# BGU7003

## Wideband silicon germanium low-noise amplifier MMIC

Rev. 02 — 22 June 2010 Product data sheet

## 1. Product profile

### 1.1 General description

The BGU7003 MMIC is a wideband amplifier in SiGe:C technology for high speed, low-noise applications in a plastic, leadless 6 pin, extremely thin small outline SOT891 package.

**CAUTION**

This device is sensitive to ElectroStatic Discharge (ESD). Therefore care should be taken during transport and handling.

### 1.2 Features

- Low noise high gain microwave MMIC
- Applicable between 40 MHz and 6 GHz
- Integrated temperature stabilized bias for easy design
- Bias current configurable with external resistor
- Noise figure NF = 0.80 dB at 1.575 GHz
- Insertion power gain = 18.3 dB at 1.575 GHz
- 110 GHz transit frequency - SiGe:C technology
- Power-down mode current consumption < 1 μA
- Optimized performance at low 5 mA supply current
- ESD protection > 1 kV Human Body Model (HBM) on all pins

### 1.3 Applications

- GPS
- Satellite radio
- Low-noise amplifiers for microwave communications systems
- WLAN and CDMA applications
- Analog / digital cordless applications

### 1.4 Quick reference data

**Table 1. Quick reference data**

*$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; $V_{ENABLE}$ ≥ 0.7 V; f = 1575 MHz; $Z_S$ = $Z_L$ = 50 Ω (input and output matched to 50 Ω) unless otherwise specified.*

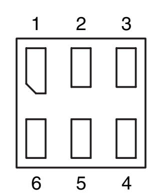
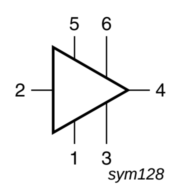
| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{CC}$ | supply voltage | RF input AC coupled | | 2.2 | - | 2.85 | V |
| $I_{CC(tot)}$ | total supply current | configurable with external resistor | [1] | 3 | - | 15 | mA |
| $T_{amb}$ | ambient temperature | | | −40 | +25 | +85 | °C |
| $P_{tot}$ | total power dissipation | $T_{sp}$ ≤ 103 °C | [2] | - | - | 70 | mW |
| $\|s_{21}\|^2$ | Insertion power gain | | | - | 18.3 | - | dB |
| NF | noise figure | | | - | 0.80 | - | dB |
| $P_{i(1dB)}$ | input power at 1 dB gain compression | | | - | −20.1 | - | dBm |
| $IP3_I$ | input third-order intercept point | jammers at $f_1$ = f + 138 MHz and $f_2$ = f + 276 MHz | | - | −0.2 | - | dBm |

[1] $I_{CC(tot)} = I_{CC} + I_{RF\_OUT} + I_{R\_BIAS}$.

[2] $T_{sp}$ is the temperature at the solder point of the ground lead.

## 2. Pinning information

**Table 2. Pinning**

| Pin | Description | Simplified outline | Graphic symbol |
|---|---|---|---|
| 1 | R_BIAS |   |   |
| 2 | RF_IN | | |
| 3 | GND | | |
| 4 | RF_OUT | | |
| 5 | ENABLE | | |
| 6 | $V_{CC}$ | | |

## 3. Ordering information

**Table 3. Ordering information**

| Type number | Package | | |
|---|---|---|---|
| | Name | Description | Version |
| BGU7003 | XSON6 | plastic extremely thin small outline package; no leads; 6 terminals; body 1 × 1 × 0.5 mm | SOT891 |

## 4. Marking

**Table 4. Marking codes**

| Type number | Marking code |
|---|---|
| BGU7003 | B3 |

## 5. Limiting values

**Table 5. 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 | | - | 3.0 | V |
| $I_{CC(tot)}$ | total supply current | configurable with external resistor | | - | 25 | mA |
| $P_{tot}$ | total power dissipation | $T_{sp} \leq 103$ °C | [1] | - | 70 | mW |
| $T_{stg}$ | storage temperature | | | –65 | +150 | °C |
| $T_j$ | junction temperature | | | - | 150 | °C |

[1] $T_{sp}$ is the temperature at the solder point of the ground lead.

## 6. Thermal characteristics

**Table 6. Thermal characteristics**

| Symbol | Parameter | Conditions | Typ | Unit |
|---|---|---|---|---|
| $R_{th(j-sp)}$ | thermal resistance from junction to solder point | | 235 | K/W |

## 7. Characteristics

**Table 7. Characteristics**

*$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; $V_{ENABLE} \geq 0.7$ V unless otherwise specified. All measurements done on characterization board without matching, de-embedded up to the pins.*

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{CC}$ | supply voltage | RF input AC coupled | | 2.2 | - | 2.85 | V |
| $I_{CC(tot)}$ | total supply current | configurable with external resistor | [1] | 3 | - | 15 | mA |
| | | $V_{ENABLE} \leq 0.4$ V | [1] | - | - | 0.001 | mA |
| $T_{amb}$ | ambient temperature | | | –40 | +25 | +85 | °C |
| $\|s_{21}\|^2$ | insertion power gain | $T_{amb}$ = 25 °C | | | | | |
| | | f = 1.575 GHz | | 16.0 | 17.5 | - | dB |
| | | f = 2.4 GHz | [2] | 14.0 | 15.2 | - | dB |
| | | f = 5.8 GHz | [2] | 10.0 | 11.4 | - | dB |
| | | $-40\ °C \leq T_{amb} \leq 85\ °C$ | | | | | |
| | | f = 1.575 GHz | [2] | 15.0 | 17.5 | - | dB |
| | | f = 2.4 GHz | [2] | 13.0 | 15.2 | - | dB |
| | | f = 5.8 GHz | [2] | 9.0 | 11.4 | - | dB |
| MSG | maximum stable gain | f = 1.575 GHz | | - | 20.5 | - | dB |
| | | f = 2.4 GHz | | - | 17.8 | - | dB |
| | | f = 5.8 GHz | | - | 15.4 | - | dB |
| $NF_{min}$ | minimum noise figure | f = 1.575 GHz | | - | 0.70 | - | dB |
| | | f = 2.4 GHz | | - | 0.80 | - | dB |
| | | f = 5.8 GHz | | - | 1.5 | - | dB |

