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BGU6005/N2 GNSS LNA evaluation board

Rev. 3 — 19 February 2015

Document information

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Abstract	This document explains the BGU6005/N2 GNSS LNA evaluation board
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	12NC: 9340 692 54598
Contact information	For more information, please visit: http://www.nxp.com

Revision history

Rev	Date	Description
3	20150219	Updated Board-number and 12nc
2	20140416	Updated with latest evaluation results
1	20140314	First publication

Contact information

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1. Introduction

NXP Semiconductors' BGU6005/N2 Global Navigation Satellite System (GNSS) LNA Evaluation Boards is designed to evaluate the performance of the GNSS LNA using:

- NXP Semiconductors' BGU6005/N2 GNSS Low Noise Amplifier
- A matching inductor
- A decoupling capacitor

NXP Semiconductors' BGU6005/N2 is a low-noise amplifier for GNSS receiver applications in a plastic, leadless 6 pin, extremely thin small outline SOT886 at 1 x 1.45 x 0.5 mm. The BGU6005/N2 features gain of 17.5 dB and a noise figure of 0.85 dB at a current consumption of `4.9 mA. The LNA components occupy a total area of approximately 4 mm^2.

In this document, the application diagram, board layout, bill of materials, and typical results are given, as well as some explanations on GNSS related performance parameters like out-of-band input third-order intercept point O_IIP3, gain compression under jamming and noise under jamming.
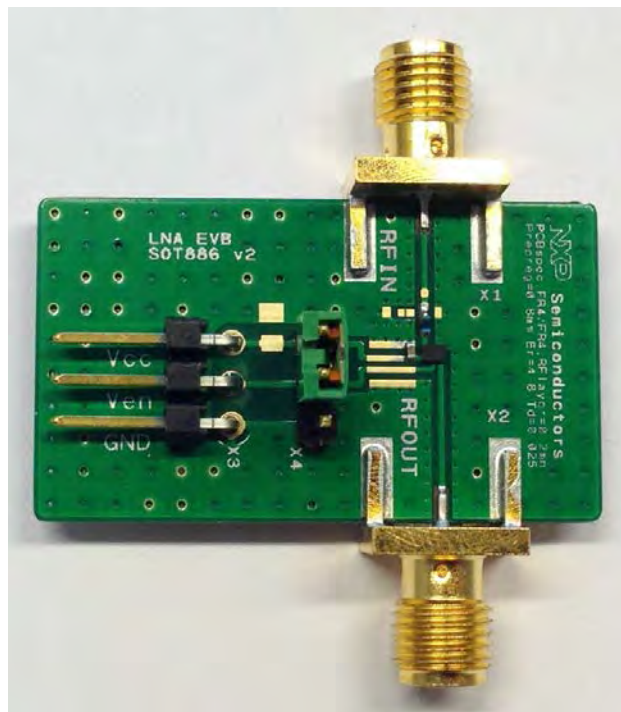

Fig 1.   BGU6005/N2 GNSS LNA evaluation board

2. General description

Modern cellular phones have multiple radio systems, so problems like co-habitation are quite common. A GNSS receiver implemented in a mobile phone requires the following factors to be taken into account.

All the different transmit signals that are active in smart phones and tablets can cause problems like inter-modulation and compression.

Since the GNSS receiver needs to receive signals with an average power level of -130 dBm, sensitivity is very important. Currently there are several GNSS chipsets on the market that can be implemented in cell phones, tablets etc. Although many of these GNSS ICs do have integrated LNA front ends, the noise performance, and as a result the system sensitivity, is not always adequate. The GNSS receiver sensitivity is a measure how accurate the coordinates are calculated. The GNSS signal reception can be improved by a so called GNSS LNA, which improves the sensitivity by amplifying the wanted GNSS signal with a low-noise amplifier.

3. BGU6005/N2 GNSS LNA evaluation board

The BGU6005/N2 LNA evaluation board simplifies the RF evaluation of the BGU6005/N2 GNSS LNA applied in a GNSS front-end, often used in mobile cell phones. The evaluation board enables testing of the device RF performance and requires no additional support circuitry. The board is fully assembled with the BGU6005/N2, including the input series inductor and decoupling capacitor. The board is supplied with two SMA connectors for input and output connection to RF test equipment. The BGU6005/N2 can operate from a 1.5 V to 3.1 V single supply and consumes typical 4.9 mA.

