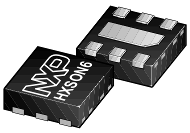


BGU7224

2.4 GHz ISM SiGe:C low-noise amplifier MMIC with bypass

Rev. 2 — 15 December 2014 Product data sheet

1. Product profile

1.1 General description

The BGU7224 is a fully integrated MMIC Low Noise Amplifier (LNA) for wireless receiver applications in the 2.4 GHz to 2.5 GHz ISM band. Manufactured in NXP's high performance SiGe:C technology, the BGU7224 couples best-in-class gain, noise figure, linearity and efficiency with the process stability and ruggedness that are the hallmarks of SiGe technology. The BGU7224 features a robust temperature-compensated internal bias network and an integral bypass / shutdown feature that stabilizes the DC operating point over temperature and enables operation in the presence of high input signals, while minimizing current consumption in bypass (standby) mode. The 1.6 mm × 1.6 mm footprint coupled with only two external component, makes the circuit board implementation of the BGU7224 the smallest IEEE 802.11b/g/n (including 256 QAM enabling “802.11n turbo”) LNA with bypass solution on the market, ideal for space sensitive applications.

1.2 Features and benefits

- IEEE 802.11b/g/n WiFi, WLAN (including 256 QAM enabling “802.11n turbo”)
- Fully integrated, high performance LNA with built-in bypass
- Integrated DC blocking at RF input and RF output, with only one external component needed.
- Low 1.0 dB noise figure with 13 mA current consumption
- Low bypass current of 2 μA (typical)
- Single supply 3.0 V to 3.6 V operation
- Integrated, temperature stabilized bias network
- Integrated concurrent 5 GHz notch filter
- High $IP3_i$ and low EVM
- High ESD protection of 2 kV (HBM) on all pins
- Small, 0.5 mm pitch, 1.6 × 1.6 × 0.5 mm QFN-style package, MSL 1 at 260 °C
- Compliant to Directive 2002/95/EC, regarding Restriction of Hazardous Substances (RoHS) following NXP’s RHF-2006 indicator D (dark green)

1.3 Applications

- IEEE 802.11b/g/n WiFi, WLAN
- Bluetooth
- IEEE 802.15.4 PAN
- Smartphones, tablets, netbooks and other portable computing devices
- Access points, routers, gateways
- Wireless video
- General purpose ISM applications

1.4 Quick reference data

Table 1. Quick reference data

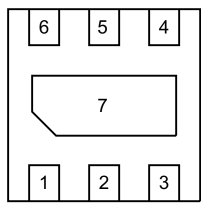
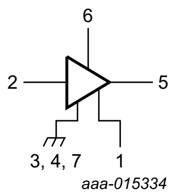
T_{amb} = 25 °C; V_{CC} = 3.3 V; Z_S = Z_L = 50 Ω; P_i = −30 dBm unless otherwise specified. All measurements done on application board (with a DC-decoupling capacitor of 4.7 nF placed close to V_{CC} [pin 6] and a 8.2 nH matching shunt inductor at RF_IN) with SMA connectors as reference plane.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_{CC}	supply current	gain mode	-	13	-	mA
		bypass mode	-	2	-	μA
G_p	power gain	gain mode [1]	13	15	17	dB
		bypass mode [1]	-	−5.5	-	dB
$P_{i(1dB)}$	input power at 1 dB gain compression	gain mode	-	−3	-	dBm
NF	noise figure	gain mode [1]	-	1.0	-	dB

[1] Printed-Circuit Board (PCB) and connector losses excluded.

2. Pinning information

Table 2. Pinning

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	CTRL	gain control, switch between gain and bypass mode	 Transparent top view	
2	RF_IN	RF in		
3	GND	ground		
4	GND	ground		
5	RF_OUT	RF out		
6	V_{CC}	supply voltage		
7	GND	ground pad		

3. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
BGU7224	HXSON6	plastic thermal enhanced extremely thin small outline package; no leads; 6 terminals; body 1.6 x 1.6 x 0.5 mm	SOT1189-1
OM7869	-	2.4 GHz WLAN evaluation board	-

4. Marking

Table 4. Marking

Type number	Marking
BGU7224	224

5. Block diagram

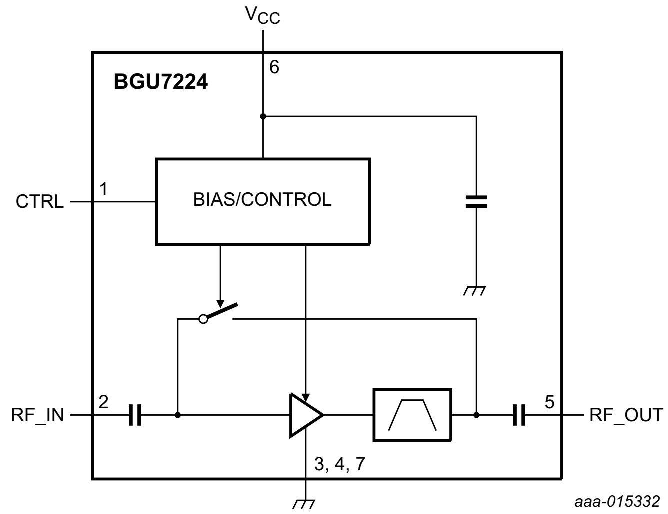


Fig 1. Block diagram

6. Limiting values

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). Absolute Maximum Ratings are given as limiting values of stress conditions during operation, that must not be exceeded under the worst case conditions.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CC}	supply voltage	RF input AC coupled [1]	–0.5	+5.0	V
$V_{I(RF\_IN)}$	input voltage on pin RF_IN	DC [1][2][3]	–0.5	+5.0	V
$V_{I(RF\_OUT)}$	input voltage on pin RF_OUT	DC [1][2][3]	–0.5	+5.0	V
$V_{I(CTRL)}$	input voltage on pin CTRL	[1][2]	–0.5	+5.0	V
T_{stg}	storage temperature		–40	+150	°C
T_j	junction temperature		-	150	°C
V_{ESD}	electrostatic discharge voltage	Human Body Model (HBM); according to the joint JEDEC/ESDA standard JS-001-2012	-	±2	kV
		Charged Device Model (CDM); according to JEDEC standard JESD22-C101	-	±1	kV
P_i	input power	f = 2462 MHz; CW			
		gain mode; V_{CC} = 3.3 V [1]	-	10	dBm
		bypass mode; V_{CC} = 3.3 V [1]	-	10	dBm

[1] Stressed with pulses of 200 ms in duration in an application circuit as depicted in Figure 33 without the shunt inductor.

[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 an internal DC blocking capacitor.

