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Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

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Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



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User manual for the BGU7003 868MHz LNA evaluation board

Rev.1.0 — 06 December 2011

User manual

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



Revision history

Rev	Date	Description
1.0	20111206	Initial document

Contact information

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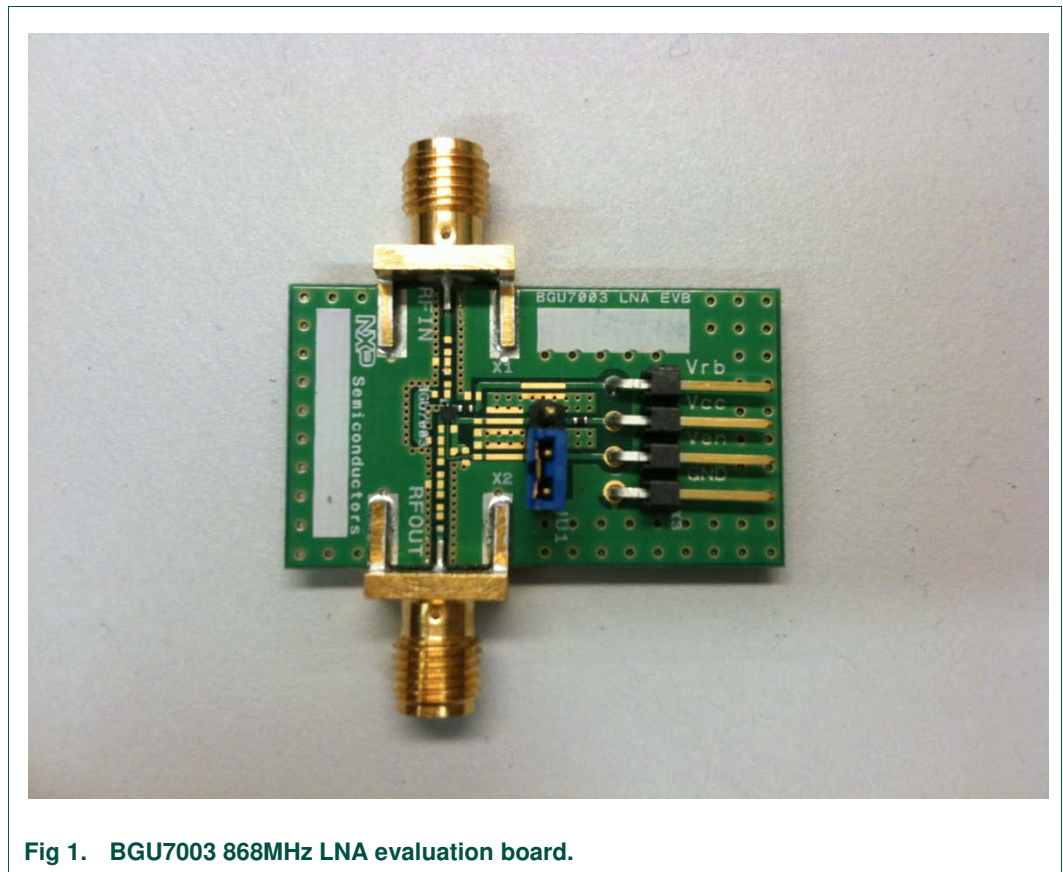
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1. Introduction

NXP Semiconductors' BGU7003 is wideband Silicon Germanium Amplifier MMICs for high speed, low noise applications. It can be used mainly for LNA applications up to 6 GHz like GPS, Satellite radio, Cordless Phone. The BGU7003 contains one RF stage and internal bias that is temperature stabilized. It also contains a power down function to shutdown the amplifier by means of a logic signal on the enable pin.

The BGU7003 is ideal for use in portable electronic devices, such as mobile phones, Personal Digital Assistants (PDAs), Personal Navigation Devices (PNDs) etc.

The 868MHz LNA BGU7003 Universal Evaluation Board (EVB) see [Fig 1](#) is designed to evaluate the performance of the BGU7003 applied as an 868MHz LNA. In this document, the application diagram, board layout, bill of material, and some typical results are given.