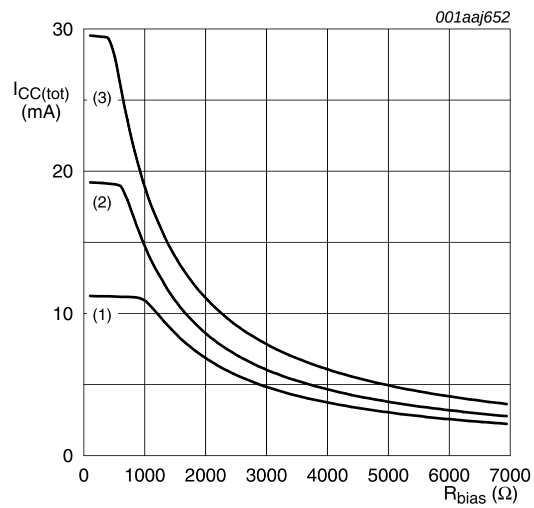
[1] $I_{CC(tot)} = I_{CC} + I_{RF\_OUT} + I_{R\_BIAS}$.

[2] Guaranteed by design and characterization.

**Table 8. ENABLE (pin 5)**

*−40 °C ≤ $T_{amb}$ ≤ +85 °C*

| $V_{ENABLE}$ (V) | State |
|---|---|
| ≤ 0.4 | OFF |
| ≥ 0.7 | ON |



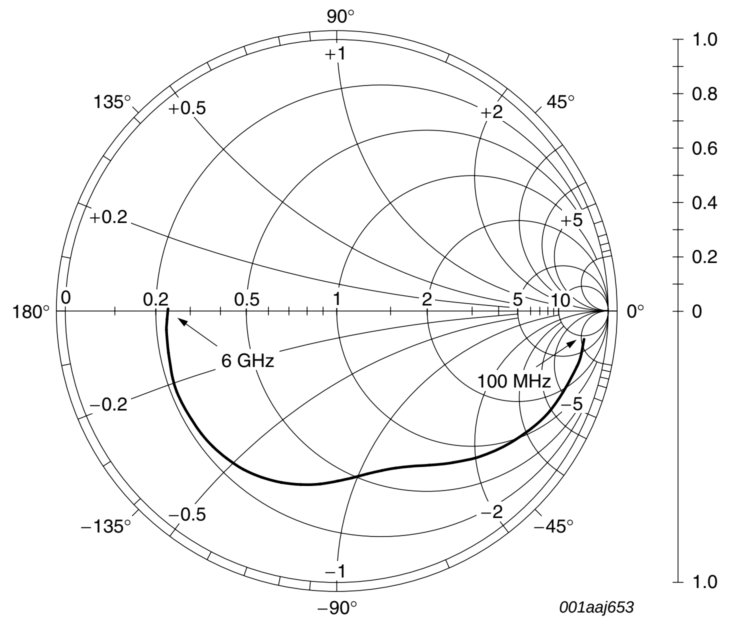

$T_{amb}$ = 25 °C.

(1) $V_{CC}$ = 2.2 V

(2) $V_{CC}$ = 2.5 V

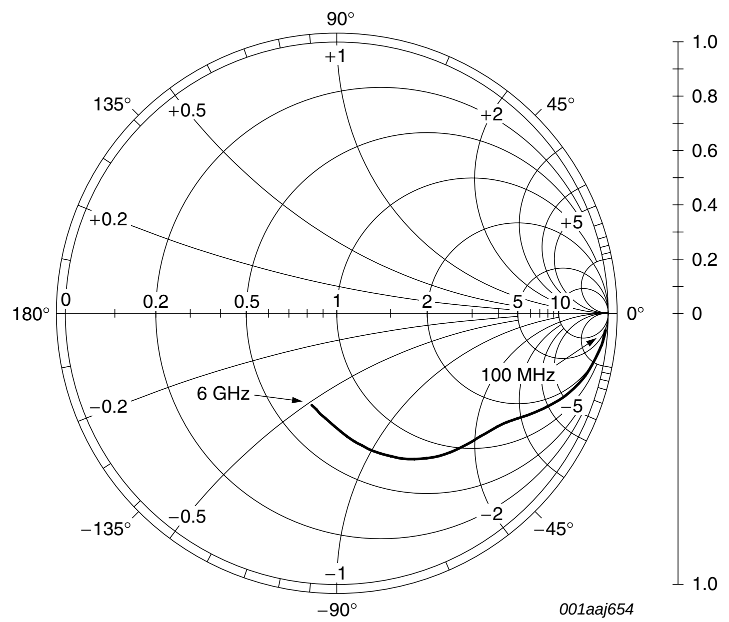
(3) $V_{CC}$ = 2.85 V

**Fig 1. Total supply current as a function of bias resistor; typical values**



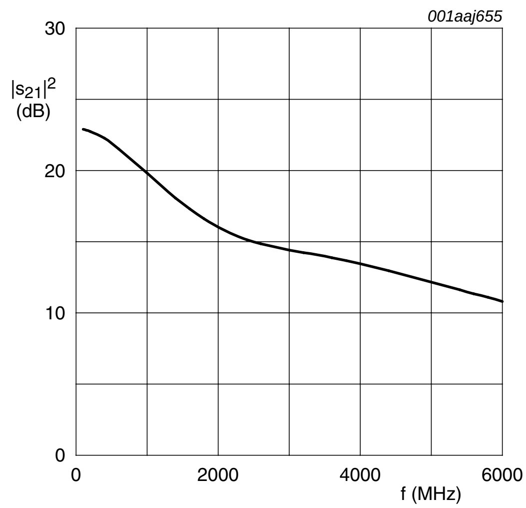

$T_{amb}$ = 25 °C; $I_{CC(tot)}$ = 5.0 mA; $V_{CC}$ = 2.5 V; $P_{drive}$ = −30 dBm; $Z_0$ = 50 Ω.

