AN11913

BGU8019 [GPS1202M] tuned for GNSS L2-band evaluation board

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Document information

Info	Content
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Abstract	This document explains the BGU8019 [GPS1202M] LNA evaluation board tuned for the GNSS L2-band.
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Revision history

Rev	Date	Description
1	20170321	First publication
2	20170717	Updated with new evaluation results

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1. Introduction

NXP Semiconductors BGU8019, also called GPS1202M, Global Navigation Satellite System (GNSS) LNA Evaluation Board (see Fig 1) is designed to evaluate the performance of the GNSS LNA using:

- NXP Semiconductors GPS1202M GNSS Low Noise Amplifier
- Matching inductors at the in- and output
- A decoupling capacitor at the power supply connection

NXP Semiconductors GPS1202M is a low-noise amplifier for GNSS receiver applications in a plastic, leadless 6 pin, extremely thin small outline SOT1232 at 1.1 x 0.7 x 0.37mm, 0.4mm pitch. The GPS1202M features gain of 18.5 dB and a noise figure of 0.55 dB at a current consumption of 4.6 mA. Its superior linearity performance removes interference and noise from co-habitation cellular transmitters, while retaining sensitivity. The LNA components occupy a total area of approximately 4.5 mm^2.

The GPS1202M used on this evaluation board is originally designed to use as a GNSS L1-band LNA. It contains internally matched circuitry for this frequency band (1559 MHz to 1610 MHz) whereas only one series inductor at the input is needed to achieve the best RF performance.

With the use of additional external components, the operating frequency range can be tuned to the GNSS L2-band (1215 MHz to 1254 MHz).

In this document, the application diagram, board layout, bill of materials, and typical results are given.

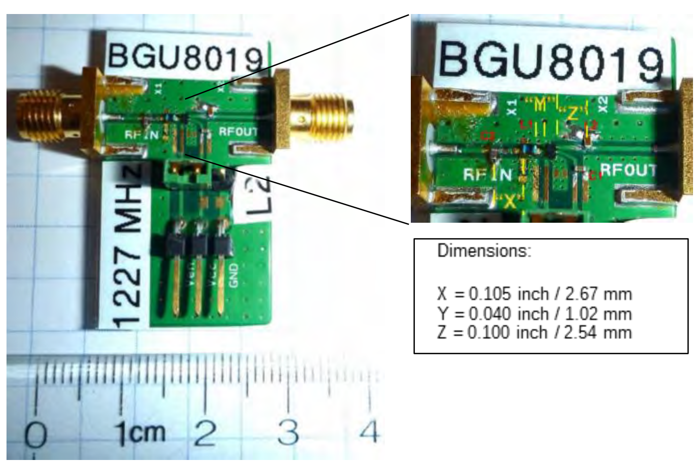


Fig 1. GPS1202M GNSS L2-band LNA evaluation board

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.

Next picture (Fig 2) depicts a part of the frequency spectrum that is occupied by the different GNSS frequency bands.

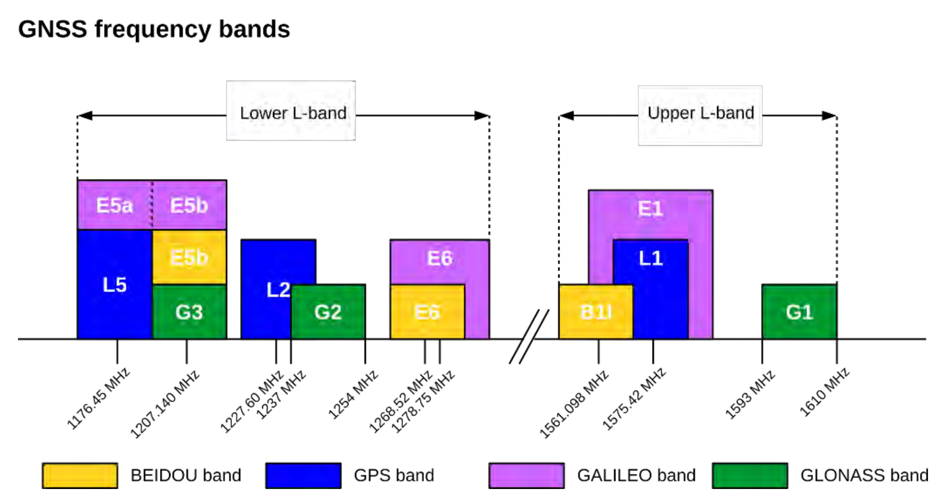


Fig 2. GNSS frequency bands

3. GPS1202M GNSS L2-band LNA evaluation board

The GPS1202M LNA evaluation board simplifies the RF evaluation of the GPS1202M 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 GPS1202M including the input parallel capacitor and series inductor, output parallel inductor and decoupling capacitor. The board is supplied with two SMA connectors (50 ohms) for input and output connection to RF test equipment. The GPS1202M can operate from a 1.5 V to 3.1 V single supply and consumes typical 4.6 mA.