2. General Description

NXP Semiconductors' BGU7003 consist of a wideband Silicon Germanium SiGe transistor with internal bias circuit. This bias circuit is temperature stabilized, which keeps the current constant over temperature. The bias current for the RF stage can be set via an external bias resistor enabling flexibility in choosing the bias current. The BGU7003 is also supplied with an enable function that allows it to be controlled with a logic signal. This disable mode it only consumes less than 0.4 μ A. In [Fig 2](#) the simplified internal circuit of the BGU7003 is given.

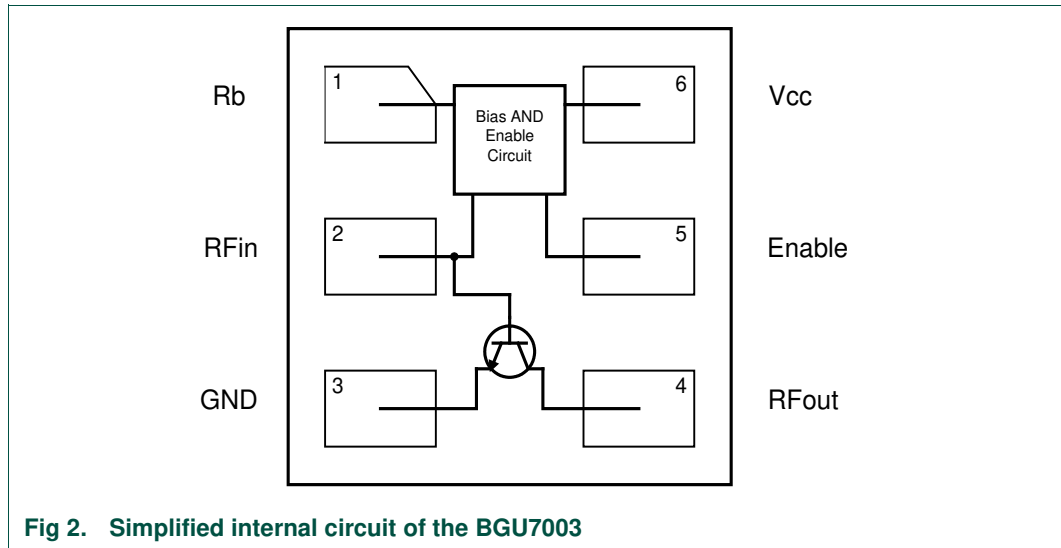


Fig 2. Simplified internal circuit of the BGU7003

The BGU7003 is not internally matched so for both input and output a matching circuit needs to be designed. The fact that no internal matching is available makes the product suitable for different application/frequency areas.

In the next paragraphs the BGU7003 applied as a 868MHz LNA is described.

3. Application Board

The BGU7003 Universal Evaluation Board 868MHz LNA simplifies the evaluation of the BGU7003 wideband amplifier MMIC, for the 868MHz application area. The BGU7003 Universal Evaluation Board enables testing of the device performance and requires no additional support circuitry. The board is fully assembled with the BGU7003 IC, including input- and output matching, to optimize the performance. The board is supplied with two SMA connectors for input and output connection to RF test equipment.

3.1 Application Circuit

The circuit diagram of the BGU7003 Universal Evaluation Board is given in [Fig 3](#).

