $T_{amb} = 25\text{ }^\circ\text{C}$.

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

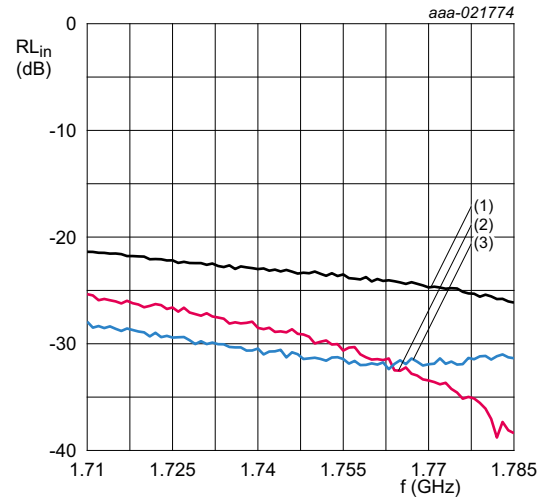
11.1 Graphs





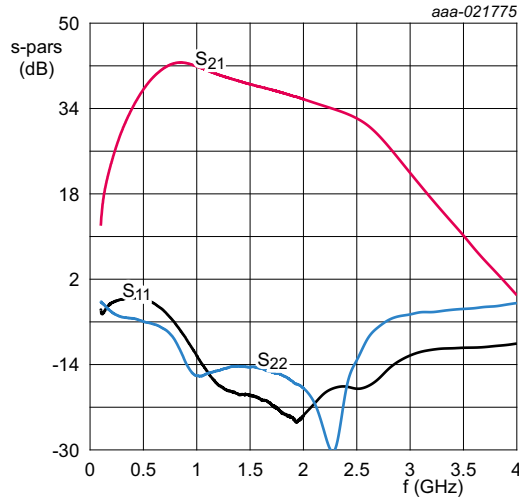
GS = LOW; $V_{CC1} = 5\text{ V}$; $V_{CC2} = 5\text{ V}$; $V_{ctrl(Gp)} = 0\text{ V}$
 (1) $T_{amb} = -40\text{ }^{\circ}\text{C}$
 (2) $T_{amb} = +25\text{ }^{\circ}\text{C}$
 (3) $T_{amb} = +85\text{ }^{\circ}\text{C}$

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



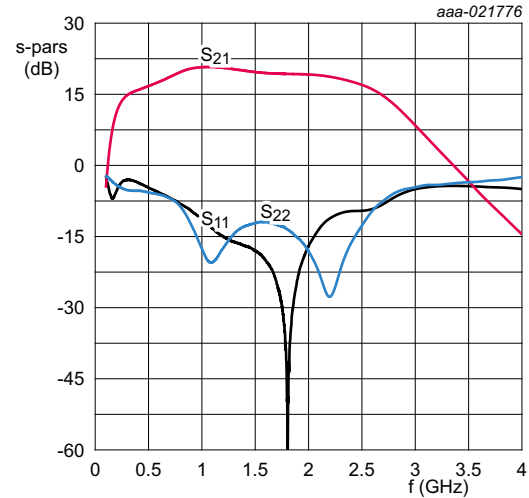
GS = HIGH; $V_{CC1} = 5\text{ V}$; $V_{CC2} = 5\text{ V}$; $V_{ctrl(Gp)} = 0\text{ V}$
 (1) $T_{amb} = -40\text{ }^{\circ}\text{C}$
 (2) $T_{amb} = +25\text{ }^{\circ}\text{C}$
 (3) $T_{amb} = +85\text{ }^{\circ}\text{C}$

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



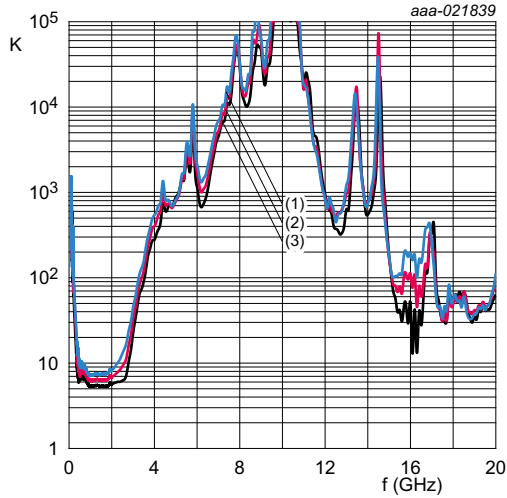
GS = LOW; $V_{CC1} = 5\text{ V}$; $V_{CC2} = 5\text{ V}$; $V_{ctrl(Gp)} = 0\text{ V}$