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3.1 Application Circuit

The circuit diagram of the evaluation board is shown in Fig 2. With jumper JU1 the enable input can be connected either to Vcc or GND.
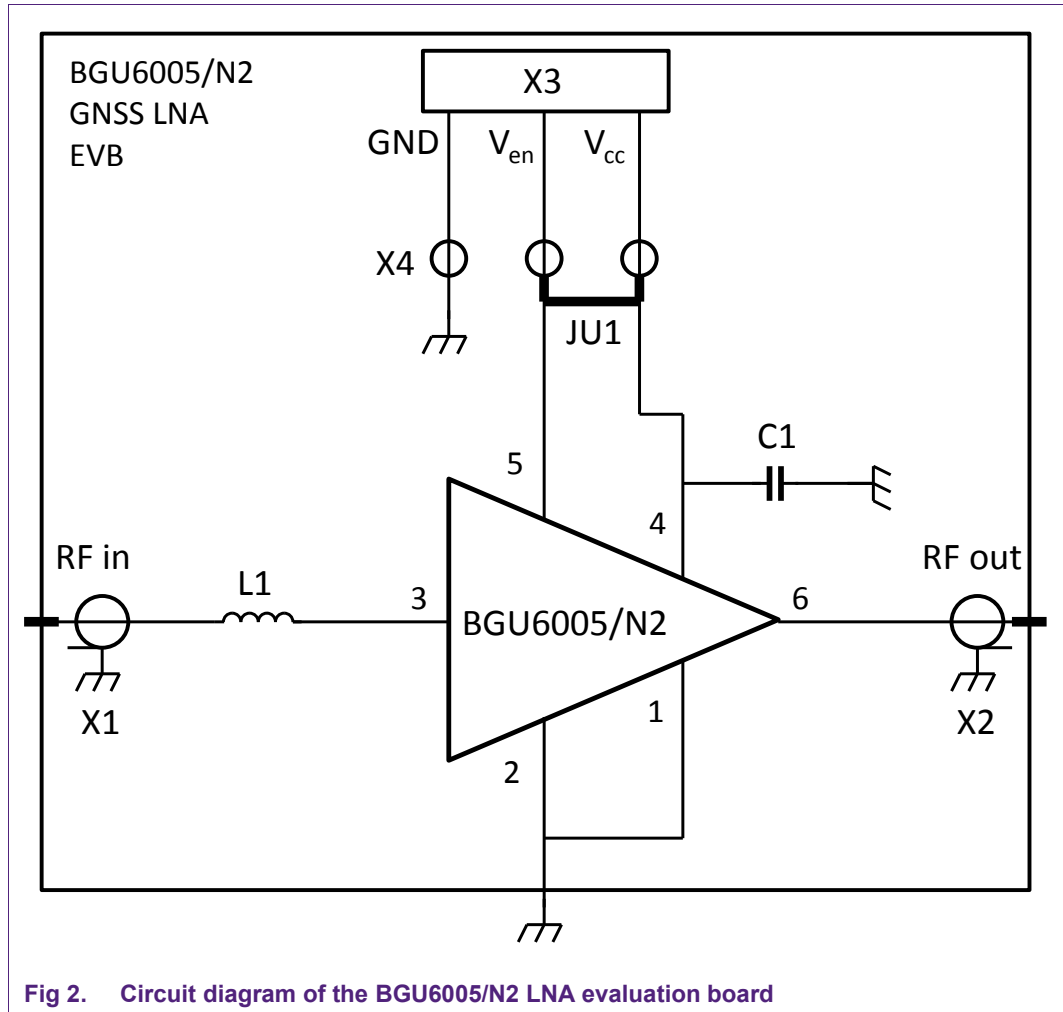