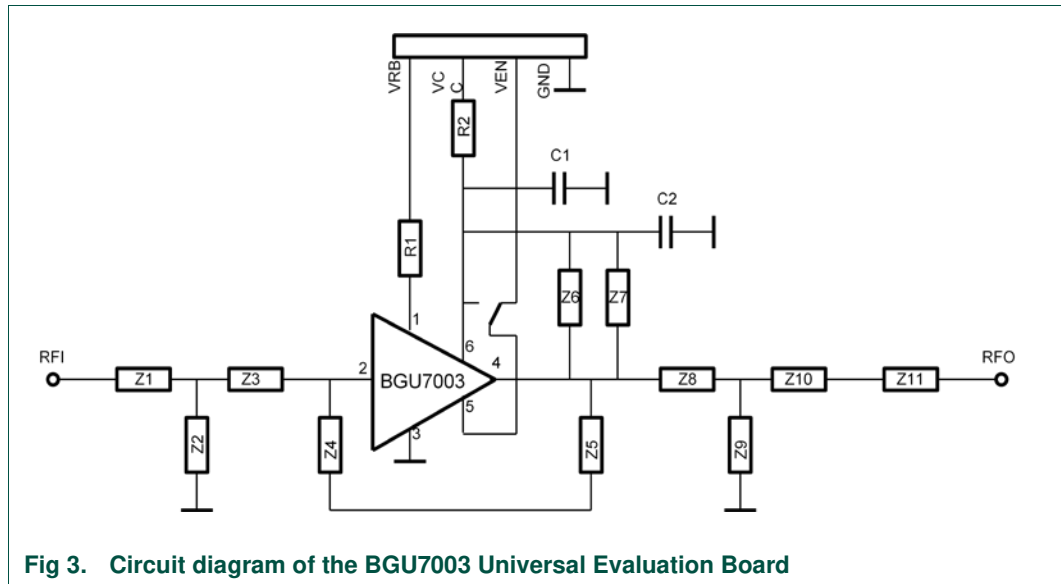


Fig 3. Circuit diagram of the BGU7003 Universal Evaluation Board

3.2 Board Layout

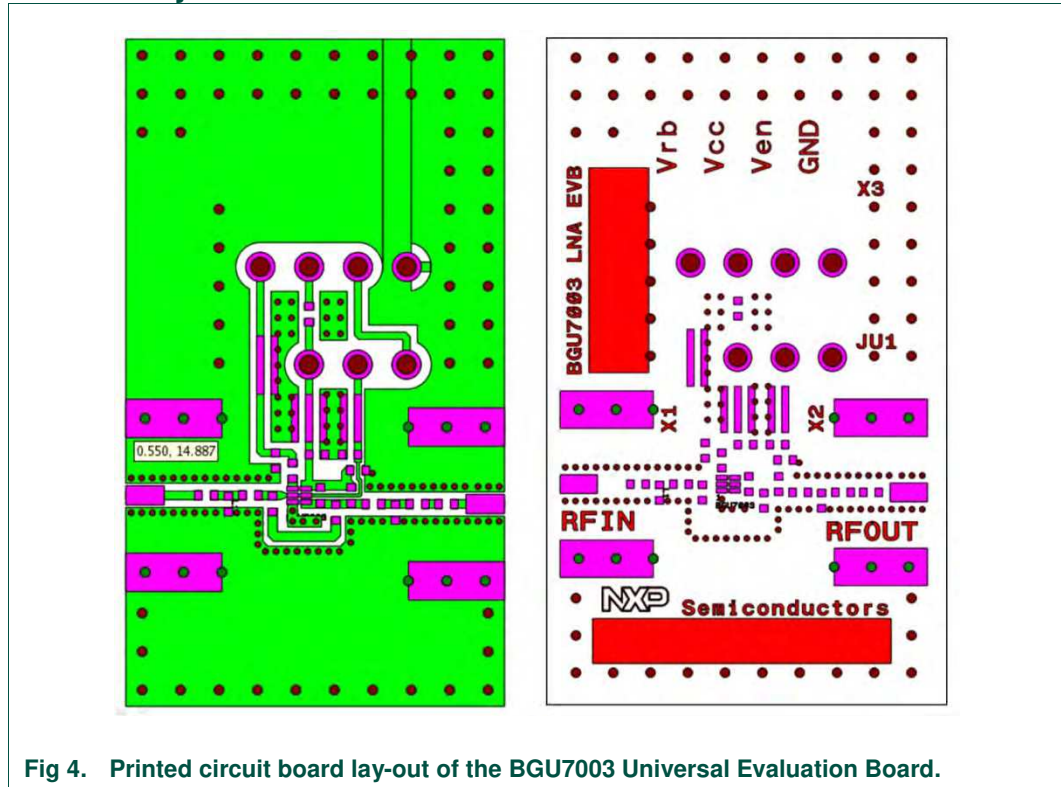


Fig 4. Printed circuit board lay-out of the BGU7003 Universal Evaluation Board.

