AN11449

Low Noise Flat Gain 40M~1GHz DVB-C LNA with BFG425W

Rev.1 — 22 October 2013 Application note

Document information

Info	Content
Keywords	BFG425W, 40M~1GHz LNA, DVB-C,
Abstract	This document provides circuit simulation, schematic, layout, BOM and typical EVB performance for a 40M ~ 1GHz DVB-C LNA

Revision history

Rev	Date	Description
1.0	20131022	Initial Draft

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1. Introduction

With the new NXP silicon bipolar double poly BFG400W series, it is possible to design low noise amplifiers for high frequency applications with a low current and a low supply voltage. These amplifiers are well suited for the new generation low voltage high frequency wireless applications.

In this note a first study of such an amplifier will be given. This amplifier is designed for a wideband working frequency from 40MHz to 1GHz. It is designed for DVB-C application, so the solution need provide a pretty good Gain flatness.

DVB-C stands for "Digital Video Broadcasting - Cable" and it is the DVB European consortium standard for the broadcast transmission of digital television over cable. This system transmits a MPEG-2 or MPEG-4 family digital audio/digital video stream, using a QAM modulation with channel coding. The standard was first published by the ETSI in 1994, and subsequently became the most widely used transmission system for digital cable television in Europe. It is deployed worldwide in systems ranging from the larger cable television networks (CATV) down to smaller satellite master antenna TV (SMATV) systems.

Key Benefits:

- High transition frequency
- Wideband applications, e.g. analog and digital cellular telephones, cordless telephones (PHS, DECT, etc.)
- Lowest current consumption meaning greener products
- SOT343F package for high performance and easy manufacturing

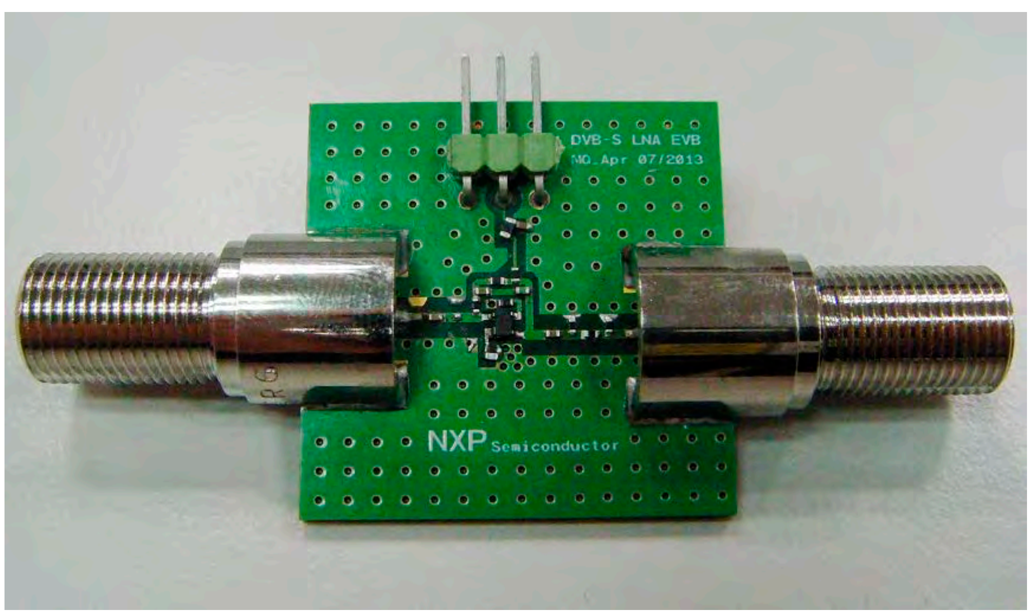


Fig 1. BFG425W 40M ~ 1GHz DVB-C LNA EVB Demo Board

2. Requirements and design of the 40M ~ 1GHz DVB-C LNA

The circuit shown in this application note is intended to demonstrate the performance of the BFG425W in a 40M ~ 1GHz LNA for DVB-C applications.

Key requirements for this application are:

- Frequency Band 40M – 1GHz
- Gain
- Input/output Match
- Linearity
- NF
- Gain Flatness

3. Design and Simulation

The 40M ~ 1GHz DVB-C LNA consists of one stage BFG425W amplifier.