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



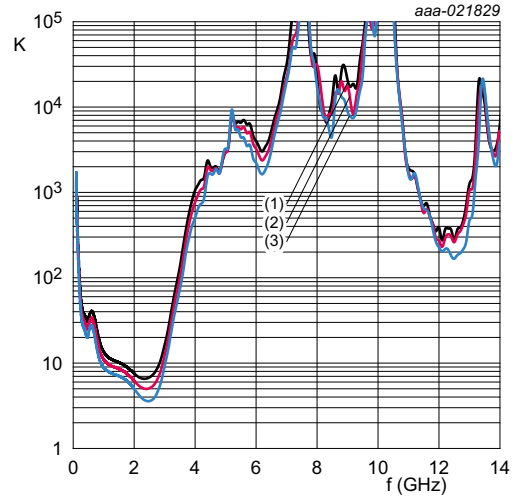
GS = HIGH; $V_{CC1} = 5\text{ V}$; $V_{CC2} = 5\text{ V}$; $V_{ctrl(Gp)} = 0\text{ V}$

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



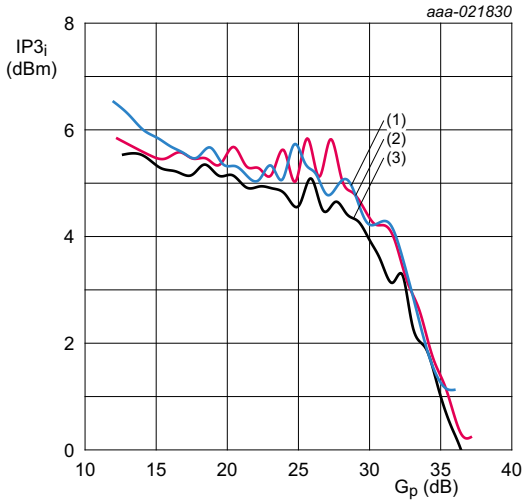
GS = LOW; $V_{CC1} = 5\text{ V}$; $V_{CC2} = 5\text{ V}$; $V_{ctrl(Gp)} = 0\text{ V}$
 (1) $T_{amb} = -40\text{ }^\circ\text{C}$
 (2) $T_{amb} = +25\text{ }^\circ\text{C}$
 (3) $T_{amb} = +85\text{ }^\circ\text{C}$

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



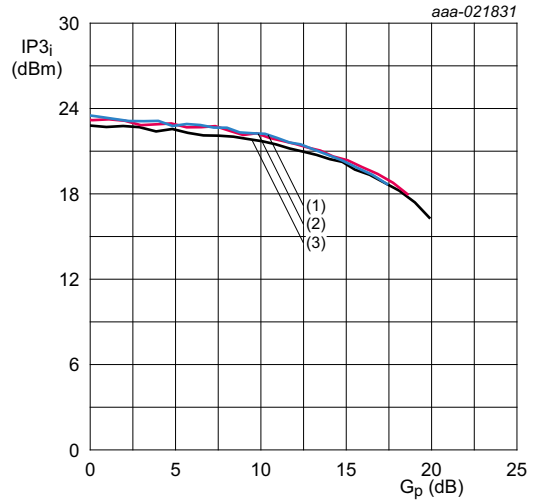
GS = HIGH; $V_{CC1} = 5\text{ V}$; $V_{CC2} = 5\text{ V}$; $V_{ctrl(Gp)} = 0\text{ V}$
 (1) $T_{amb} = -40\text{ }^\circ\text{C}$
 (2) $T_{amb} = +25\text{ }^\circ\text{C}$
 (3) $T_{amb} = +85\text{ }^\circ\text{C}$

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



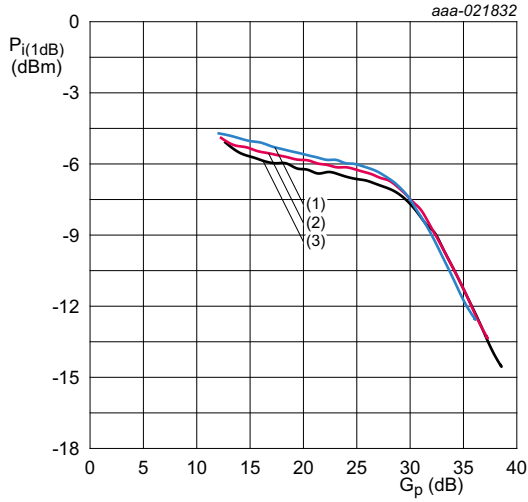
GS = LOW; $V_{CC1} = 5\text{ V}$; $V_{CC2} = 5\text{ V}$; $f = 1750\text{ MHz}$
 (1) $T_{amb} = -40\text{ }^\circ\text{C}$
 (2) $T_{amb} = +25\text{ }^\circ\text{C}$
 (3) $T_{amb} = +85\text{ }^\circ\text{C}$