**Fig 2. Input reflection coefficient ($S_{11}$); typical values**



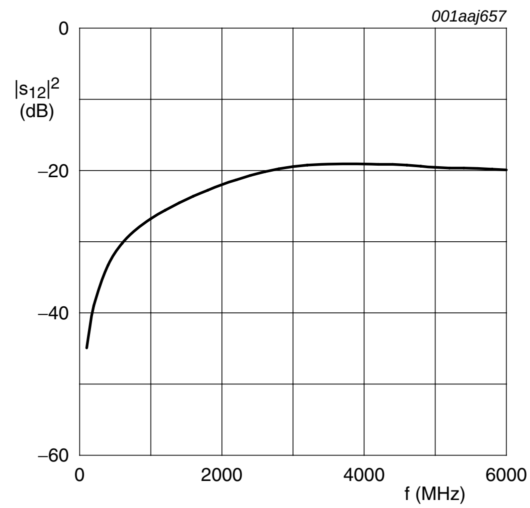

$T_{amb}$ = 25 °C; $I_{CC(tot)}$ = 5.0 mA; $V_{CC}$ = 2.5 V; $P_{drive}$ = −30 dBm; $Z_0$ = 50 Ω.

**Fig 3. Output reflection coefficient ($S_{22}$); typical values**



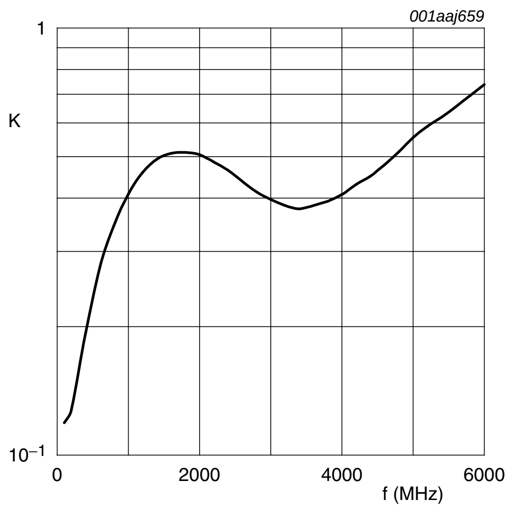

$T_{amb}$ = 25 °C; $I_{CC(tot)}$ = 5.0 mA; $V_{CC}$ = 2.5 V;
$P_{drive}$ = −30 dBm; $Z_0$ = 50 Ω.

**Fig 4. Insertion power gain ($|s_{21}|^2$) as a function of frequency; typical values**



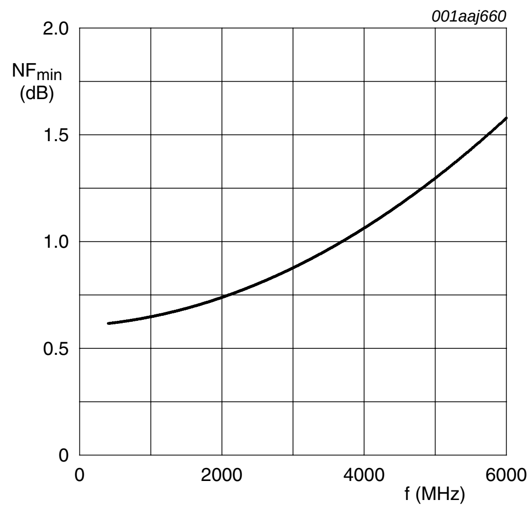

$T_{amb}$ = 25 °C; $I_{CC(tot)}$ = 5.0 mA; $V_{CC}$ = 2.5 V;
$P_{drive}$ = −30 dBm; $Z_0$ = 50 Ω.

**Fig 5. Isolation ($|s_{12}|^2$) as a function of frequency; typical values**



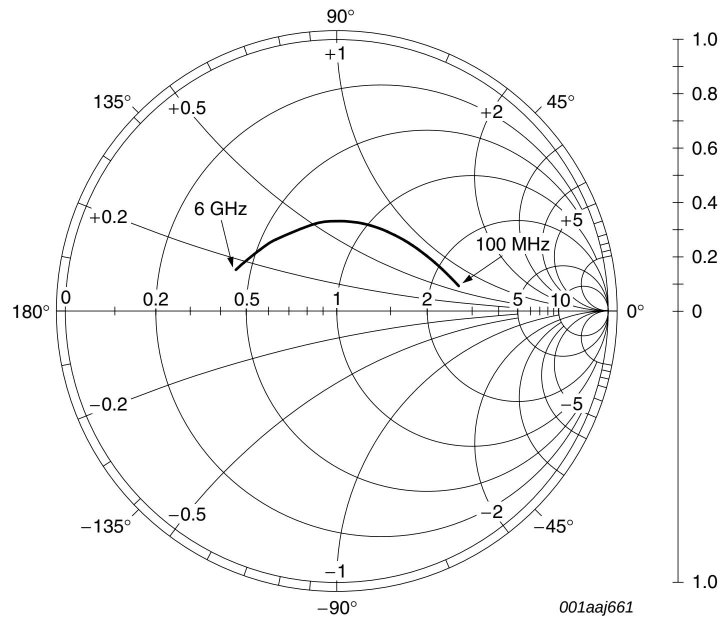

$T_{amb}$ = 25 °C; $I_{CC(tot)}$ = 5.0 mA; $V_{CC}$ = 2.5 V;
$P_{drive}$ = −30 dBm; $Z_0$ = 50 Ω.