7. Thermal characteristics

Table 6. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-case)}$	thermal resistance from junction to case		250	K/W

8. Static characteristics

Table 7. Static characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage	RF input, AC coupled	3.0	3.3	3.6	V
I_{CC}	supply current	P_i = –30 dBm				
		gain mode	-	13	-	mA
		bypass mode	-	2	-	μA
$I_{I(CTRL)}$	input current on pin CTRL	gain mode	-	50	-	μA
T_{amb}	ambient temperature		–40	+25	+85	°C

9. Dynamic characteristics

Table 8. Dynamic characteristics

T_{amb} = 25 °C; V_{CC} = 3.3 V; Z_S = Z_L = 50 Ω; P_i = –30 dBm unless otherwise specified. All measurements done on application board (with a DC-decoupling capacitor of 4.7 nF placed close to V_{CC} [pin 6] and a 8.2 nH matching shunt inductor at RF_IN) with SMA connectors as reference plane.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f	frequency	[1]	2400	-	2500	MHz
G_p	power gain	gain mode [2]	13	15	17	dB
		bypass mode [2]	-	–5.5	-	dB
RL_{in}	input return loss	gain mode	-	10	-	dB
		bypass mode	-	13	-	dB
RL_{out}	output return loss	gain mode	-	11	-	dB
		bypass mode	-	13	-	dB
ISL	isolation	gain mode	-	22	-	dB
G_{flat}	gain flatness	bandwidth across 40 MHz				
		gain mode	-	±0.2	-	dB
		bypass mode	-	±0.2	-	dB
$P_{i(1dB)}$	input power at 1 dB gain compression	gain mode	-	–3	-	dBm
$IP3_I$	input third-order intercept point	two-tone; 5 MHz spacing				
		P_i = –20 dBm; gain mode	-	5.5	-	dBm
		P_i = 3 dBm; bypass mode	-	34	-	dBm
NF	noise figure	gain mode [2]	-	1.0	-	dB

Table 8. Dynamic characteristics *…continued*

T_{amb} = 25 °C; V_{CC} = 3.3 V; Z_S = Z_L = 50 Ω; P_i = −30 dBm unless otherwise specified. All measurements done on application board (with a DC-decoupling capacitor of 4.7 nF placed close to V_{CC} [pin 6] and a 8.2 nH matching shunt inductor at RF_IN) with SMA connectors as reference plane.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$t_{sw(G)}$	gain switch time	$V_{I(CTRL)}$ = 0 V to 3.3 V					
		gain mode	[3]	-	150	-	ns
		bypass mode	[4]	-	20	-	ns
K	Rollett stability factor	0 GHz ≤ f ≤ 20 GHz; gain mode		-	> 1	-	

[1] ISM 2.4 GHz (in band).

[2] Printed-Circuit Board (PCB) and connector losses excluded.

[3] measured from 50 % of $V_{I(CTRL)}$ control signal to 90% of maximum RF output signal.

[4] measured from 50 % of $V_{I(CTRL)}$ control signal to 10% of maximum RF output signal.

10. Gain control

Table 9. Gain control (pin CTRL)

T_{amb} = 25 °C; V_{CC} = 3.3 V.

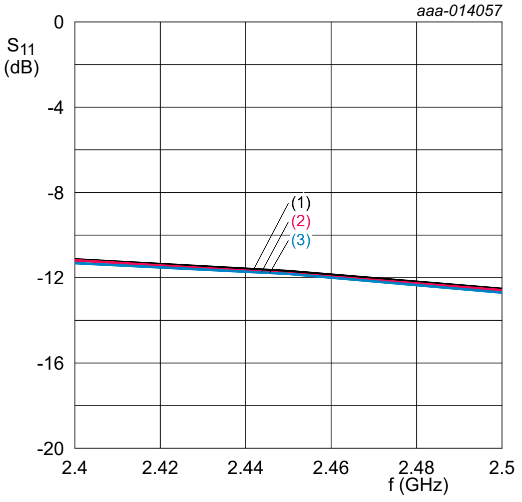
$V_{I(CTRL)}$ (V)	Mode
≤ 0.5	bypass
≥ 2.5	gain

11. Application information

Please contact your local sales representative for more information. Application note *AN11390* is available on the NXP website.

11.1 Graphs

Typical performance measured on the application board.



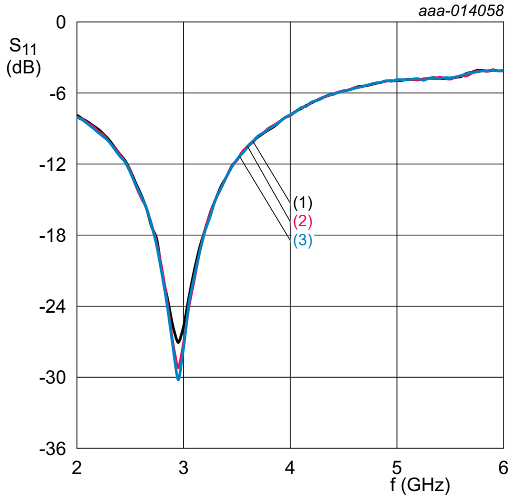
T_{amb} = 25 °C; gain mode

(1) $V_{CC} = V_{I(CTRL)}$ = 3.0 V

(2) $V_{CC} = V_{I(CTRL)}$ = 3.3 V

(3) $V_{CC} = V_{I(CTRL)}$ = 3.6 V

Fig 2. Input reflection coefficient as a function of frequency at different supply voltages



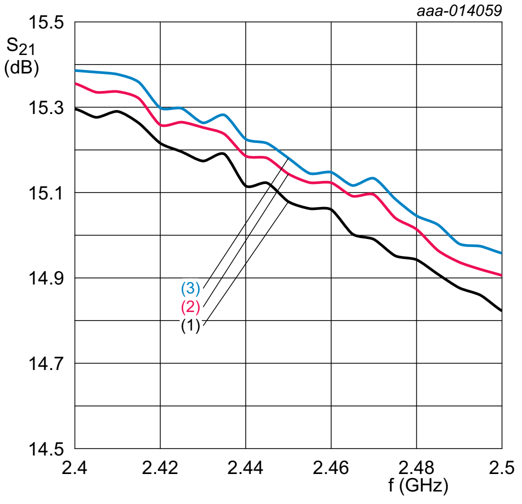
T_{amb} = 25 °C; gain mode

(1) $V_{CC} = V_{I(CTRL)}$ = 3.0 V

(2) $V_{CC} = V_{I(CTRL)}$ = 3.3 V

(3) $V_{CC} = V_{I(CTRL)}$ = 3.6 V

Fig 3. Input reflection coefficient as a function of frequency at different supply voltages



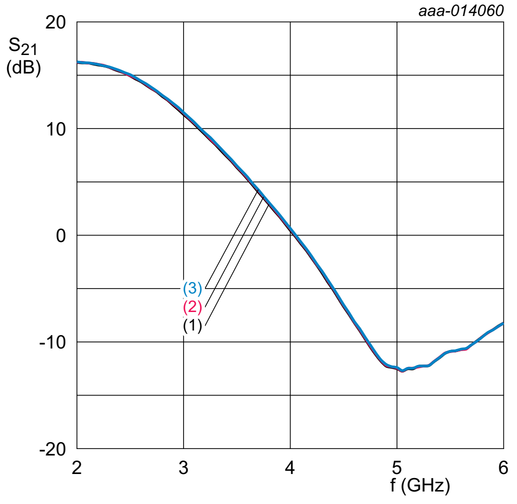
T_{amb} = 25 °C; gain mode

(1) $V_{CC} = V_{I(CTRL)}$ = 3.0 V

(2) $V_{CC} = V_{I(CTRL)}$ = 3.3 V

(3) $V_{CC} = V_{I(CTRL)}$ = 3.6 V

Fig 4. Forward transmission coefficient as a function of frequency at different supply voltages