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



GS = HIGH; $V_{CC1} = 5\text{ V}$; $V_{CC2} = 5\text{ V}$; $f = 1750\text{ MHz}$
 (1) $T_{amb} = -40\text{ }^\circ\text{C}$
 (2) $T_{amb} = +25\text{ }^\circ\text{C}$
 (3) $T_{amb} = +85\text{ }^\circ\text{C}$

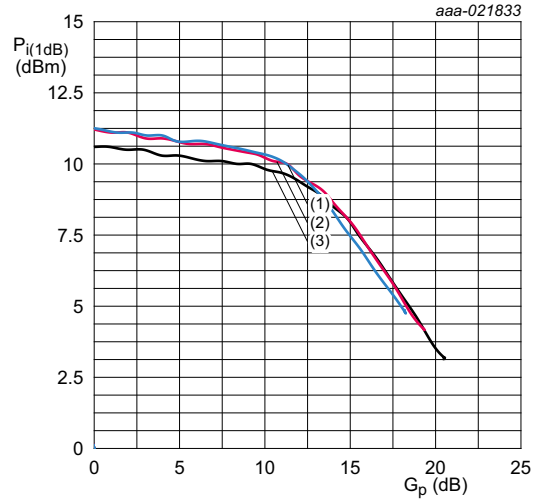
Fig 12. Input third-order intercept point as a function of power gain in low gain mode; typical values



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

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

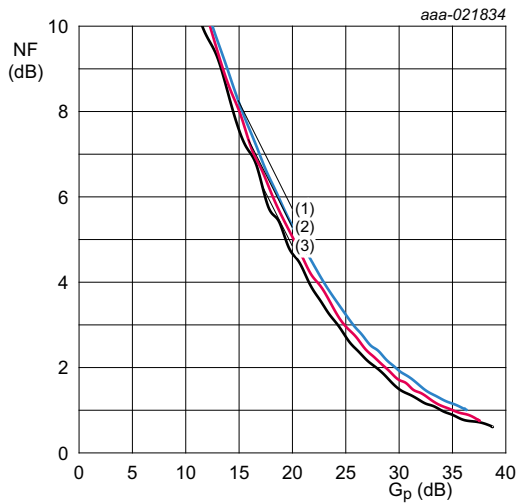
Fig 13. Input power at 1 dB gain compression as a function of power gain in high gain mode; typical values



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

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

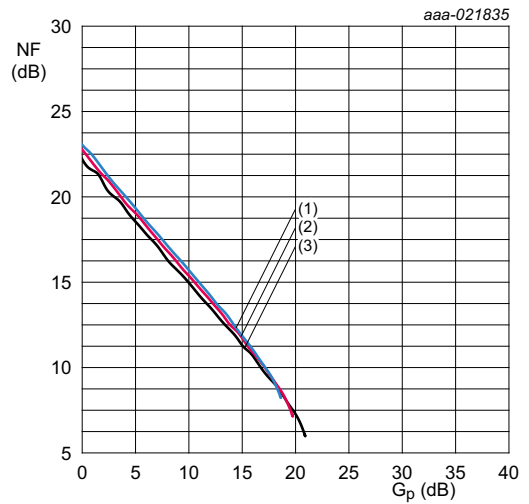
Fig 14. Input power at 1 dB gain compression as a function of power gain in low gain mode; typical values



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

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

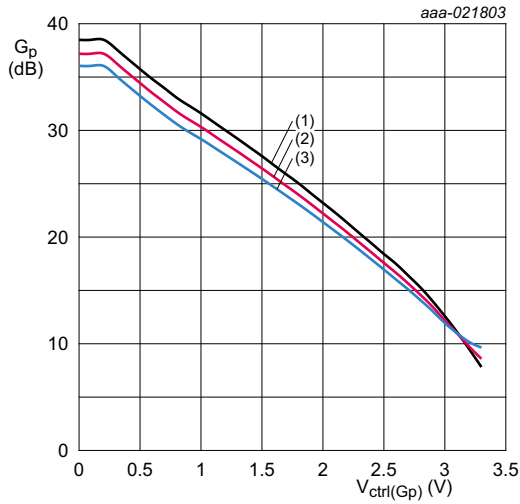
Fig 15. Noise figure as a function of power gain in high gain mode; typical values