The design has been simulated, and the simulation results are given in the following figures.

The LNA shows excellent match at input/output with greater than 9.0dB return loss from 40MHz to 1GHz and wideband gain around 13.3dB, with good +/-1.1dB gain flatness between whole 960MHz frequency band. Customer also could tune the value of attenuator resistors at output of Demo, to reach the Gain level they want.

In addition, the LNA provide Noise Figure performance below 2.8dB in whole frequency band. With only 18mA it also shows a high input IP2 level of 14dBm @400MHz, as well as high input IP3 of 5.5dBm @400MHz.

Due to frequency limitation of 75-to-50 ohm adaptor, we can’t measure K-factor to high frequency band, but simulation result gives out the LNA is unconditionally stable at 10MHz-10GHz.

3.1 BFG425W 40M ~ 1GHz DVB-C LNA Simulation

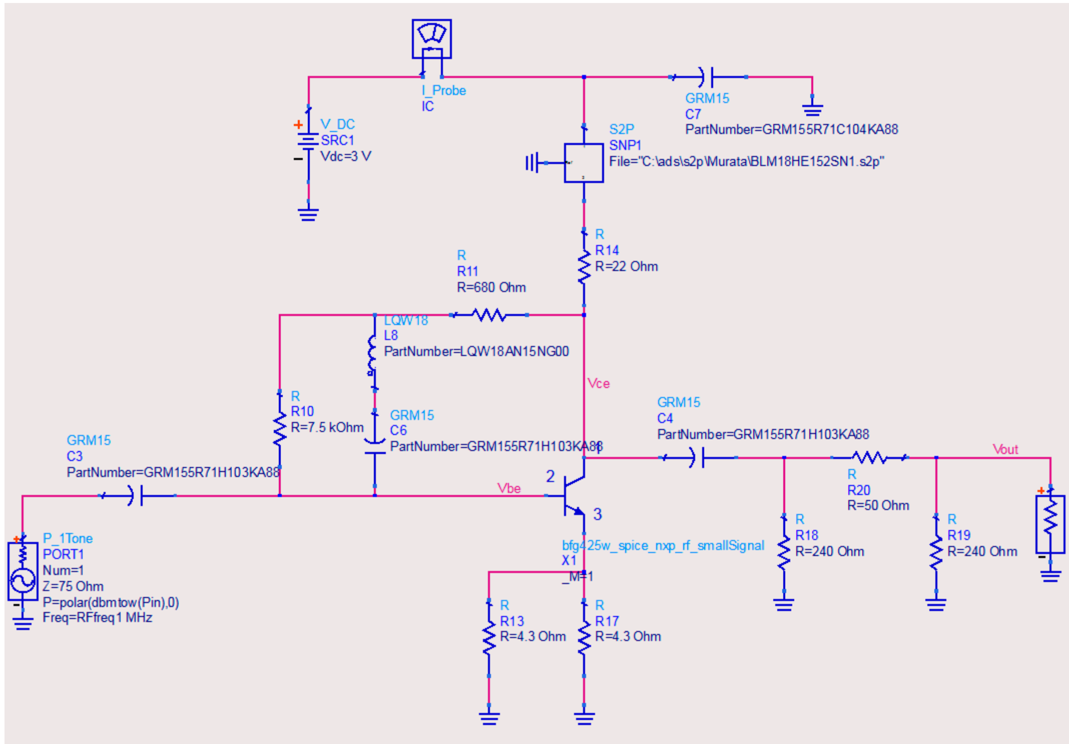


Fig 2. BFG425W 40M ~ 1GHz DVB-C LNA Simulation: Circuit (Capacitors GRM1555 & Inductors LQG15)