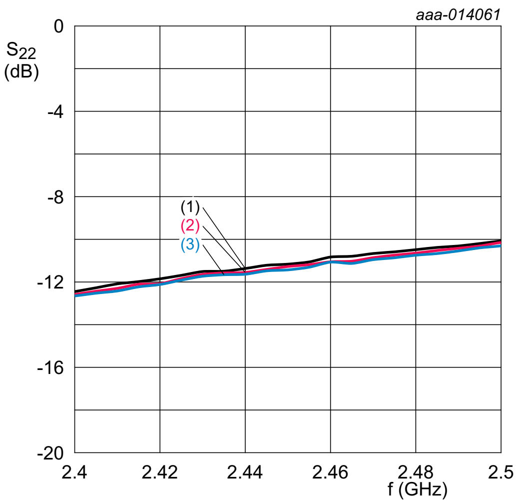
T_{amb} = 25 °C; gain mode

(1) $V_{CC} = V_{I(CTRL)}$ = 3.0 V

(2) $V_{CC} = V_{I(CTRL)}$ = 3.3 V

(3) $V_{CC} = V_{I(CTRL)}$ = 3.6 V

Fig 5. Forward transmission coefficient as a function of frequency at different supply voltages



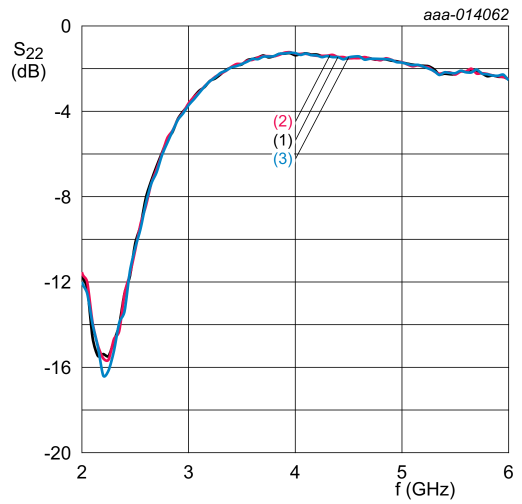
T_{amb} = 25 °C; gain mode

(1) $V_{CC} = V_{I(CTRL)}$ = 3.0 V

(2) $V_{CC} = V_{I(CTRL)}$ = 3.3 V

(3) $V_{CC} = V_{I(CTRL)}$ = 3.6 V

Fig 6. Output reflection coefficient as a function of frequency at different supply voltages



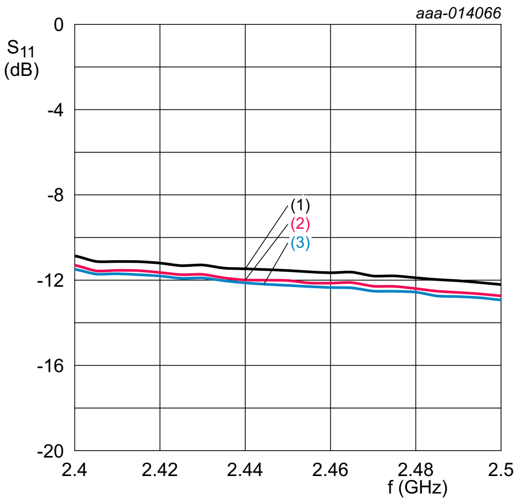
T_{amb} = 25 °C; gain mode

(1) $V_{CC} = V_{I(CTRL)}$ = 3.0 V

(2) $V_{CC} = V_{I(CTRL)}$ = 3.3 V

(3) $V_{CC} = V_{I(CTRL)}$ = 3.6 V

Fig 7. Output reflection coefficient as a function of frequency at different supply voltages



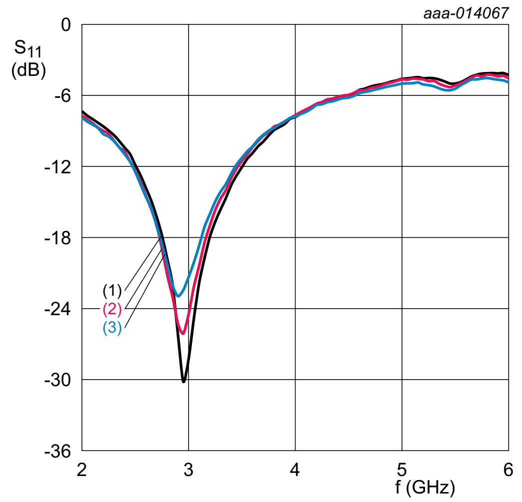
$V_{CC} = V_{I(CTRL)}$ = 3.3 V; gain mode

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 8. Input reflection coefficient as a function of frequency at different ambient temperatures



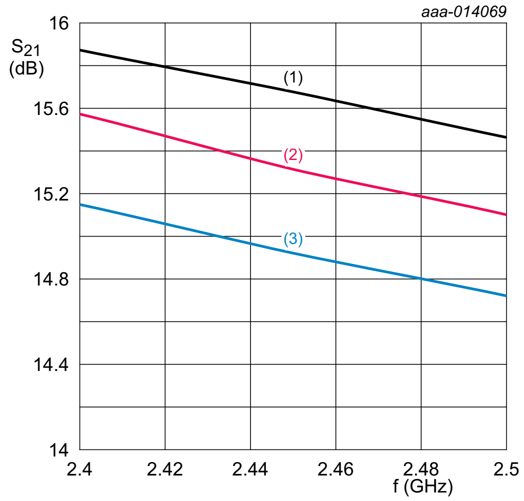
$V_{CC} = V_{I(CTRL)}$ = 3.3 V; gain mode

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 9. Input reflection coefficient as a function of frequency at different ambient temperatures



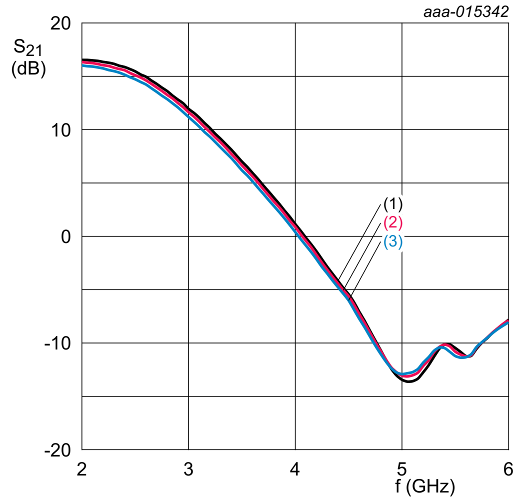
$V_{CC} = V_{I(CTRL)} = 3.3$ V; gain mode