**Fig 6. Rollet's stability factor as a function of frequency; typical values**



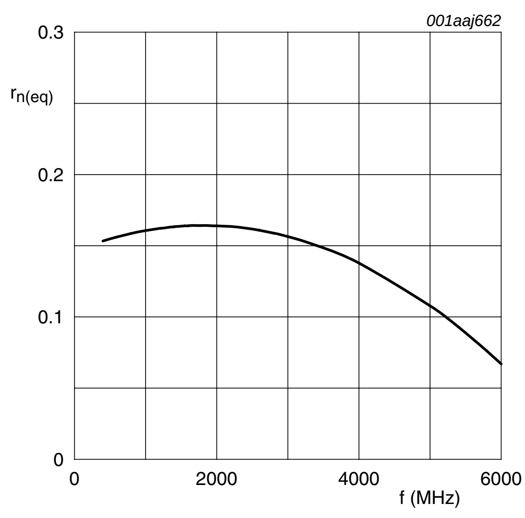

$T_{amb}$ = 25 °C; $I_{CC(tot)}$ = 5.0 mA; $V_{CC}$ = 2.5 V;
$P_{drive}$ = −30 dBm; $Z_0$ = 50 Ω.

**Fig 7. Minimum noise figure as a function of frequency; typical values**




$T_{amb}$ = 25 °C; $I_{CC(tot)}$ = 5.0 mA; $V_{CC}$ = 2.5 V.

**Fig 8. Optimum source reflection coefficient for minimum noise figure; typical values**




$T_{amb}$ = 25 °C; $I_{CC(tot)}$ = 5.0 mA; $V_{CC}$ = 2.5 V.

Normalized to 50 Ω.

**Fig 9. Equivalent noise resistance as a function of frequency; typical values**

# 8. Application information GPS LNA

Other applications available. Please contact your local sales representative for more information. Application note(s) available on the NXP website.

## 8.1 Application circuit

In Figure 10 the application diagram as supplied on the evaluation board is given.

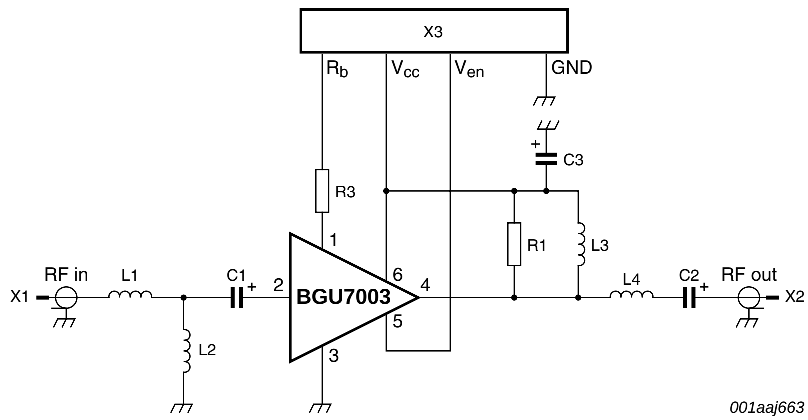



**Fig 10. Circuit diagram of the evaluation board**

**Table 9. List of components**

*For circuit, see Figure 10.*

| Component | Description | Value | | Supplier name/type | Remarks |
|---|---|---|---|---|---|
| C1, C2 | capacitor | 100 pF | [1] | MurataGRM1555 | DC blocking |
| C3 | capacitor | 180 pF | [1] | MurataGRM1555 | decoupling |
| L1 | inductor | 2.7 nH | [1] | Murata/LQW15A high quality factor, low series resistance | input matching |
| L2 | inductor | 33 nH | [1] | Murata/LQW15A high quality factor, low series resistance | input matching |
| L3 | inductor | 3.9 nH | [1] | Murata/LQG15HS | output matching / DC shunt |
| L4 | inductor | 4.7 nH | [1] | Murata/LQG15HS | output matching |
| R1 | resistor | 180 Ω | [1] | | |
| R2 | resistor | 0 Ω | [1] | | bridge |
| R3 | resistor | 3300 Ω | [1] | | bias setting |
| X1, X2 | SMA RF connector | - | | Johnson, end launch SMA 142-0701-841 | RF input / RF output |
| X3 | DC header | - | | Molex, PCB header, right angle, 1 row, 4 way 90121-0764 | bias connector |

[1] all capacitors, inductors and resistors have 0402 footprint.

## 8.2 Application board layout

Figure 11 shows the board layout with component identifications.