Fig 2.   Circuit diagram of the BGU6005/N2 LNA evaluation board

3.2 PCB Layout

A good PCB layout is an essential part of an RF circuit design. The LNA evaluation board of the BGU6005/N2 can serve as a guideline for laying out a board using the BGU6005/N2. Use controlled impedance lines for all high frequency inputs and outputs. Bypass Vcc with decoupling capacitors, preferably 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 of the GND pins is also essential for good RF performance. Either connect the GND pins directly to the ground plane or through vias, or do both, which is recommended. The material that has been used for the evaluation board is FR4 using the stack shown in Fig 4.
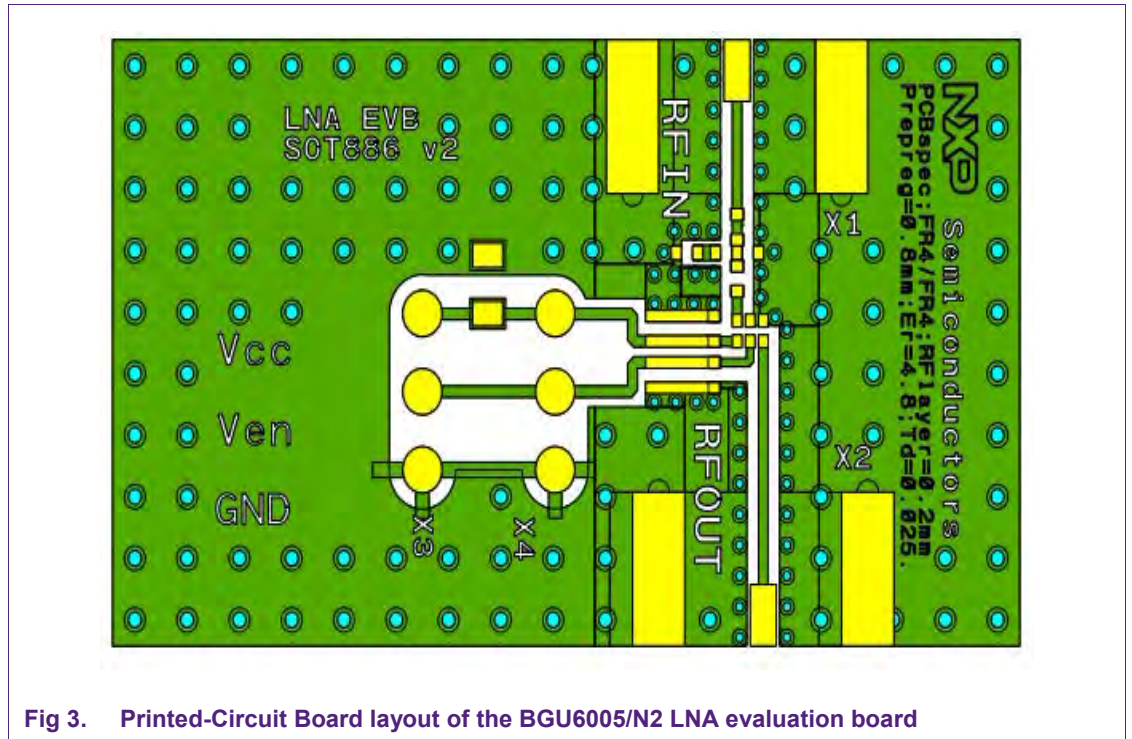
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Fig 3.   Printed-Circuit Board layout of the BGU6005/N2 LNA evaluation board

20um Cu

20um Cu

20um Cu

0.2mm FR4 critical

0.8mm FR4 only for
mechanical rigidity of PCB

(1)   Material supplier is ISOLA DURAVER; εr = 4.6-4.9: $T\delta = 0.02$
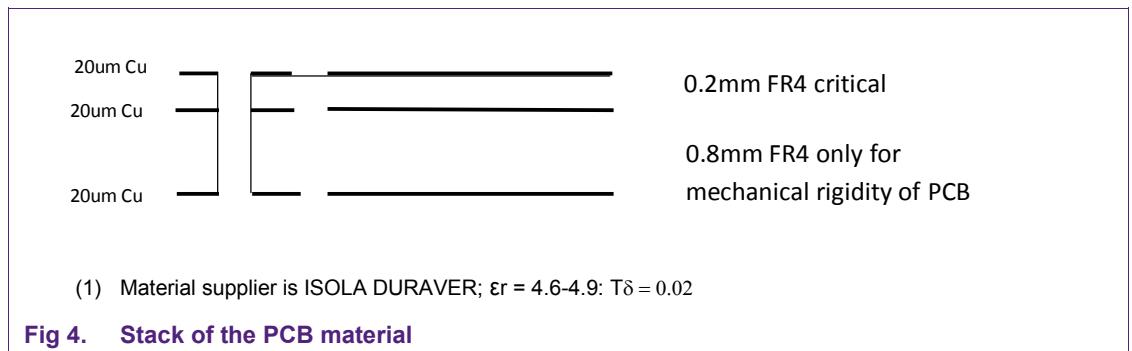
Fig 4.   Stack of the PCB material