3.1 Application Circuit

The circuit diagram of the evaluation board is shown in Fig 3. With jumper JU1 the enable input can be connected either to V_{cc} or GND.

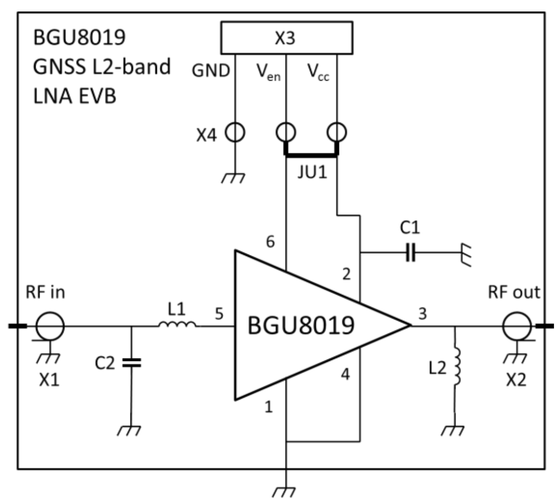


Fig 3. Circuit diagram of the GPS1202M L2-band LNA evaluation board

3.2 PCB Layout

A good PCB layout is an essential part of an RF circuit design. The LNA evaluation board of the GPS1202M can serve as a guideline for laying out a board using the GPS1202M (see Fig 4). 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.

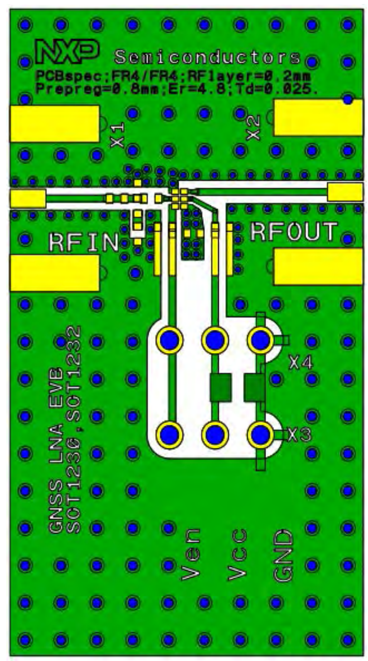
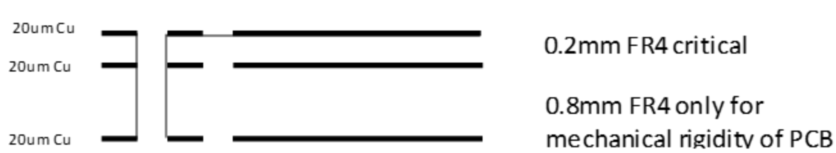


Fig 4. Printed-Circuit Board layout of the GPS1202M LNA evaluation board

The material that has been used for the evaluation board is FR4 using the stack shown in Fig 5.



[1] Material supplier is ISOLA DURAVER; εr = 4.6-4.9: Tδ = 0.02

Fig 5. Stack of the PCB material

3.3 Bill of materials

Table 1. BOM of the GPS1202M GNSS LNA evaluation board

Designator	Description	Footprint	Value	Supplier Name/type	Comment
A	GPS1202M	1.1 x 0.7 x 0.37mm^3, 0.4mm pitch		NXP	SOT1232
PCB		20 x 35mm		GPS1202M GNSS LNA EV Kit	
C1	Capacitor	0402	1nF	Murata GRM1555	Decoupling
C2	Capacitor	0402	0.5 pF	Murata GRM1555	Input matching
L1	Inductor	0402	13 nH	Murata LQW15	Input matching
L2	Inductor	0402	6.2 nH	Murata LQP15	Output 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 V_{en} to V_{cc} or separate V_{en} voltage
JU1	JUMPER				

3.4 GPS1202M product description

NXP Semiconductors GPS1202M 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 GPS1202M. The GPS1202M 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 GPS1202M 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. In this application the GPS1202M is tuned for the GNSS L2-band.