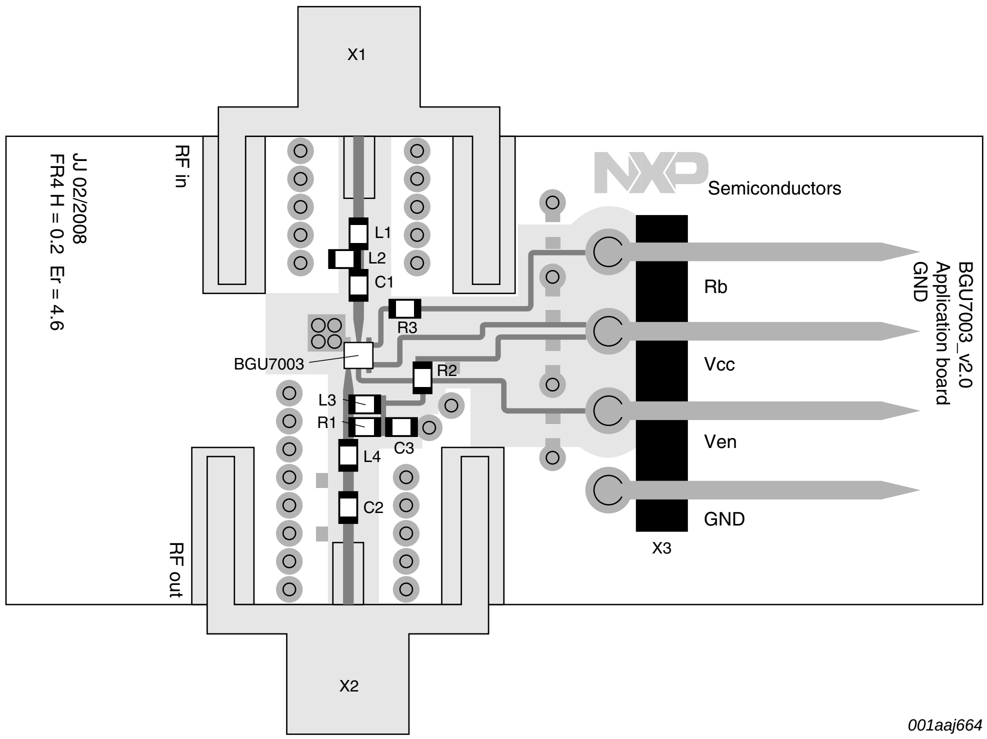
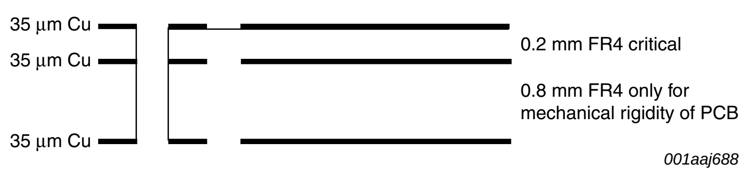



**Fig 11. Printed-Circuit Board (PCB) of the BGU7003 evaluation board**

## 8.3 Printed-Circuit Board

The material that has been used for the evaluation board is FR4 using the stack shown in Figure 12.




Material supplier is ISOLA DURAVER; $\varepsilon_r$ = 4.6 to 4.9; tan $\delta$ = 0.02.

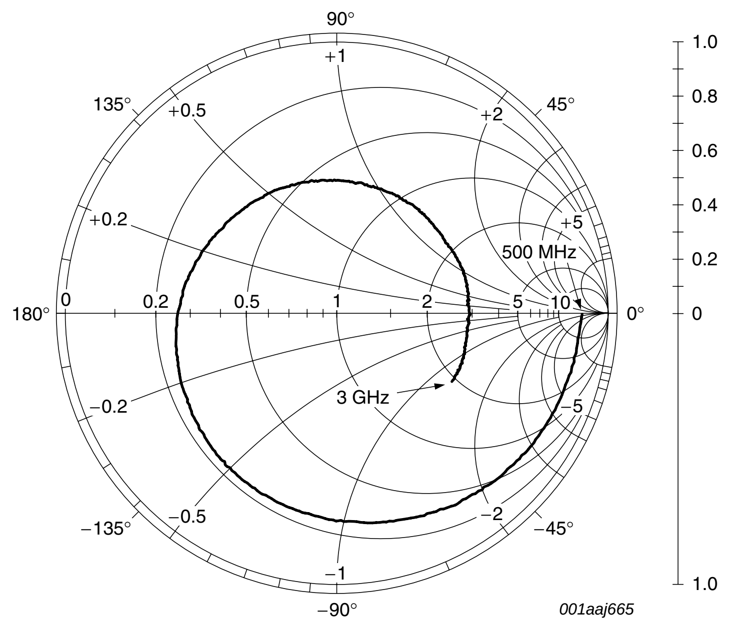
**Fig 12. Stack of the PCB material**

## 8.4 GPS evaluation board

**Table 10. GPS application characteristics**

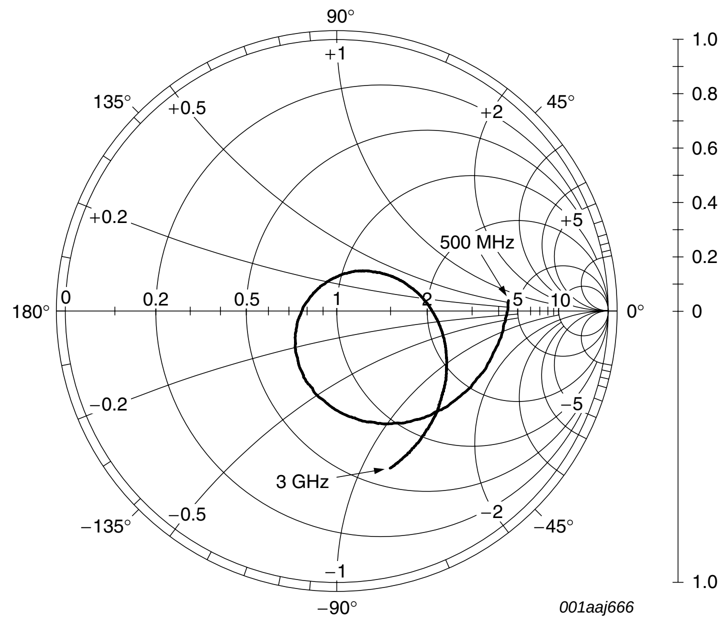
*$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; f = 1.575 GHz; $V_{ENABLE} \geq$ 0.7 V; $Z_S = Z_L$ = 50 Ω (input and output matched to 50 Ω) unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $\lvert s_{21}\rvert^2$ | Insertion power gain | | - | 18.3 | - | dB |
| $\lvert s_{11}\rvert^2$ | input return loss | | - | –5.4 | - | dB |
| $\lvert s_{22}\rvert^2$ | output return loss | | - | –19.5 | - | dB |
| $\lvert s_{12}\rvert^2$ | isolation | | - | –24.6 | - | dB |
| NF | noise figure | | - | 0.80 | - | dB |
| $P_{i(1dB)}$ | input power at 1 dB gain compression | | - | –20.1 | - | dBm |
| $P_{L(1dB)}$ | output power at 1 dB gain compression | | - | –2.8 | - | dBm |
| $IP3_I$ | input third-order intercept point | jammers at $f_1$ = f + 138 MHz and $f_2$ = f + 276 MHz | - | –0.2 | - | dBm |
| | | $f_1$ = f + 5 MHz; $f_2$ = f + 10 MHz | - | –5.2 | - | dBm |