3.3 PCB layout

A good PCB Layout is an essential part of an RF circuit design. The BGU7003 Universal Evaluation Board can serve as a guideline for laying out a board using the BGU7003. Use controlled impedance lines for all high frequency inputs and outputs. Bypass V_{CC} with decoupling capacitors, preferable located as close as possible to the device. For long bias lines it may be necessary to add decoupling capacitors along the line further away from the device. Proper grounding the GND pin is also essential for good RF performance. Either connect the GND pin directly to the ground plane or through vias, or do both. The material that has been used for the EVB is FR4 using the stack shown in [Fig 5](#). Material supplier is ISOLA DURAVER; $\epsilon_r = 4.6-4.9$; $T\delta = 0.02$.

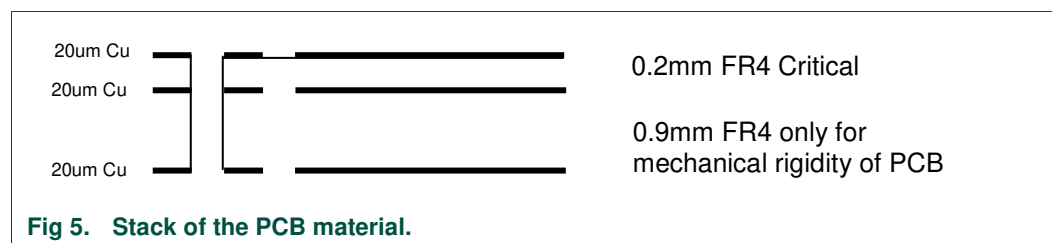


Fig 5. Stack of the PCB material.

3.4 Bill of materials

Table 1. BOM of the BGU7003 868MHz LNA evaluation board.

Designator	Description	Footprint	Value	Supplier Name/type	Comment
Z1	L	0402	10nH	muRata / LQW15 (wire wound)	Input Match (Optional: 15nH)
Z2	C	0402	1pF		Input Match (Optional: not mounted)
Z3	C	0402	100pF		DC-Block
Z4	not mounted	0402			-
Z5	not mounted	0402			-
Z6	L	0402	33nH	muRata / LQG15	Output Match
Z7	R	0402	100Ω	Various	Stability
Z8	L	0402	2.7nH	muRata / LQG15	Output Match
Z9	C	0402	1.5pF		Output Match / stability
Z10	C	0402	100pF		DC-Block
Z11	R	0402	0Ω	Various	Short
C1	n.m.	0402			Decoupling
C2	C	0402	100pF		Decoupling
R1	R	0402	3k9Ω	Various	Bias setting.
R2	R	0402	0Ω	Various	Short
B3	MMIC		BGU7003	NXP	-

4. Required Equipment

In order to measure the BGU7003 Universal Evaluation Board the following is necessary.

- DC Power Supply up to 30 mA at 2 to 2.8 V (up to 15V for bias control)
- An RF signal generator capable of generating an RF signal at the operating frequency of 1GHz.
- An RF spectrum analyzer that covers at least the operating frequency of 1GHz as well as a few of the harmonics, so up to 6 GHz should be sufficient.
- "Optional" a version with the capability of measuring noise figure is convenient.
- Amp meter to measure the supply current (optional).
- A network analyzer for measuring gain, return loss and reverse Isolation.
- Noise figure analyzer and noise source.
- Proper RF cables

5. Connections and Set_up

The BGU7003 Universal Evaluation Board 868MHz LNA is fully assembled and tested. Please follow the steps below for a step-by-step guide to operate the BGU7003 Universal Evaluation Board and testing the device functions.