It requires only three external components to build a GNSS L2-band LNA having the following advantages:

- Low noise
- System optimized gain
- High linearity under jamming
- 1.1 x 0.7 x 0.37, 0.4mm pitch: SOT1232
- Low current consumption
- Short power settling time

3.5 Inductors

The evaluation board is supplied with a Murata LQW15 series inductor of 13 nH at the input and a Murata LQP15 parallel inductor of 6.2 nH at the output. L1 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.

Table 1. Series Inductor options

Type	Murata	Size 0201	Size 0402	Size 0603	Comment
Multilayer Non-Magnetic Core	LQG		15H NF↑↑	18H NF↑	
Film	LQP	03T NF↑↑	15M NF↑		
Wirewound Non-Magnetic Core	LQW		15A **Default**	18A NF↓	Lowest NF

4. Typical LNA evaluation board results

At the average power levels of –130 dBm that have to be received by a GNSS receiver, the system will not have in-band intermodulation problems caused by the GNSS-signal itself. Third-Order Intercept points are described in more detail in a separate User Manual: UM10453: 2-Tone Test BGU7005 and BGU7007 GNSS LNA.

Table 2. Typical results measured on the evaluation Board

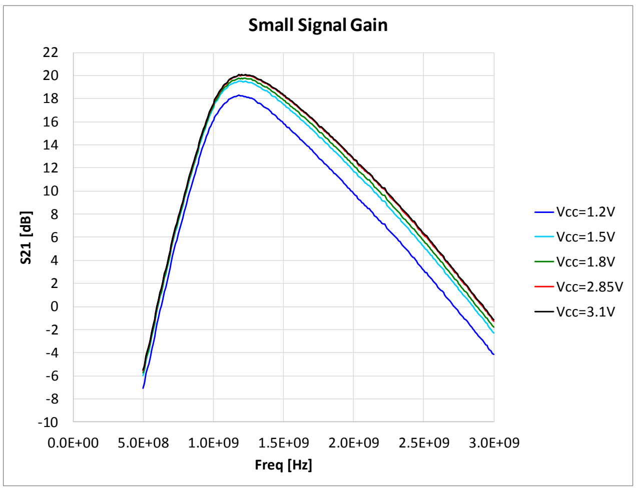
Operating temperature = 25 °C

Parameter	Symbol	Condition	LNA EVB	LNA EVB	LNA EVB	LNA EVB	LNA EVB	Unit	Remarks
Supply Voltage	V_{CC}		1.2	1.5	1.8	2.85	3.1	V	
Supply Current	I_{CC}		4.2	4.2	4.4	4.6	4.8	mA	
Noise Figure	NF	1230 MHz	0.70	0.65	0.65	0.60	0.60	dB	[1]
Power Gain	G_p	1230 MHz	18.3	19.4	19.7	20.0	20.1	dB	
Input Return Loss	RL_{in}	1230 MHz	10.4	12.5	13.2	14.2	14.4	dB	
Output Return Loss	RL_{out}	1230 MHz	18.7	18.4	18.6	18.6	18.6	dB	
Reverse Isolation	ISO_{rev}	1230 MHz	33	33	33	33	33	dB	
Input 1dB Gain Compression	P_i1dB	1230 MHz	-21.6	-15.1	-13.1	-10.4	-10.1	dBm	
Output 1dB Gain Compression	P_o1dB	1230 MHz	-4.2	3.4	5.7	8.6	8.8	dBm	
Input third order intercept point	IIP3	1230 MHz Δf=10 MHz	-13.4	-13.5	-5.3	-3.5	-3.5	dBm	
Output third order intercept point	OIP3	1230 MHz Δf=10 MHz	5.0	6.7	15.5	18.2	18.3	dBm	
Power settling time	T_{on}			<2	< 2	< 2	< 2	μs	
	T_{off}			<1	< 1	< 1	< 1	μs	
Stability factor	K	0.5 – 5 GHz	>1	>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.