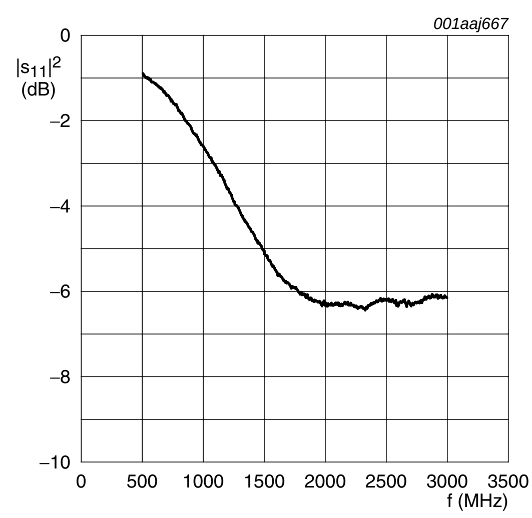

$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; $V_{ENABLE} \geq$ 0.7 V; $Z_S = Z_L$ = 50 Ω (input and output matched to 50 Ω).

**Fig 13. Input reflection coefficient ($S_{11}$); typical values**



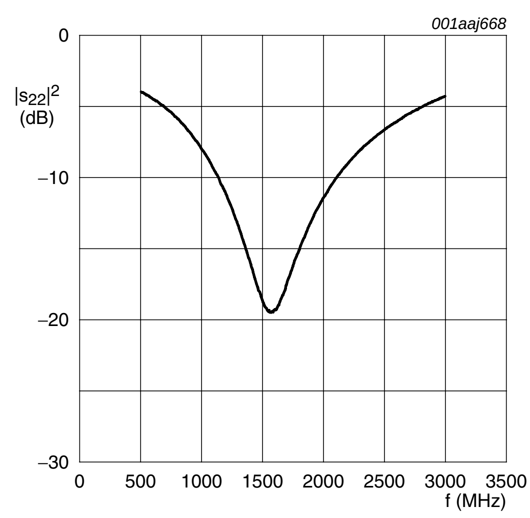

$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; $V_{ENABLE}$ ≥ 0.7 V; $Z_S$ = $Z_L$ = 50 Ω (input and output matched to 50 Ω).

**Fig 14. Output reflection coefficient ($S_{22}$); typical values**



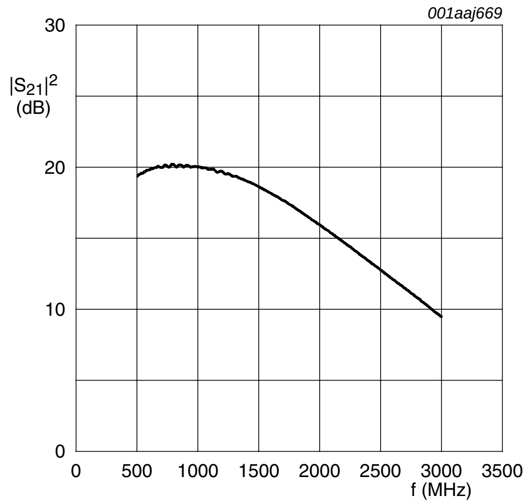

$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; $V_{ENABLE}$ ≥ 0.7 V; $Z_S$ = $Z_L$ = 50 Ω (input and output matched to 50 Ω).

**Fig 15. Input return loss ($|s_{11}|^2$) as a function of frequency; typical values**



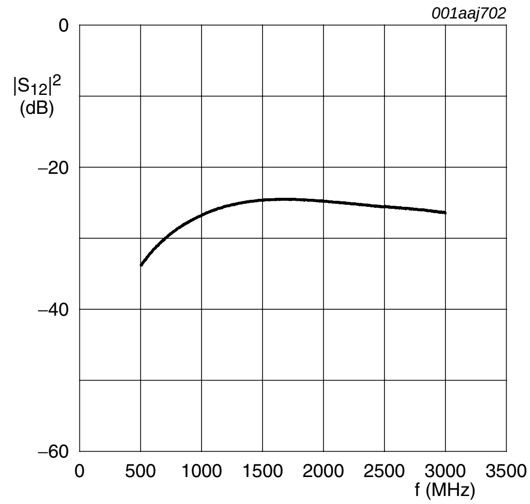

$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; $V_{ENABLE}$ ≥ 0.7 V; $Z_S$ = $Z_L$ = 50 Ω (input and output matched to 50 Ω).