(1) $T_{amb} = -40$ °C

(2) $T_{amb} = +25$ °C

(3) $T_{amb} = +85$ °C

Fig 10. Forward transmission coefficient as a function of frequency at different ambient temperatures



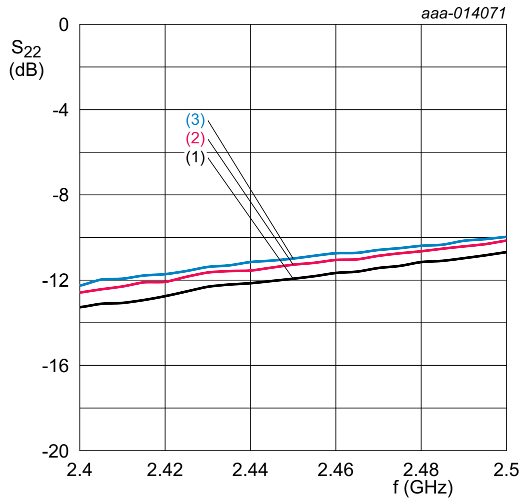
$V_{CC} = V_{I(CTRL)} = 3.3$ V; gain mode

(1) $T_{amb} = -40$ °C

(2) $T_{amb} = +25$ °C

(3) $T_{amb} = +85$ °C

Fig 11. Forward transmission coefficient as a function of frequency at different ambient temperatures



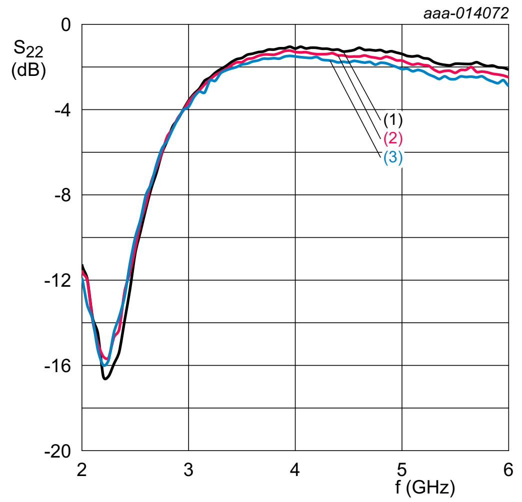
$V_{CC} = V_{I(CTRL)} = 3.3$ V; gain mode

(1) $T_{amb} = -40$ °C

(2) $T_{amb} = +25$ °C

(3) $T_{amb} = +85$ °C

Fig 12. Output reflection coefficient as a function of frequency at different ambient temperatures



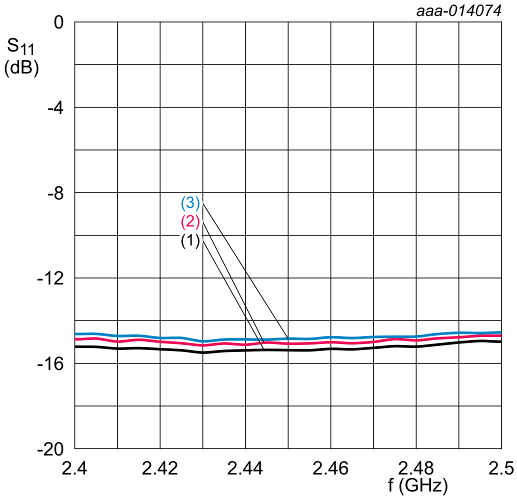
$V_{CC} = V_{I(CTRL)} = 3.3$ V; gain mode

(1) $T_{amb} = -40$ °C

(2) $T_{amb} = +25$ °C

(3) $T_{amb} = +85$ °C

Fig 13. Output reflection coefficient as a function of frequency at different ambient temperatures



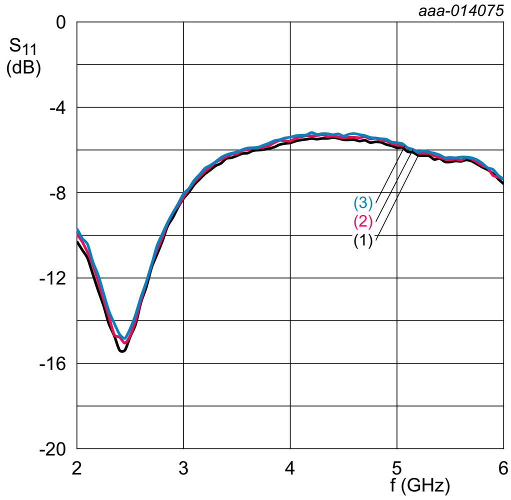
T_{amb} = 25 °C; $V_{I(CTRL)}$ = 0 V; bypass mode

(1) V_{CC} = 3.0 V

(2) V_{CC} = 3.3 V

(3) V_{CC} = 3.6 V

Fig 14. Input reflection coefficient as a function of frequency at different supply voltages



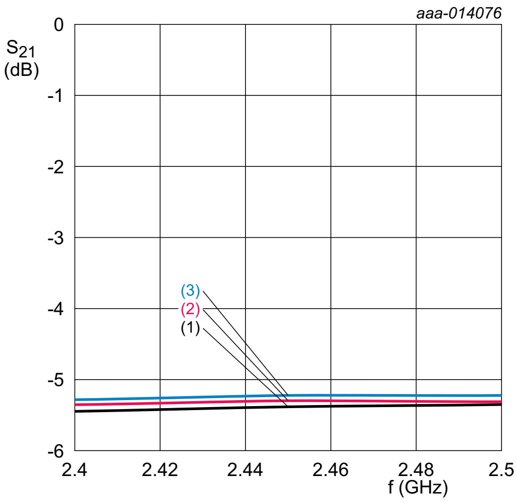
T_{amb} = 25 °C; $V_{I(CTRL)}$ = 0 V; bypass mode

(1) V_{CC} = 3.0 V

(2) V_{CC} = 3.3 V

(3) V_{CC} = 3.6 V

Fig 15. Input reflection coefficient as a function of frequency at different supply voltages



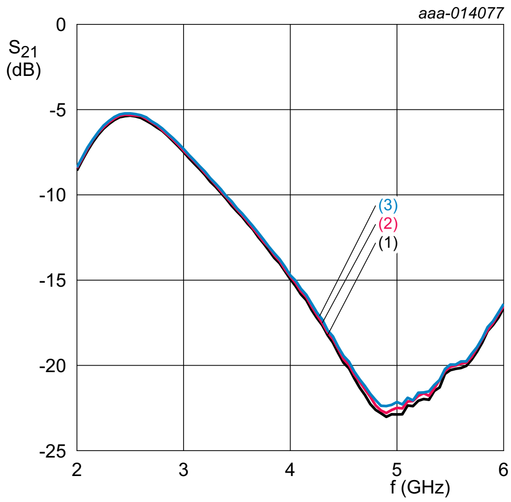
T_{amb} = 25 °C; $V_{I(CTRL)}$ = 0 V; bypass mode