1. Connect the DC power supply set to 2.8V to the V_{CC} , V_{Rb} V_{en} and GND terminals. Set the power supply to the desired supply voltage, between 2.2 and 2.85V, but never exceed 3.0V as it might damage the BGU7003.
2. Connect the RF signal generator and the Spectrum Analyzer; to the RF input and the RF output of the BGU7003 Universal Evaluation Board respectively. Do not turn on the RF output of the signal generator yet, set it to -40dBm output power at 868MHz, set the spectrum analyzer on 868MHz center frequency and a reference level of 0dBm.
3. Turn on the DC power supply and it should read approximately 5mA.
4. Enable the RF output of the generator; the spectrum analyzer displays a tone of 868MHz at around -26 dBm.
5. In order to evaluate the board on different bias currents through RF stage of the MMIC the Voltage on Rb (V_{Rb}) can be connected to a separate power supply. This is enabling the control of the bias current.
6. To evaluate the enable function the V_{en} terminal of the board can also be connected to a separate DC power supply that either gives a voltage >0.6V (amplifier on) or <0.5V amplifier off.
7. Instead of using a signal generator and spectrum analyzer one can also use a Network Analyzer in order to measure Gain as well as in- and output return loss.
8. For Noise figure evaluation, either a noise-figure analyzer or a spectrum analyzer with noise option can be used. The use of a 5 dB noise source, like the Agilent 364A is recommended. When measuring the noise figure of the evaluation board, any kind of adaptors, cables etc between the noise source and the BGU7003 Universal Evaluation Board should be avoided, since this affects the noise performance.