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

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

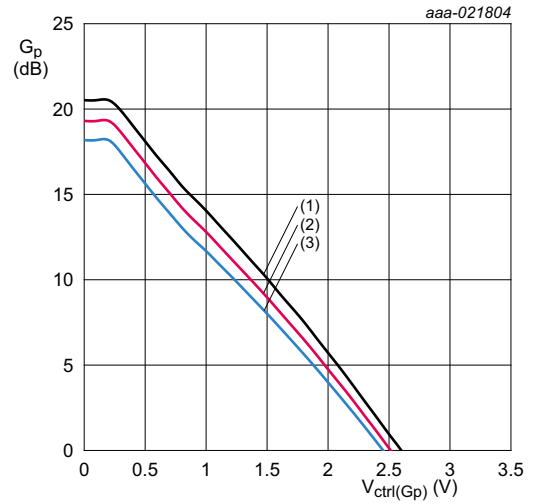
Fig 16. Noise figure as a function of power gain in low gain mode; typical values



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

- (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 17. Power gain as a function of frequency in high gain mode; typical values



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

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

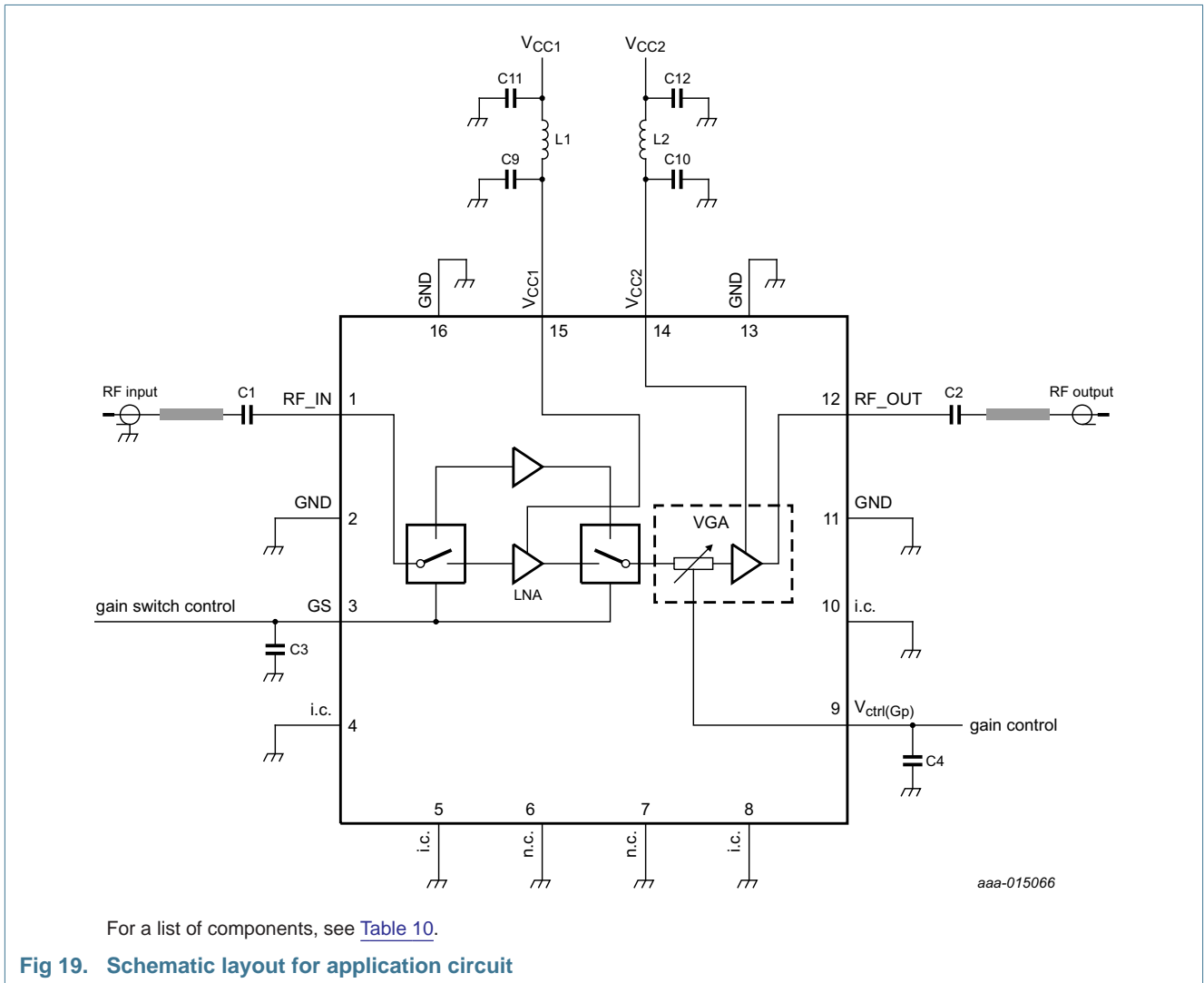
Fig 18. Power gain as a function of frequency in low gain mode; typical values