(1) V_{CC} = 3.0 V

(2) V_{CC} = 3.3 V

(3) V_{CC} = 3.6 V

Fig 16. Forward transmission coefficient as a function of frequency at different supply voltages



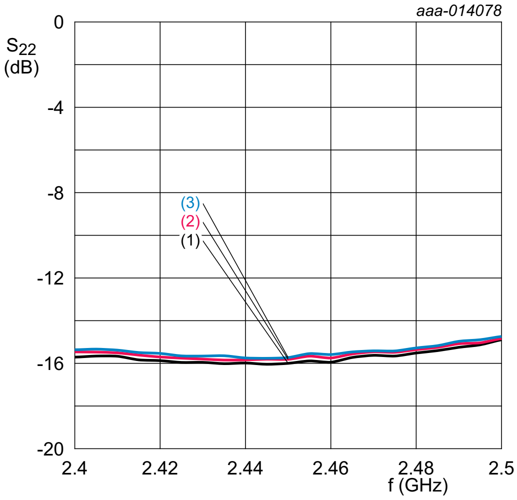
T_{amb} = 25 °C; $V_{I(CTRL)}$ = 0 V; bypass mode

(1) V_{CC} = 3.0 V

(2) V_{CC} = 3.3 V

(3) V_{CC} = 3.6 V

Fig 17. Forward transmission coefficient as a function of frequency at different supply voltages



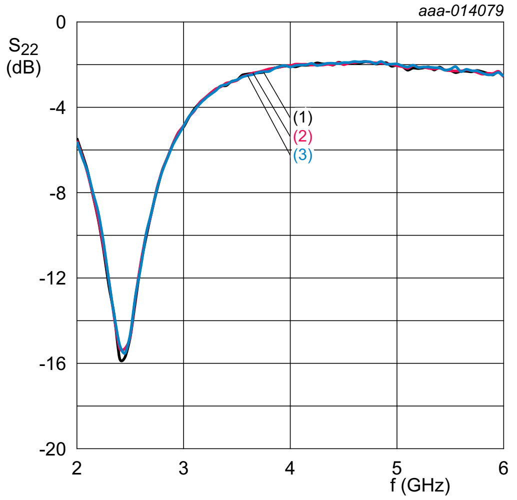
T_{amb} = 25 °C; $V_{I(CTRL)}$ = 0 V; bypass mode

(1) V_{CC} = 3.0 V

(2) V_{CC} = 3.3 V

(3) V_{CC} = 3.6 V

Fig 18. Output reflection coefficient as a function of frequency at different supply voltages



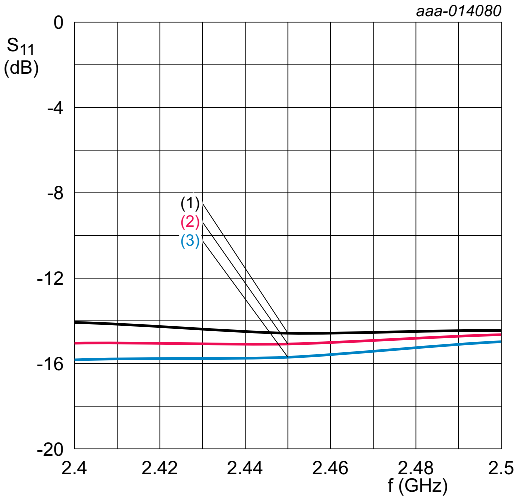
T_{amb} = 25 °C; $V_{I(CTRL)}$ = 0 V; bypass mode

(1) V_{CC} = 3.0 V

(2) V_{CC} = 3.3 V

(3) V_{CC} = 3.6 V

Fig 19. Output reflection coefficient as a function of frequency at different supply voltages



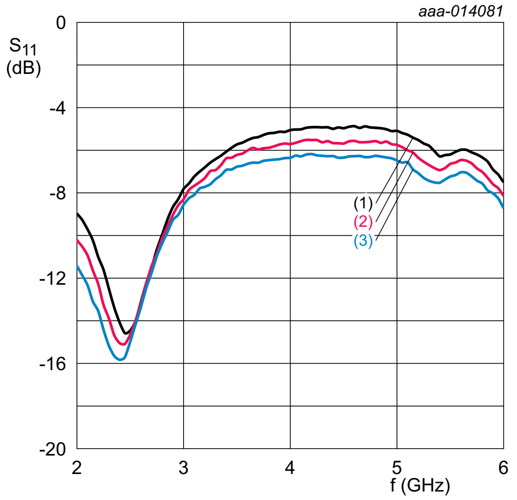
V_{CC} = 3.3 V; $V_{I(CTRL)}$ = 0 V; bypass mode

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 20. Input reflection coefficient as a function of frequency at different ambient temperatures



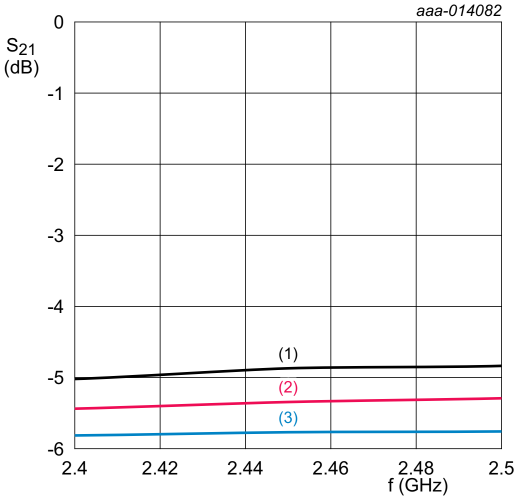
V_{CC} = 3.3 V; $V_{I(CTRL)}$ = 0 V; bypass mode

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 21. Input reflection coefficient as a function of frequency at different ambient temperatures



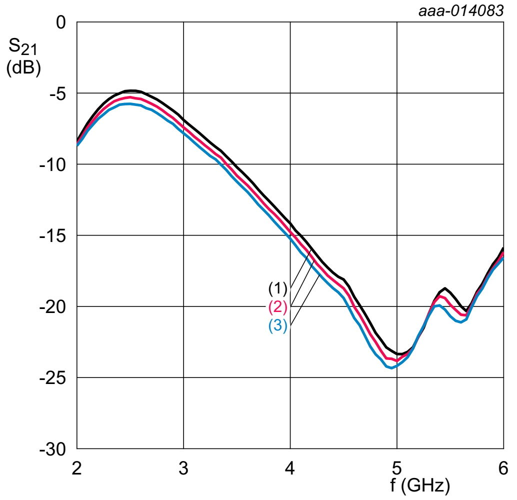
V_{CC} = 3.3 V; $V_{I(CTRL)}$ = 0 V; bypass mode

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 22. Forward transmission coefficient as a function of frequency at different ambient temperatures