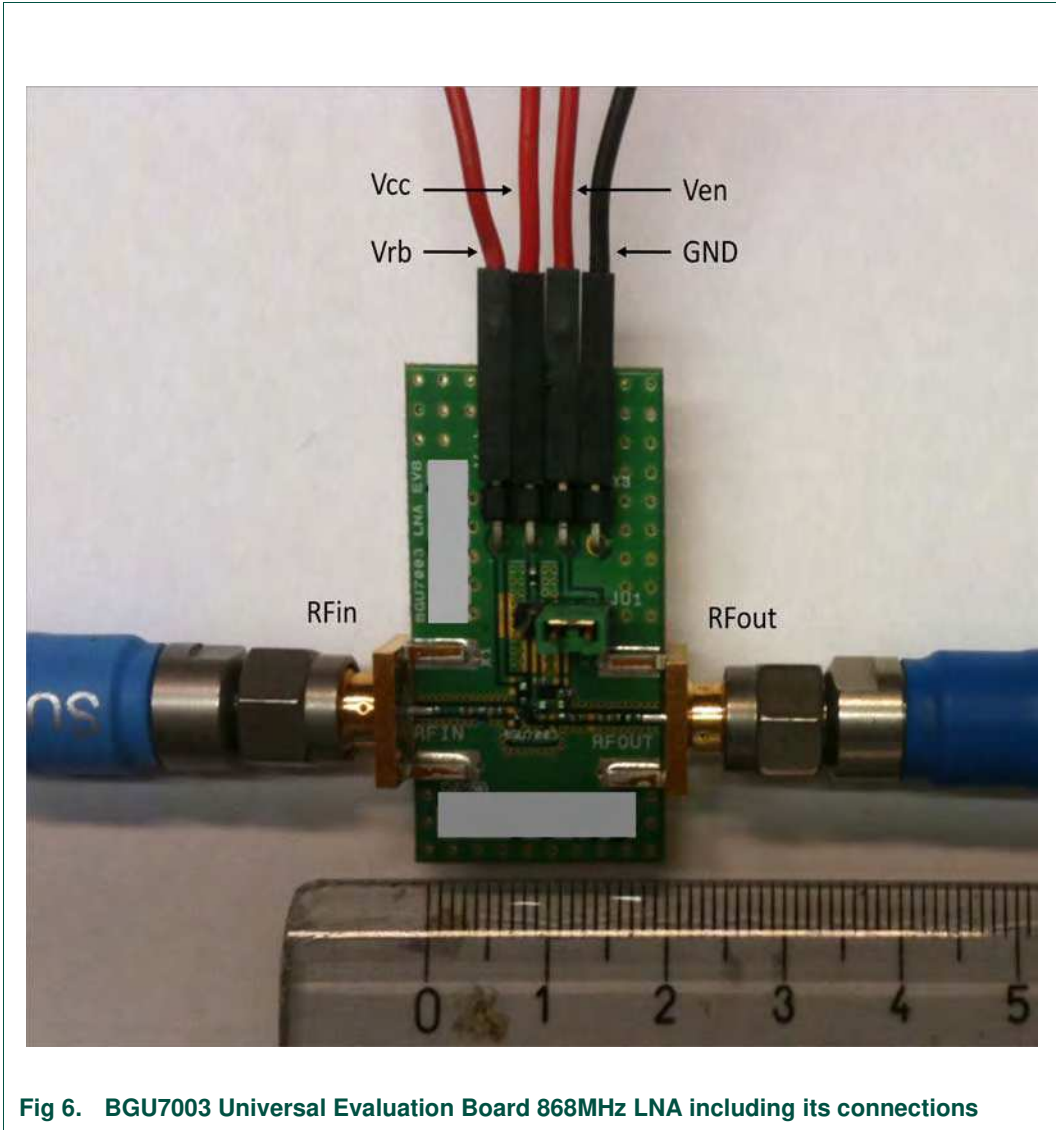


Fig 6. BGU7003 Universal Evaluation Board 868MHz LNA including its connections

6. Typical EVB Results

The tables and figures in this paragraph show the results measured for a numbers of EVB's.

Table 2. Typical results measured on the Evaluation Boards.

Operating Frequency is 868MHz; Vcc and Ven = 2.8V (Icc~5mA) Temp = 25 °C, unless otherwise specified.

Parameter	Symbol	BGU7003 EVB	Unit	Comment
Noise Figure	NF	0.9	dB	[1]
Power Gain	Gp	19	dB	[2]
Input Return Loss	IRL	4	dB	[2]
Output Return Loss	ORL	11	dB	[2]
Reverse Isolation		30	dB	[2]
Output 1dB Gain	OP1dB	-6.5	dBm	
Output third order	OIP3	8.5	dBm	[3]
on/off switching time	T _{on/off}	0.7	μs	

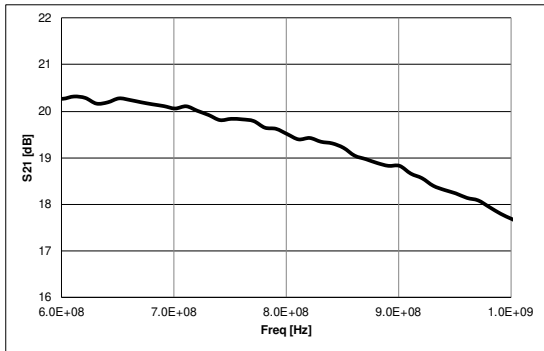
[1] The NF and Gain figures are being measured at the SMA connectors of the EVB, so the losses of the connectors and the PCB are not subtracted. If you do so the NF will improve approximately 0.1 dB.

[2] Pin=-45dBm

[3] 2-Tone test with F₁=868MHz, F₂=873MHz (Spacing 5MHz). Highest spurious used for calculations.

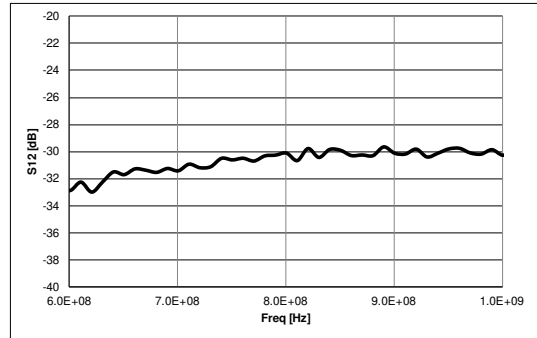
The figures on the next page give measured S-Parameter-, 2-Tone test- and P1dB- results of a typical BGU7003 868MHz LNA made with the Universal Board.

This 868MHz LNA was designed with a trade-off between optimal input-match and lowest NF. To improve the IRL, Z2 (see **Error! Reference source not found.**) can be removed, and Z1 (10nH) can be increased to ~15nH. As a result the IRL will improve with ~3dB and the NF will increase with ~0.2dB (IRL~7dB => NF~1.2dB).