**Fig 16. Output return loss ($|s_{22}|^2$) as a function of frequency; typical values**



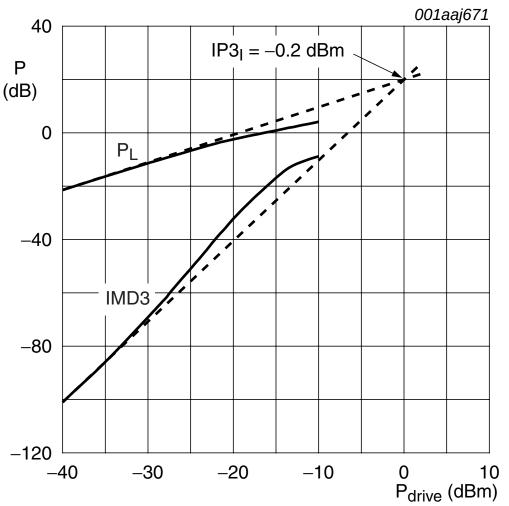

$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; $V_{ENABLE}$ ≥ 0.7 V; $Z_S$ = $Z_L$ = 50 Ω (input and output matched to 50 Ω).

**Fig 17. Insertion power gain ($|s_{21}|^2$) as a function of frequency; typical values**



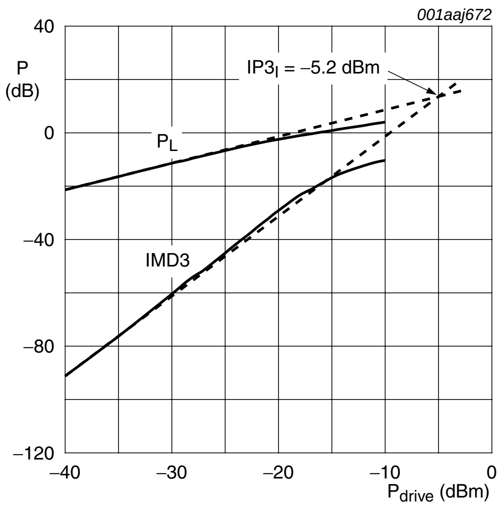

$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; $V_{ENABLE}$ ≥ 0.7 V; $Z_S$ = $Z_L$ = 50 Ω (input and output matched to 50 Ω).

**Fig 18. Reverse Isolation ($|s_{12}|^2$) as a function of frequency; typical values**



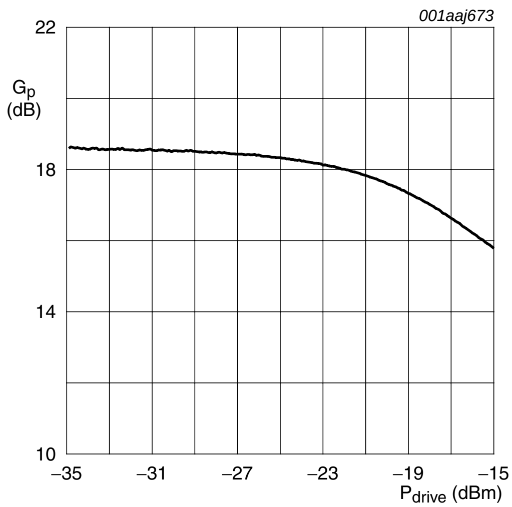

$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; f = 1.575 GHz; $f_1$ = f + 138 MHz; $f_2$ = f + 276 MHz; $V_{ENABLE}$ ≥ 0.7 V; $Z_S$ = $Z_L$ = 50 Ω (input and output matched to 50 Ω)

**Fig 19. Load power and third order intermodulation distortion as function of drive power; typical values**



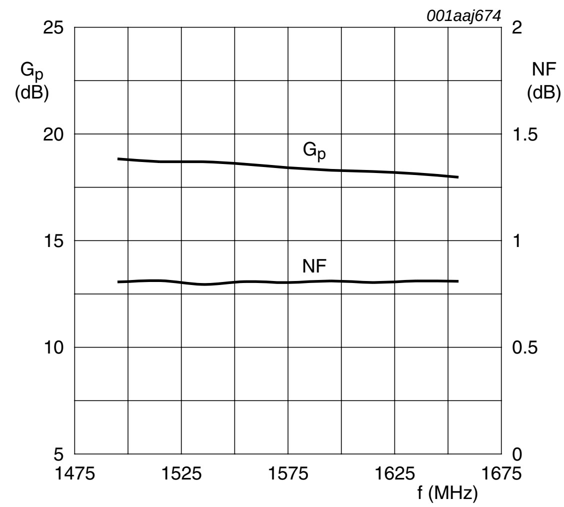

$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; f = 1.575 GHz; $f_1$ = f + 5 MHz; $f_2$ = f + 10 MHz; $V_{ENABLE}$ ≥ 0.7 V; $Z_S$ = $Z_L$ = 50 Ω (input and output matched to 50 Ω)

**Fig 20. Load power and third order intermodulation distortion as function of drive power; typical values**




$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; f = 1.575 GHz; $V_{ENABLE} \geq 0.7$ V; $Z_S = Z_L = 50\ \Omega$ (input and output matched to 50 Ω).