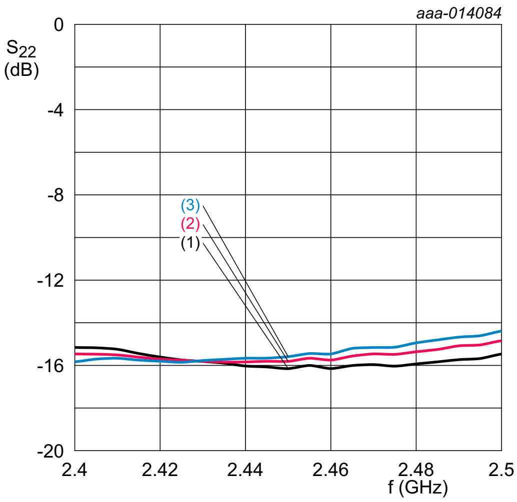
V_{CC} = 3.3 V; $V_{I(CTRL)}$ = 0 V; bypass mode

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 23. Forward transmission coefficient as a function of frequency at different ambient temperatures



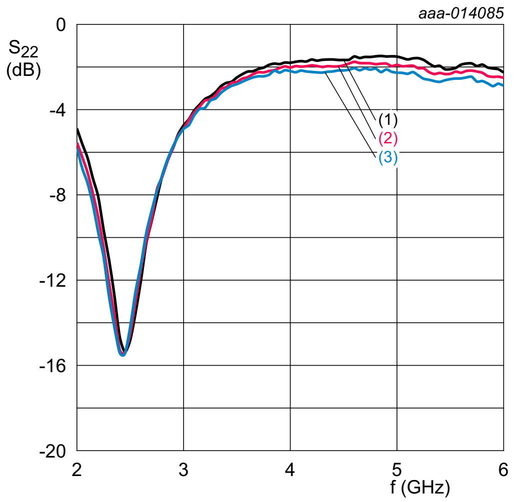
V_{CC} = 3.3 V; $V_{I(CTRL)}$ = 0 V; bypass mode

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 24. Output reflection coefficient as a function of frequency at different ambient temperatures



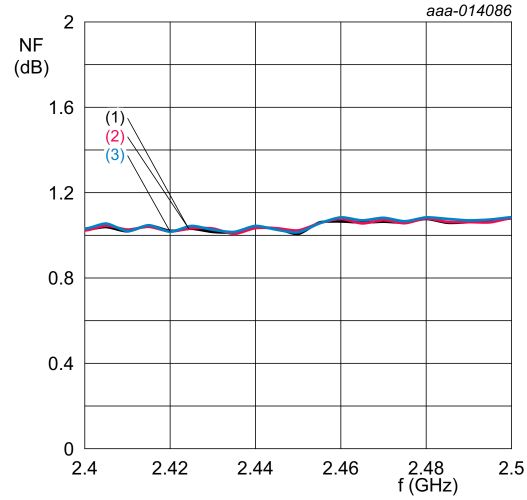
V_{CC} = 3.3 V; $V_{I(CTRL)}$ = 0 V; bypass mode

(1) T_{amb} = –40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 25. Output reflection coefficient as a function of frequency at different ambient temperatures



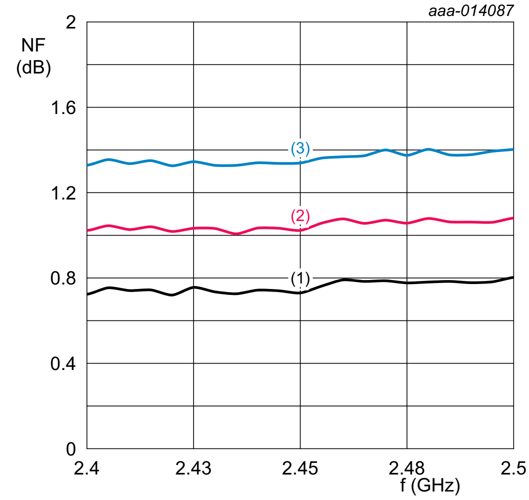
T_{amb} = 25 °C; gain mode

(1) $V_{CC} = V_{I(CTRL)}$ = 3.0 V

(2) $V_{CC} = V_{I(CTRL)}$ = 3.3 V

(3) $V_{CC} = V_{I(CTRL)}$ = 3.6 V

Fig 26. Noise figure as a function of frequency at different supply voltages



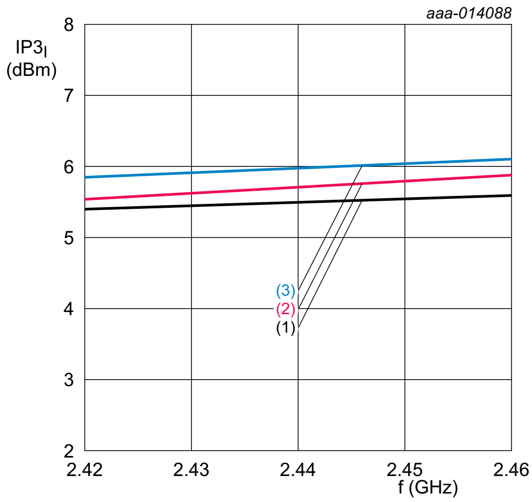
$V_{CC} = V_{I(CTRL)}$ = 3.3 V; gain mode

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 27. Noise figure as a function of frequency at different ambient temperatures



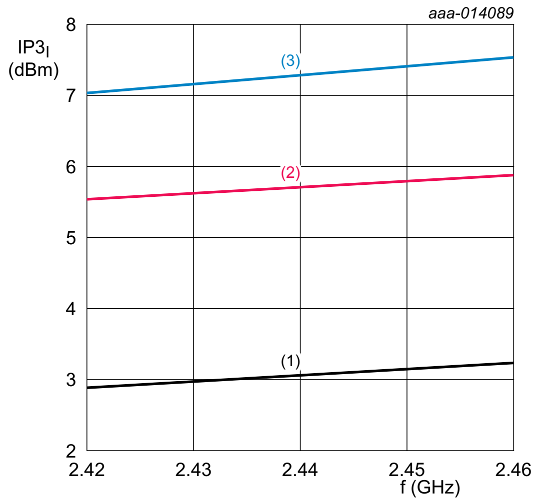
T_{amb} = 25 °C; two tone; 5 MHz spacing; P_i = −20 dBm; gain mode

(1) $V_{CC} = V_{I(CTRL)}$ = 3.0 V

(2) $V_{CC} = V_{I(CTRL)}$ = 3.3 V

(3) $V_{CC} = V_{I(CTRL)}$ = 3.6 V

Fig 28. Input third-order intercept point as a function of frequency at different supply voltages



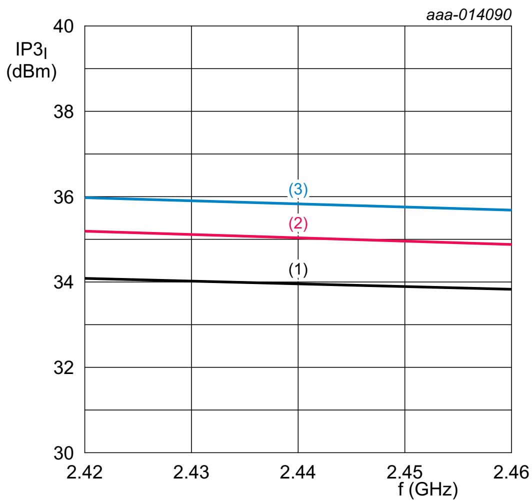
$V_{CC} = V_{I(CTRL)}$ = 3.3 V; two tone; 5 MHz spacing; P_i = −20 dBm; gain mode