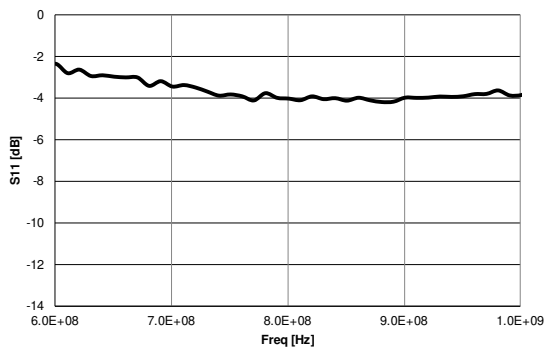
Vsup=2.8V / ~5mA.

Fig 7. BGU7003 UNI EVB 868MHz LNA: S₂₁



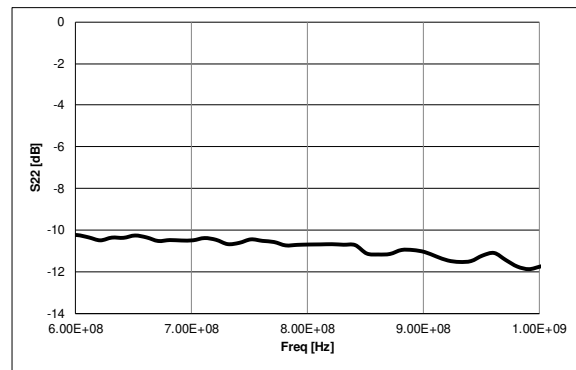
Vsup=2.8V / ~5mA.

Fig 8. BGU7003 UNI EVB 868MHz LNA: S₁₂



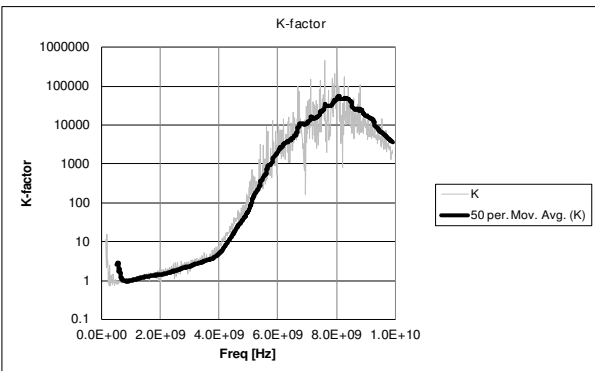
Vsup=2.8V / ~5mA.

Fig 9. BGU7003 UNI EVB 868MHz LNA: S₁₁



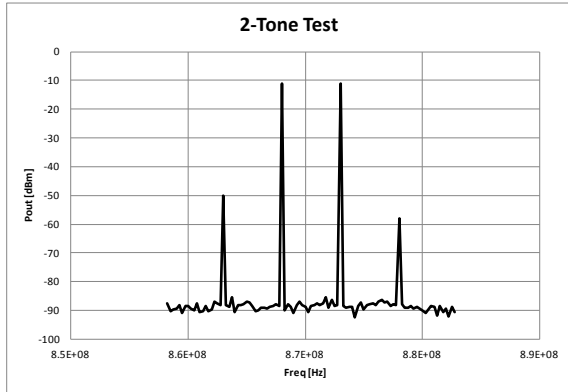
Vsup=2.8V / ~5mA.

Fig 10. BGU7003 UNI EVB 868MHz LNA: S₂₂



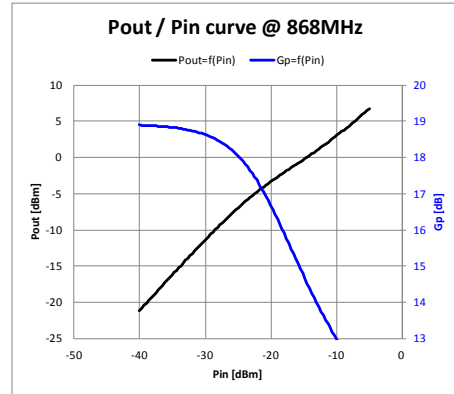
Vsup=2.8V / ~5mA.

Fig 11. BGU7003 UNI EVB 868MHz LNA: K-Factor



Vsup=2.8V / ~5mA.

Fig 12. BGU7003 UNI EVB 868MHz LNA: 2-Tone Test



Vsup=2.8V / ~5mA.

Fig 13. BGU7003 UNI EVB 868MHz LNA: P1dB Test

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