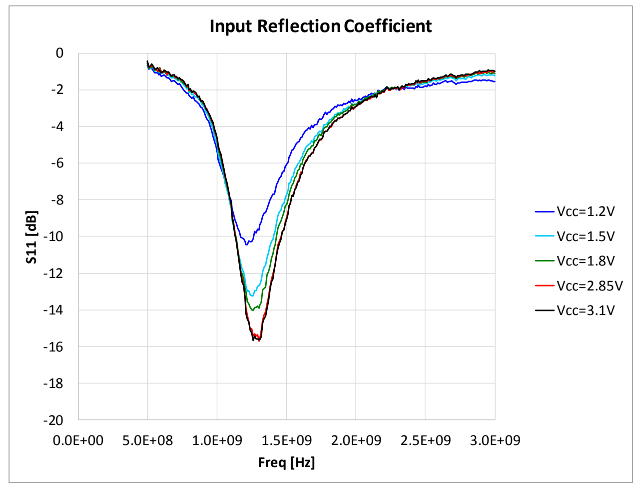
4.1 S-parameters

The S-parameters are measured at the SMA connectors of the application board. Next figures (Fig 6, Fig 7, Fig 8 and Fig 9) depicts the measurement result of the 2-port S-parameter measurement.



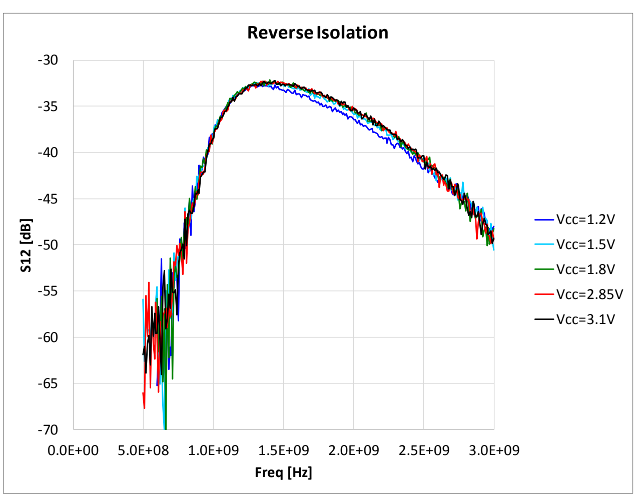
Pin = -45 dBm

Fig 6. Small signal gain (S21)



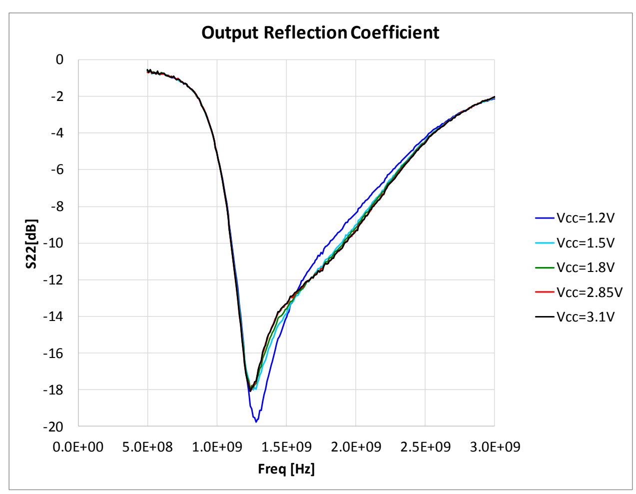
Pin = -45 dBm

Fig 7. Input Reflection Coefficient (S11)



Pin = -45 dBm

Fig 8. Reverse Isolation (S12)



Pin = -45 dBm

Fig 9. Output Reflection Coefficient (S22)

4.2 Stability factor

The stability factor “K” can be calculated with use of the S-parameter data. Stability factors less than one, indicates a possible instability issue of the circuit. Next figure (Fig 10) depicts the stability factor “K” up to a frequency of 5 GHz. Below approximately 500 MHz, the stability factor becomes noisy and is therefore unsuitable as an indicator of instability and can be neglected.