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4. Bill of materials

Table 1.   BOM of the BGU6005/N2 GNSS LNA evaluation board

Designator	Description	Footprint	Value	Supplier Name/type	Comment
D1	BGU6005/N2	1 x 1.45 x 0.5 mm		NXP	SOT886.
PCB		20x35mm		BGU6005/N2 GNSS LNA EV Kit	
C1	Capacitor	0402	1nF	Murata GRM1555	Decoupling
L1	Inductor	0402	5.6nH	Murata LQW15	Input matching
X1, X2	SMA RD connector	-	-	Johnson, End launch SMA 142-0701-841	RF input/ RF output
X3	DC header	-	-	Molex, PCB header, Right Angle, 1 row, 3 way 90121-0763	Bias connector
X4	JUMPER Stage	-	-	Molex, PCB header, Vertical, 1 row, 3 way 90120-0763	Connect Ven to Vcc or separate Ven voltage
JU1	JUMPER				

4.1 BGU6005/N2

NXP Semiconductors' BGU6005/N2 GNSS low noise amplifier is designed for the GNSS frequency band. The integrated biasing circuit is temperature stabilized, which keeps the current constant over temperature. It also enables the superior linearity performance of the BGU6005/N2. The BGU6005/N2 is also equipped with an enable function that allows it to be controlled via a logic signal. In disabled mode it consumes less than1 µA.

The output of the BGU6005/N2 is internally matched for 1575.42 MHz whereas only one series inductor at the input is needed to achieve the best RF performance. Both the input and output are AC coupled via an integrated capacitor.

It requires only two external components to build a GNSS LNA having the following advantages:

- Low noise
- System optimized gain
- High linearity under jamming
- 1 x 1.45 x 0.5 mm: SOT886
- Low current consumption
- Short power settling time

4.2 Series inductor

The evaluation board is supplied with Murata LQW15 series inductor of 5.6 nH. This is a wire wound type of inductor with high quality factor (Q) and low series resistance (Rs). This type of inductor is recommended in order to achieve the best noise performance. High Q inductors from other suppliers can be used. If it is decided to use other low cost inductors with lower Q and higher Rs the noise performance will degrade.

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5. Required Equipment

In order to measure the evaluation board the following is necessary:

- ✓ DC Power Supply op to 30 mA at 1.5 V to 3.1 V

- ✓ Two RF signal generators capable of generating RF signals at the operating frequency of 1575.42 MHz, as well as the jammer frequencies 1713.42 MHz and 1851.42 MHz

- ✓ An RF spectrum analyzer that covers at least the operating frequency of 1575.42 MHz as well as a few of the harmonics. 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

- ✓ Directional coupler

- ✓ Proper RF cables

6. Connections and setup

The BGU6005/N2 GNSS LNA evaluation board is fully assembled and tested. Please follow the steps below for a step-by-step guide to operate the LNA evaluation board and testing the device functions.

1. Connect the DC power supply to the V_{cc} and GND terminals. Set the power supply to the desired supply voltage, between 1.5 V and 3.1 V, but never exceed 3.1 V as it might damage the BGU6005/N2.

2. Jumper JU1 is connected between the V_{cc} terminal of the evaluation board and the V_{en} pin of the BGU6005/N2.

3. Connect the RF signal generator and the spectrum analyzer to the RF input and the RF output of the evaluation board, respectively. Do not turn on the RF output of the signal generator yet, set it to -45 dBm output power at 1575.42 MHz, set the spectrum analyzer at 1575.42 MHz center frequency and a reference level of 0 dBm.

4. Turn on the DC power supply and it should read approximately 4.9 mA.

5. Enable the RF output of the generator: The spectrum analyzer displays a tone around –27.5 dBm at 1575.42 MHz.

6. 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.