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 29. Input third-order intercept point as a function of frequency at different ambient temperatures



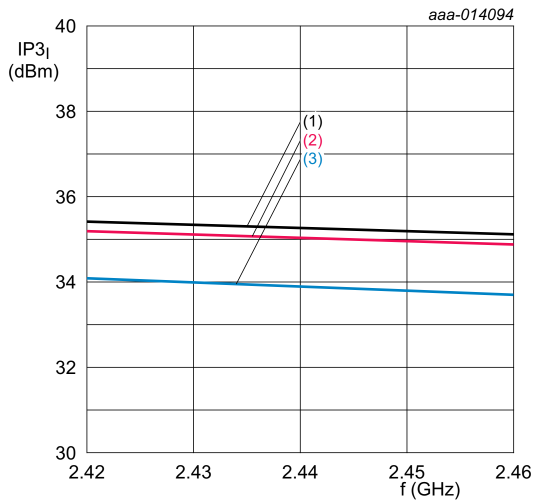
T_{amb} = 25 °C; $V_{I(CTRL)}$ = 0 V; two tone; 5 MHz spacing; P_i = 3 dBm; bypass mode

(1) $V_{CC} = V_{I(CTRL)}$ = 3.0 V

(2) $V_{CC} = V_{I(CTRL)}$ = 3.3 V

(3) $V_{CC} = V_{I(CTRL)}$ = 3.6 V

Fig 30. Input third-order intercept point as a function of frequency at different supply voltages



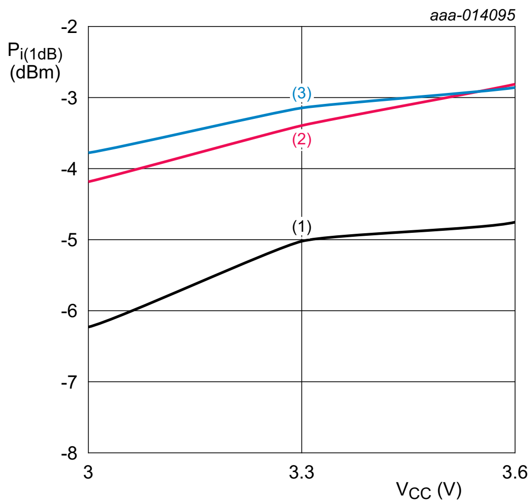
V_{CC} = 3.3 V; $V_{I(CTRL)}$ = 0 V; two tone; 5 MHz spacing; P_i = 3 dBm; bypass mode

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 31. Input third-order intercept point as a function of frequency at different ambient temperatures



$V_{I(CTRL)} = V_{CC}$; f = 2.44 MHz; gain mode

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 32. input power at 1 dB gain compression as a function of supply voltage at different ambient temperatures

11.2 Application circuit

In Figure 33 the application diagram as supplied on the evaluation board is given.

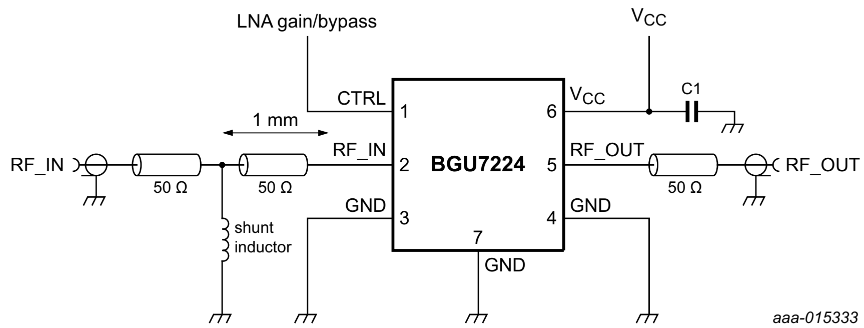


Fig 33. Evaluation board schematic

Note that in Figure 33 the schematic for the BGU7224 evaluation board is shown using only two external components. A DC-decoupling capacitor placed close to V_{CC} (pin 6) and a matching shunt inductor at RF_IN.

The BGU7224 can also be used without the matching inductor at RF_IN. However, in this case the input return loss will be less than 10 dB (approximately 9 dB) at a frequency of 2.4 GHz.

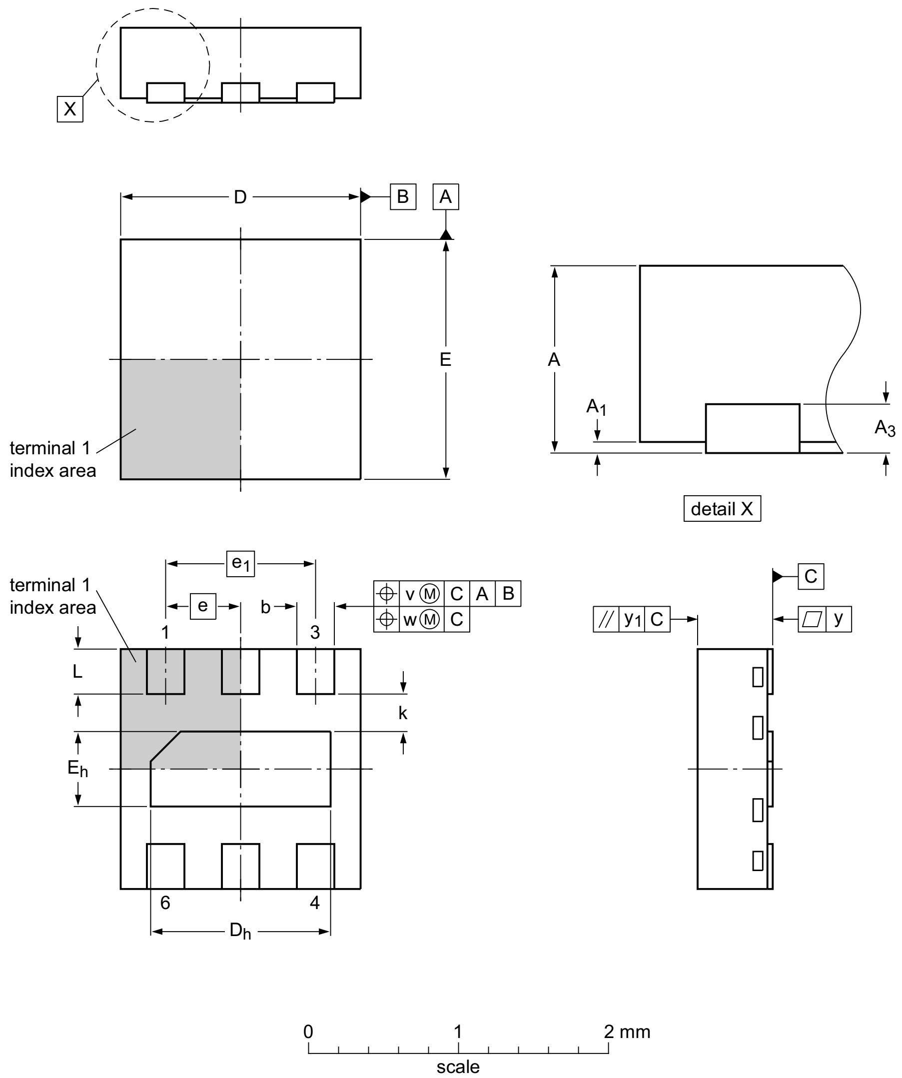
Table 10. List of components
See Figure 33 for evaluation board schematic.
Preferred vendors different from the ones listed can be chosen, but be aware that the performance could be affected.