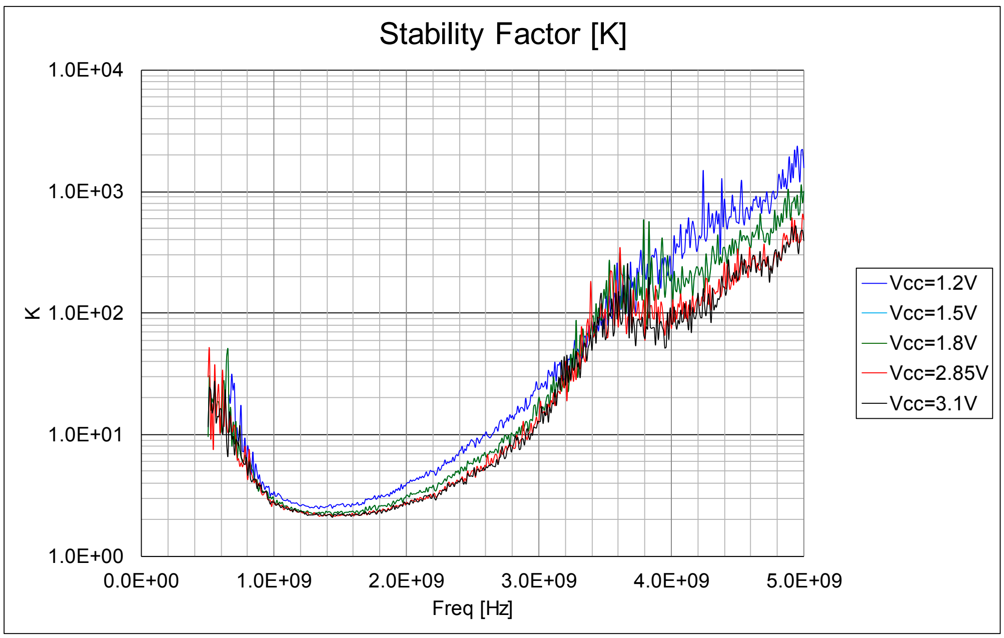


Fig 10. Stability factor (K)

4.3 In-band 1dB gain compression

The 1dB compression point depends on the supply voltage. Next figure (Fig 11) depicts the 1dB compression point at a frequency of 1230 MHz at different supply voltages. Before the application enters the compression region, a gain expansion is noticed due to the adaptive biasing of the circuit.

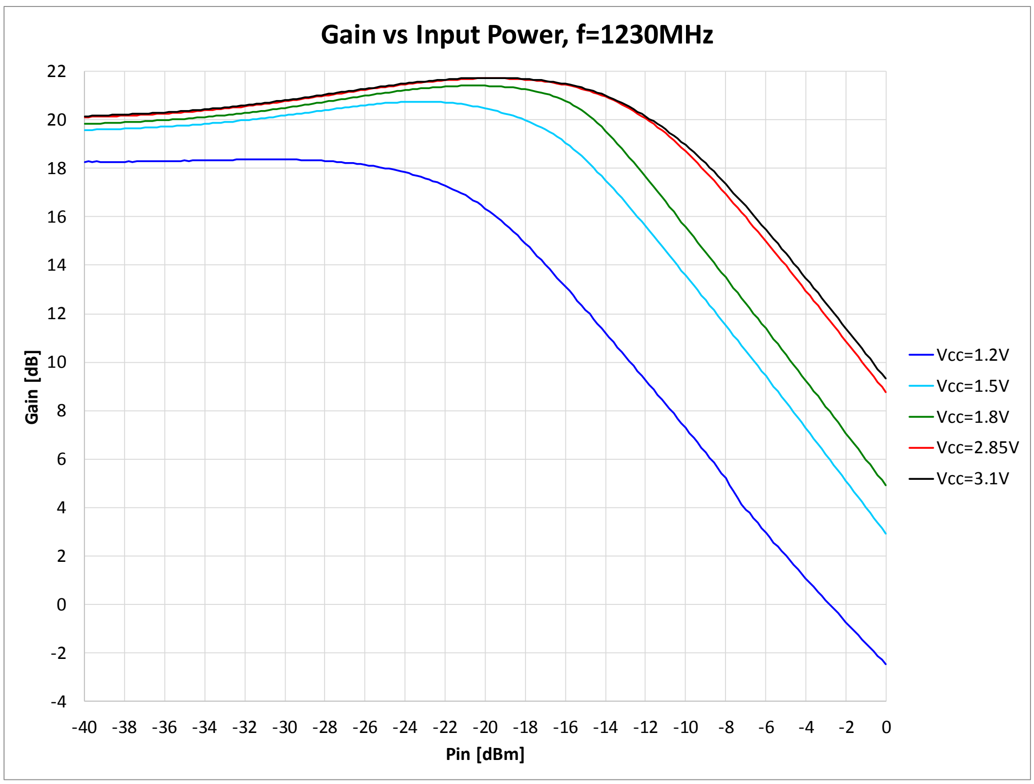


Fig 11. 1 dB compression point (P1dB)

4.4 Noise figure

The Noise Figure is measured at different supply voltage levels at an ambient temperature of 25°C. The Noise Figure levels are comparable with the GPS1202M GNSS LNA for the L1 band.