7. 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 364B is recommended. When measuring the noise figure of the evaluation board, any kind of adaptors, cables etc between the noise source and the evaluation board should be minimized, since this affects the noise figure.
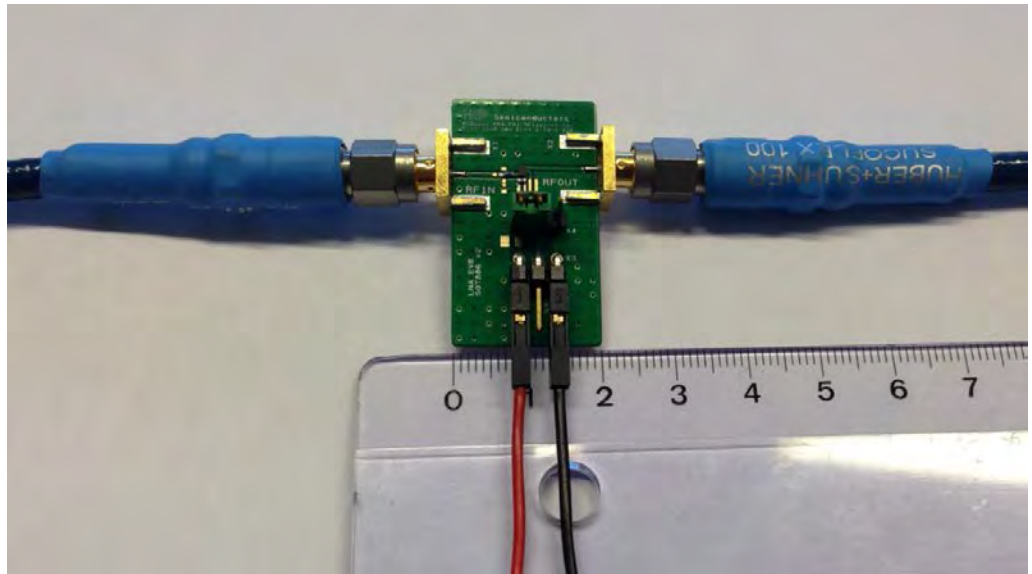
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**Fig 5.   Evaluation board including its connections**

7.   Typical Board Performance

Measurements have been carried out using the setup as discussed in Chapter 6.
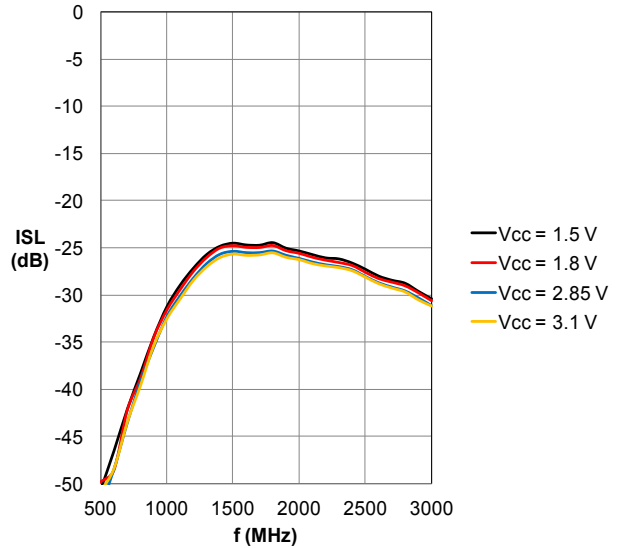
7.1   S-Parameters

S-Parameters of the DUT are measured between port RFin and RFout of the EVB between the frequencies 500 MHz and 3 GHz, with input power of -45dBm at room temperature (Tamb=25 °C).