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

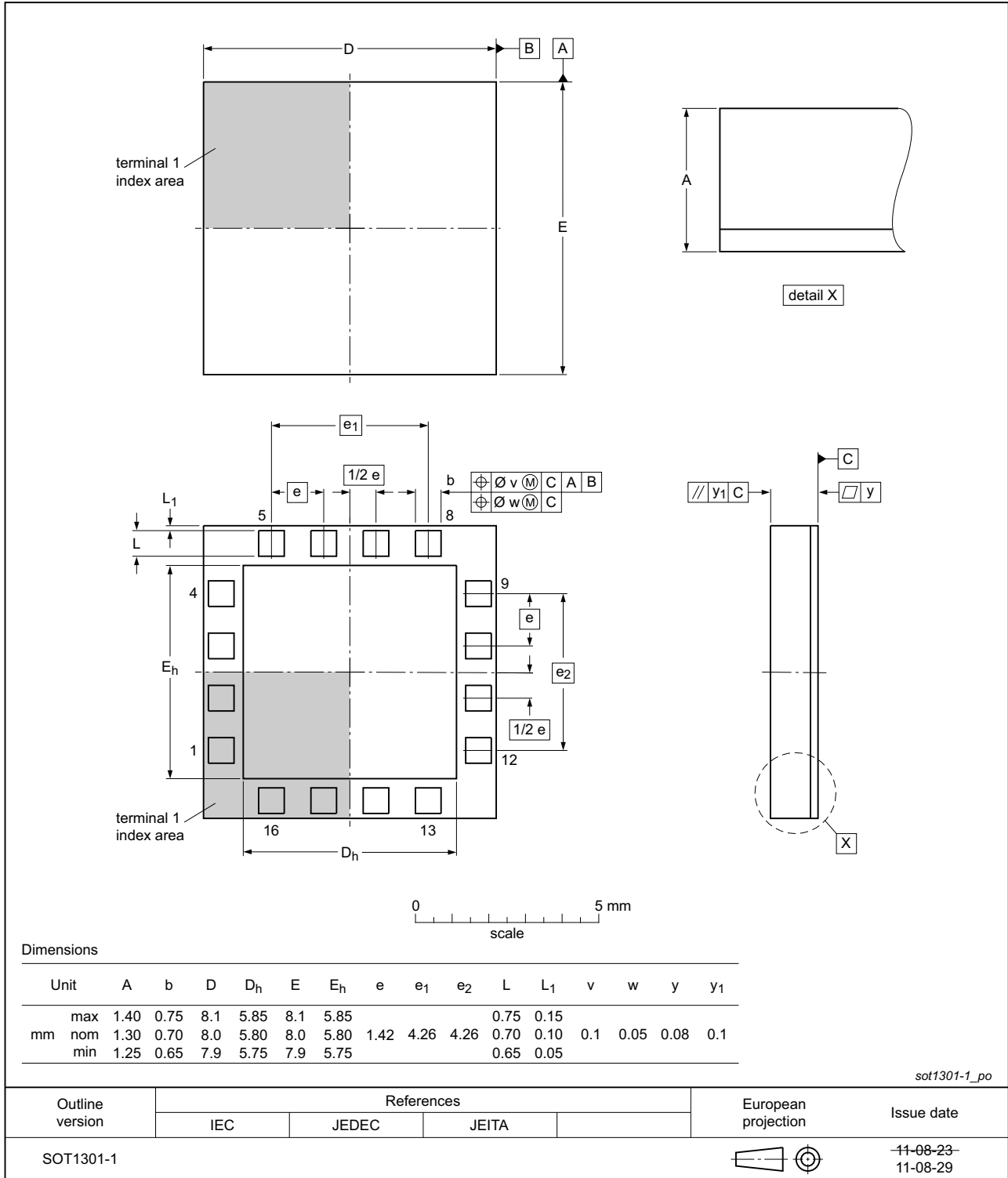


Fig 20. Package outline SOT1301-1 (HLQFN16R)

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:	<ul style="list-style-type: none"> • 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:	<ul style="list-style-type: none"> • Table 6 on page 4: The value for $R_{th(j-case)}$ 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".

[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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