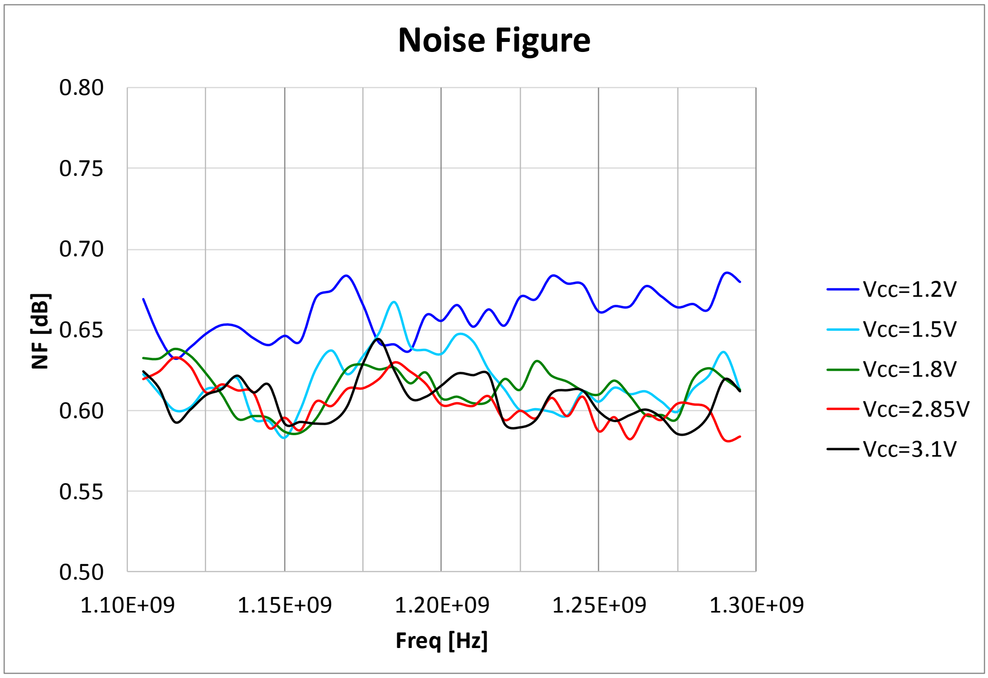


Fig 12. Noise Figure (NF)

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 1230 MHz.
- ✓ An RF spectrum analyzer that covers at least the operating frequency of 1230 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 GPS1202M 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 GPS1202M.
2. Jumper JU1 is connected between the V_{cc} terminal of the evaluation board and the V_{en} pin of the GPS1202M.
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 1225 MHz, set the spectrum analyzer at 1225 MHz center frequency and a reference level of 0 dBm.
4. Turn on the DC power supply and it should read approximately 4.6 mA.
5. Enable the RF output of the generator: The spectrum analyzer displays a tone around –26.5 dBm at 1225 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.

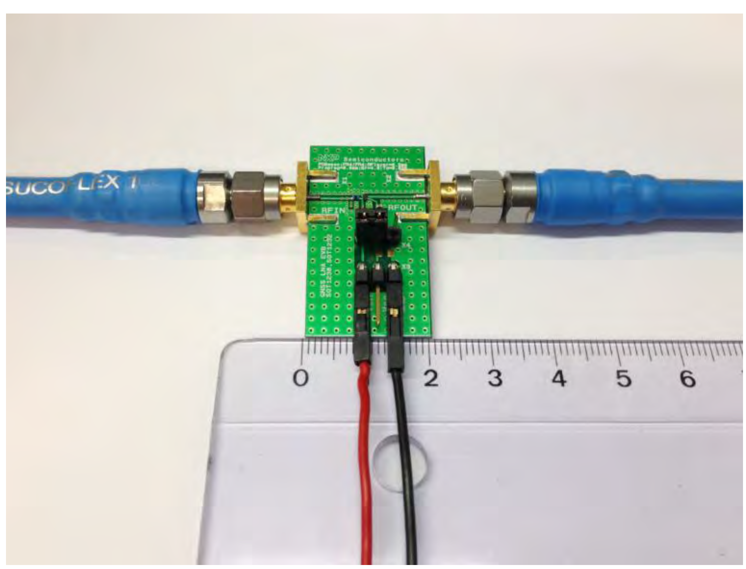


Fig 13. Evaluation board including its connections

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