Component	Description	Value	Remarks
C1	capacitor	4.7 nF	Murata GRM155 series
shunt inductor	inductor	8.2 nH	Murata LQP15 series
RF_IN, RF_OUT	SMA connector	-	Emerson Network Power
V_{CC}, LNA gain/bypass	3-pin connector	-	Molex

For more details or information please see application note *AN11390*.

12. Package outline

HXSON6: plastic, thermal enhanced extremely thin small outline package; no leads; 6 terminals; body 1.6 x 1.6 x 0.5 mm **SOT1189-1**



Dimensions

Unit(1)		A	A_1	A_3	b	D	D_h	E	E_h	e	e_1	k	L	v	w	y	y_1
	max	0.5	0.05		0.30	1.7	1.3	1.7	0.6				0.35				
mm	nom			0.127	0.25	1.6	1.2	1.6	0.5	0.5	1		0.30	0.1	0.05	0.05	0.05
	min		0.00		0.20	1.5	1.1	1.5	0.4			0.2	0.25				

Note

1. Plastic or metal protrusions of 0.075 mm maximum per side are not included.

sot1189-1_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT1189-1	- - -	- - -	- - -			~~10-08-02~~ 10-10-11

Fig 34. Package outline SOT1189-1 (HXSON6)

13. Soldering

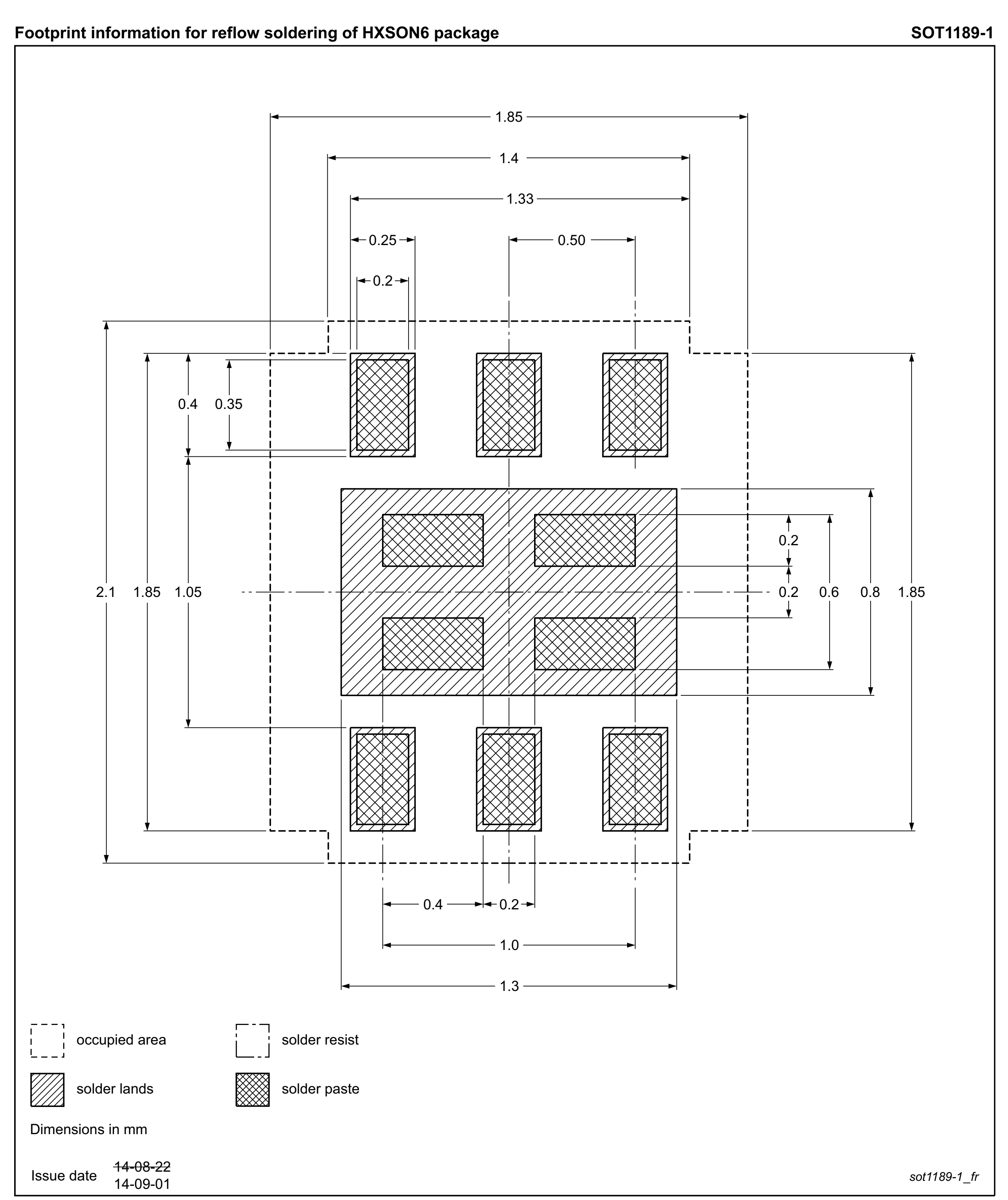


Fig 35. Reflow soldering footprint

14. Abbreviations

Table 11. Abbreviations

Acronym	Description
CW	Continuous Wave
ESD	ElectroStatic Discharge
EVM	Error Vector Magnitude
HBM	Human Body Model
IEEE	Institute of Electrical and Electronics Engineers
ISM	Industrial Scientific Medical
MMIC	Monolithic Microwave Integrated Circuit
MSL	Moisture Sensitivity Level
PAN	Personal Area Network
RHF	RoHS Halogen Free
QAM	Quadrature Amplitude Modulation
QFN	Quad-Flat No-leads
SiGe:C	Silicon Germanium Carbon
SMA	SubMiniature version A
WLAN	Wireless Local Area Network

15. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
BGU7224 v.2	20141215	Product data sheet	-	BGU7224 v.1
Modifications:	• The status of this document has been changed to Product data sheet.			
BGU7224 v.1	20141023	Preliminary 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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18. Contents

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