A typical result the S-parameters as a function of frequency and supply voltage are given in the following figures
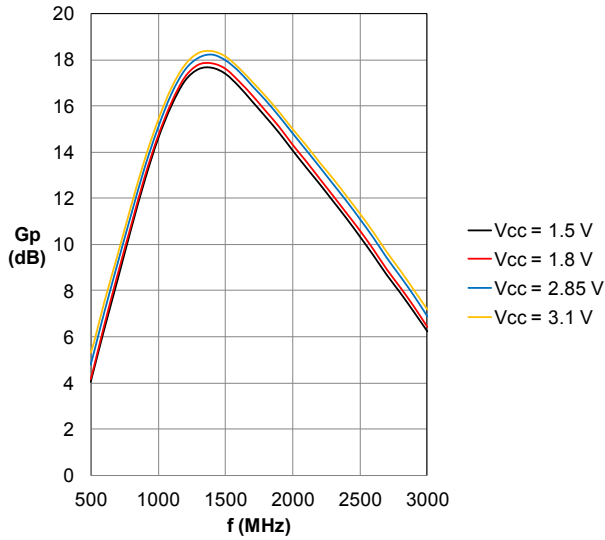
Pi = -45 dBm; Tamb = 25 °C

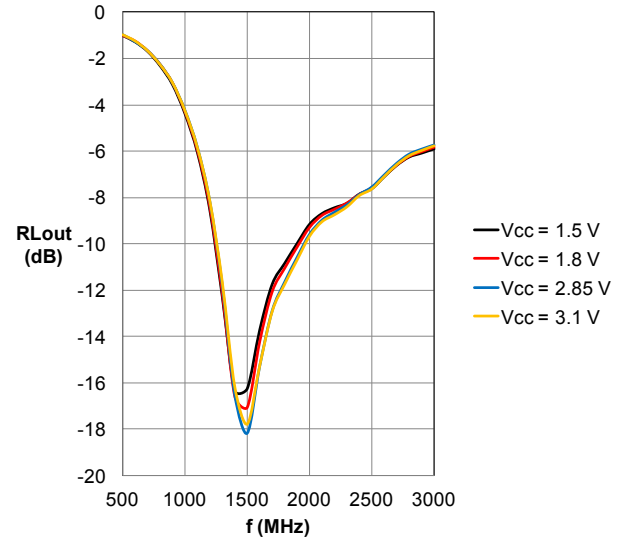**Fig 6.** **S₂₁ (Power gain) as a function of frequency; typical values**

Pi = -45 dBm; Tamb = 25 °C

Fig 7. **S₁₂ (Isolation) as a function of frequency; typical values**
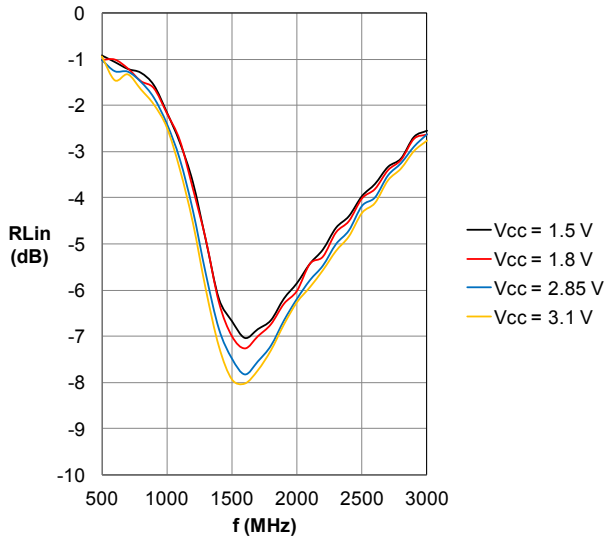
Pi = -45 dBm; Tamb = 25 °C