**Fig 21. Power gain as a function of drive power; typical values**

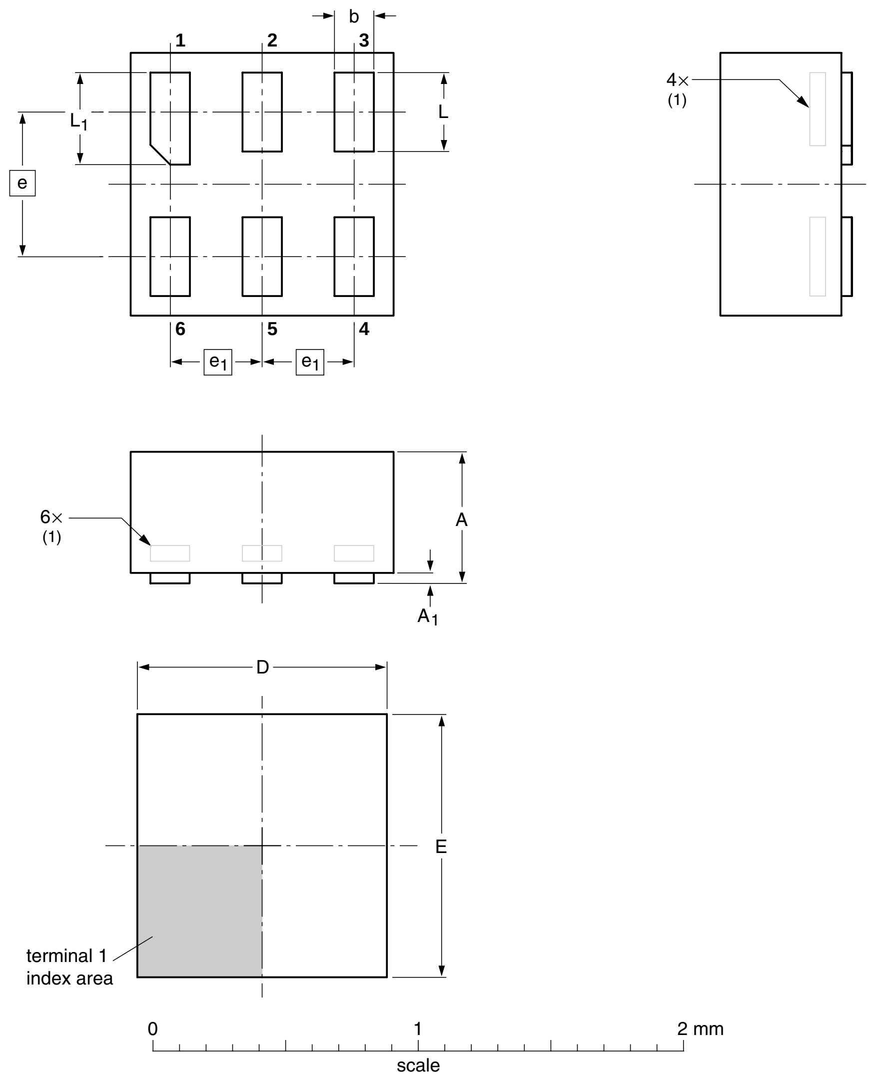



$T_{amb}$ = 25 °C; $V_{CC}$ = 2.5 V; $I_{CC(tot)}$ = 5.0 mA; $V_{ENABLE} \geq 0.7$ V; $Z_S = Z_L = 50\ \Omega$ (input and output matched to 50 Ω).

**Fig 22. Power gain and noise figure as function of frequency; typical values**

# 9. Package outline

**XSON6: plastic extremely thin small outline package; no leads; 6 terminals; body 1 x 1 x 0.5 mm** **SOT891**




**DIMENSIONS (mm are the original dimensions)**

| UNIT | A max | $A_1$ max | b | D | E | e | $e_1$ | L | $L_1$ |
|---|---|---|---|---|---|---|---|---|---|
| mm | 0.5 | 0.04 | 0.20<br>0.12 | 1.05<br>0.95 | 1.05<br>0.95 | 0.55 | 0.35 | 0.35<br>0.27 | 0.40<br>0.32 |

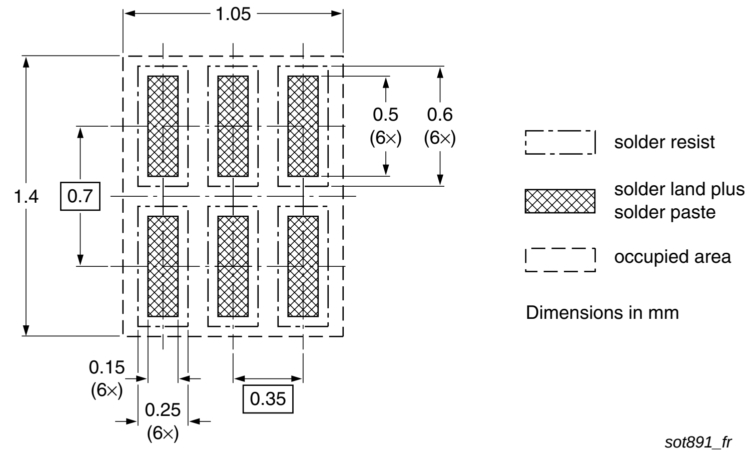
**Note**

1. Can be visible in some manufacturing processes.

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT891 | | | | | | ~~05-04-06~~<br>07-05-15 |

**Fig 23. Package outline SOT891 (XSON6)**

## 10. Soldering




Reflow soldering is the only recommended soldering method.

**Fig 24. Reflow soldering footprint**

## 11. Abbreviations

**Table 11. Abbreviations**

| Acronym | Description |
|---|---|
| AC | Alternating Current |
| CDMA | Code Division Multiple Access |
| DC | Direct Current |
| FR4 | Flame Retardant 4 |
| GPS | Global Positioning System |
| LNA | Low-Noise Amplifier |
| MMIC | Monolithic Microwave Integrated Circuit |
| RF | Radio Frequency |
| SiGe:C | Silicon Germanium Carbon |
| SMA | SubMiniature version A |
| WLAN | Wireless Local Area Network |

## 12. Revision history

**Table 12. Revision history**

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| BGU7003 v.2 | 20100622 | Product data sheet | - | BGU7003 v.1 |
| Modifications: | • Legal information updated. | | | |
| BGU7003 v.1 | 20090302 | Product data sheet | - | - |

# 13. Legal information

## 13.1 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.

## 13.2 Definitions

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## 14. Contact information

For more information, please visit: **http://www.nxp.com**

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

## 15. Contents





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