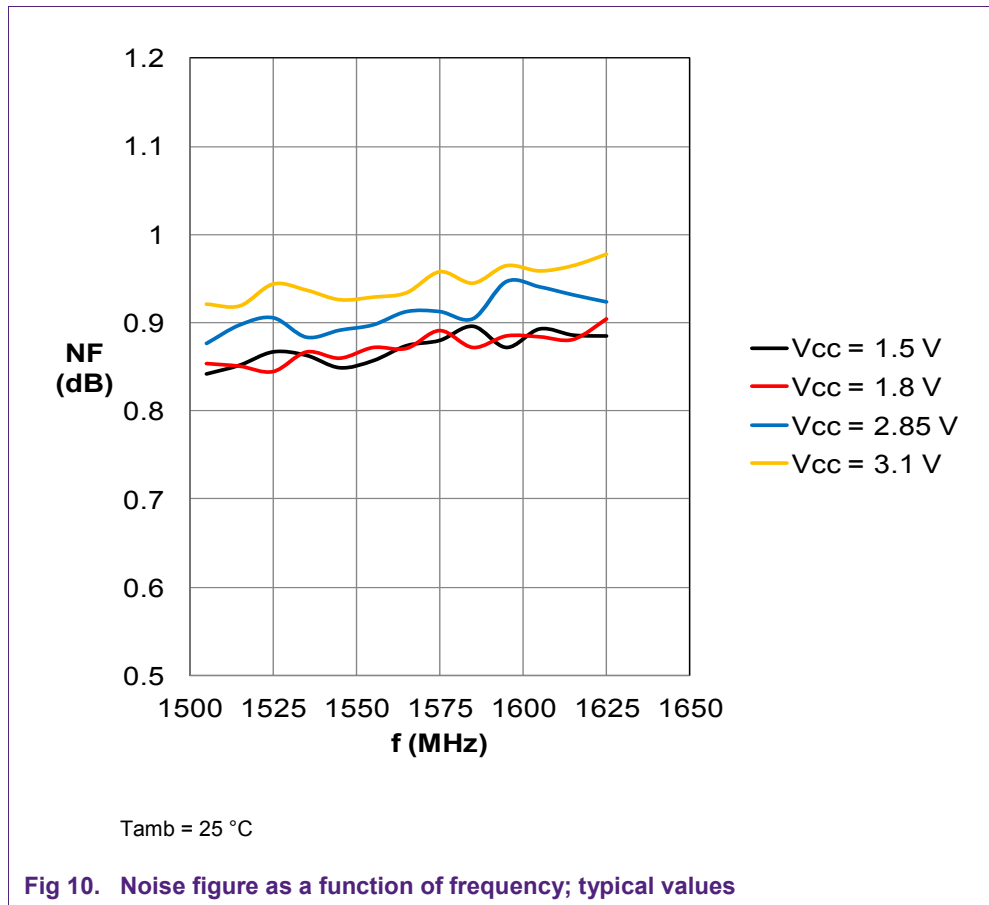**Fig 8.** **S₁₁ (Input return loss) as a function of frequency; typical values**

Pi = -45 dBm; Tamb = 25 °C

Fig 9. **S₂₂ (Output return loss) as a function of frequency; typical values**

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7.2 Noise figure

The Noise Figure of the DUT is measured between port RFin and RFout of the EVB between the frequencies 1500 MHz and 1650 MHz and at room temperature (Tamb=25 °C).

A typical result of Noise figure as a function of frequency and supply voltage is given below.

Tamb = 25 °C

Fig 10. Noise figure as a function of frequency; typical values

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8. Typical LNA evaluation board results

Table 2. Typical results measured on the evaluation boards
Operating Frequency is f = 1575.42 MHz unless otherwise specified; Temp = 25 °C

Parameter	Symbol	LNA EVB	LNA EVB	LNA EVB	LNA EVB	Unit	Remarks
Supply Voltage	V_{CC}	1.5	1.8	2.85	3.1	V	
Supply Current	I_{CC}	4.8	4.9	5.2	5.3	mA	
Noise Figure	NF	0.9	0.9	0.9	0.9	dB	[1]
Power Gain	G_p	17	17	17.5	18	dB	
Input Return Loss	RL_{in}	7.0	9	9	9	dB	
Output Return Loss	RL_{out}	14.1	15	15	16	dB	
Reverse Isolation	ISO_{rev}	24	24	25	25	dB	
Input 1dB Gain Compression	P_i1dB	-10	-9	-6	-5	dBm	
Output 1dB Gain Compression	P_o1dB	6	7	10.5	12	dBm	
Input third order intercept point	IIP3	2	3	6	7	dBm	[2]
Output third order intercept point	OIP3	19	20	23.5	25	dBm	[2]
Power settling time	T_{on}	<2	< 2	< 2	< 2	µs	
	T_{off}	<1	< 1	< 1	< 1	µs	

[1] The noise figure and gain figures are measured at the SMA connectors of the evaluation board. The losses of the connectors and the PCB of approximately 0.05 dB are not subtracted. Measured at T_{anb} = 25 °C.

[2] Out of band IP3, jammers at f_1=f+138MHz and f_2=f+276MHz, where f=1575.42MHz. $P_{in}(f_1)$=-20dBm, $P_{in}(f_2)$=-65dBm

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10. List of figures

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