3.2 BFG425W 40M ~ 1GHz DVB-C LNA Simulation Results

3.2.1 Gain and Match in 40M ~ 1GHz Band

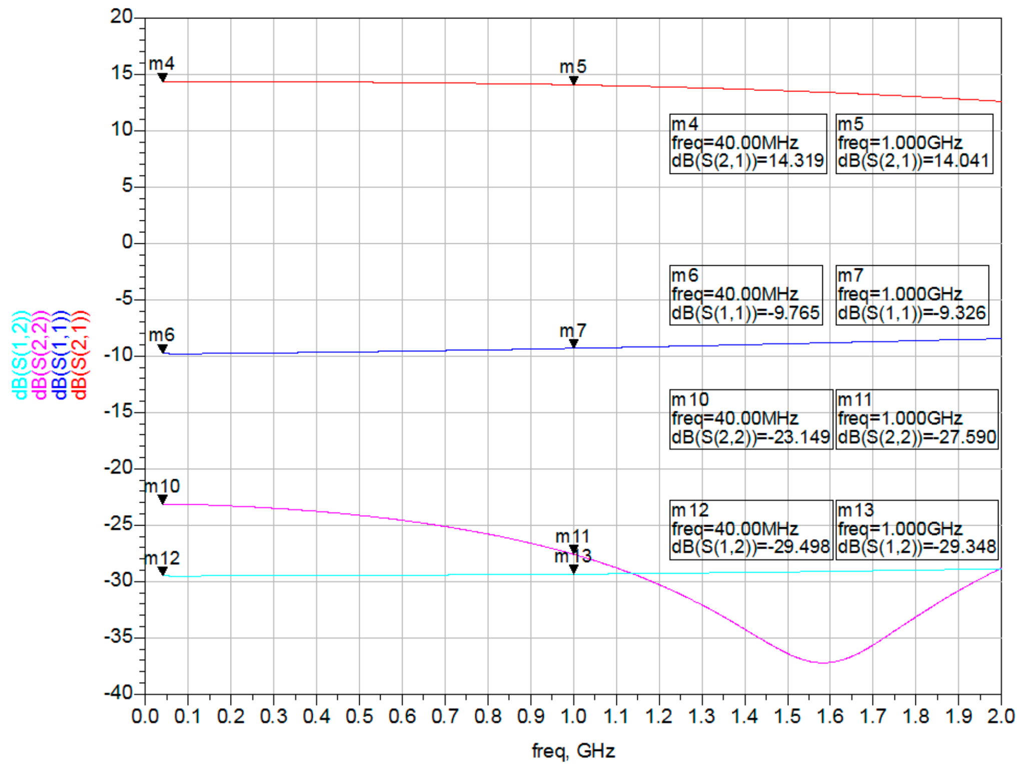


Fig 3. BFG425W 40M ~ 1GHz DVB-C LNA Simulation: Gain and Match

3.2.2 Noise Figure in 40M ~ 1GHz Band

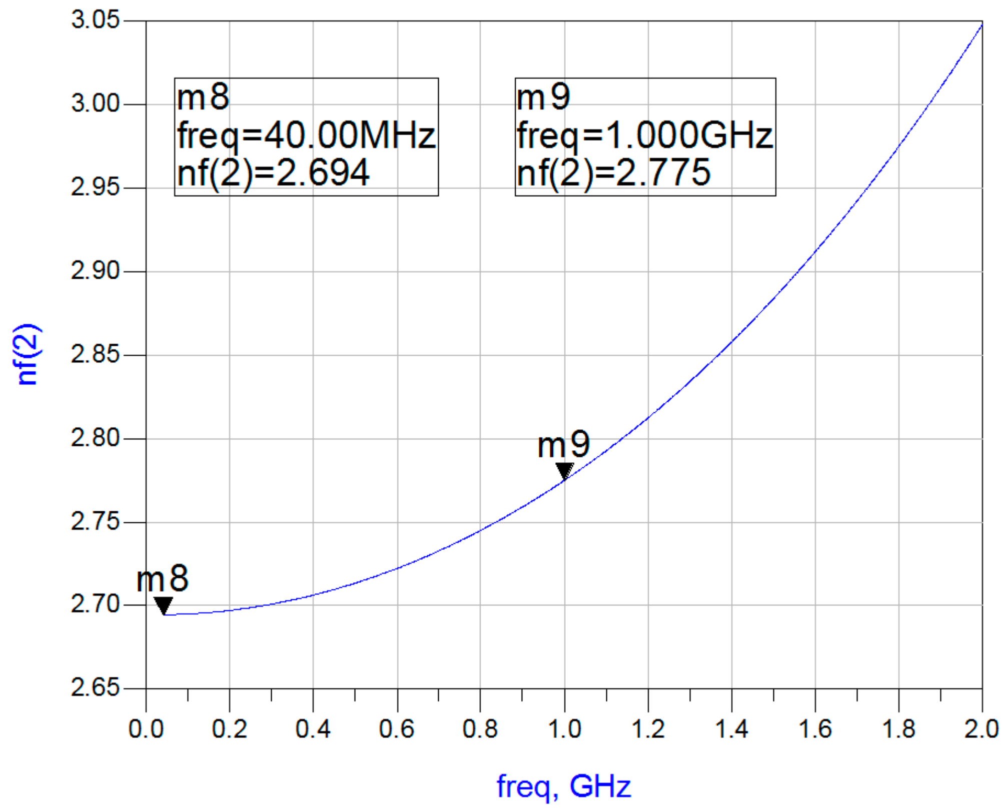


Fig 4. BFG425W 40M ~ 1GHz DVB-C LNA Simulation: Noise Figure

3.2.3 Stability

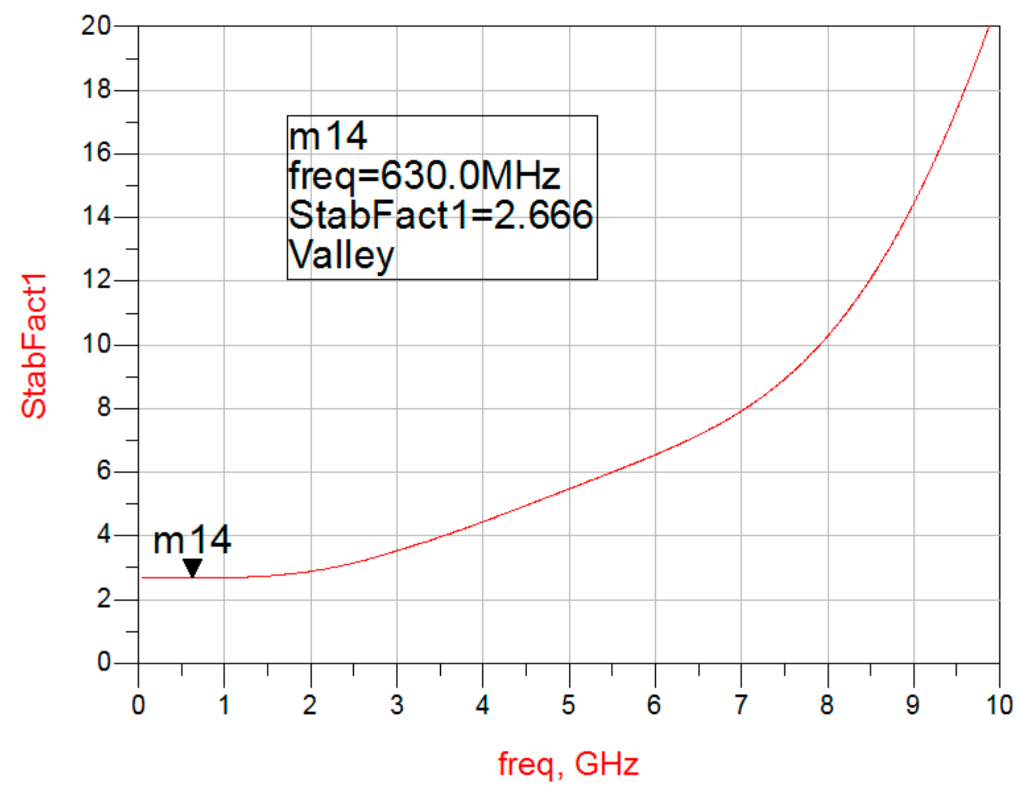


Fig 5. BFG425W 40M ~ 1GHz DVB-C LNA Simulation: Stability

4. Application Board

The 40M ~ 1GHz DVB-C LNA evaluation board simplifies the evaluation of the BFG425W application. The evaluation board enables testing of the device performance and requires no additional support circuitry. The board is fully assembled with the BFG425W transistor, including input and output matching components, to optimize performance.

The board is supplied with two F connectors at input and output, in order to keep same performance in real STB(set top box). Please make it clear, in this Demo micro-stripe line and F connector are all design for 75ohm.

4.1 Application Circuit Schematic

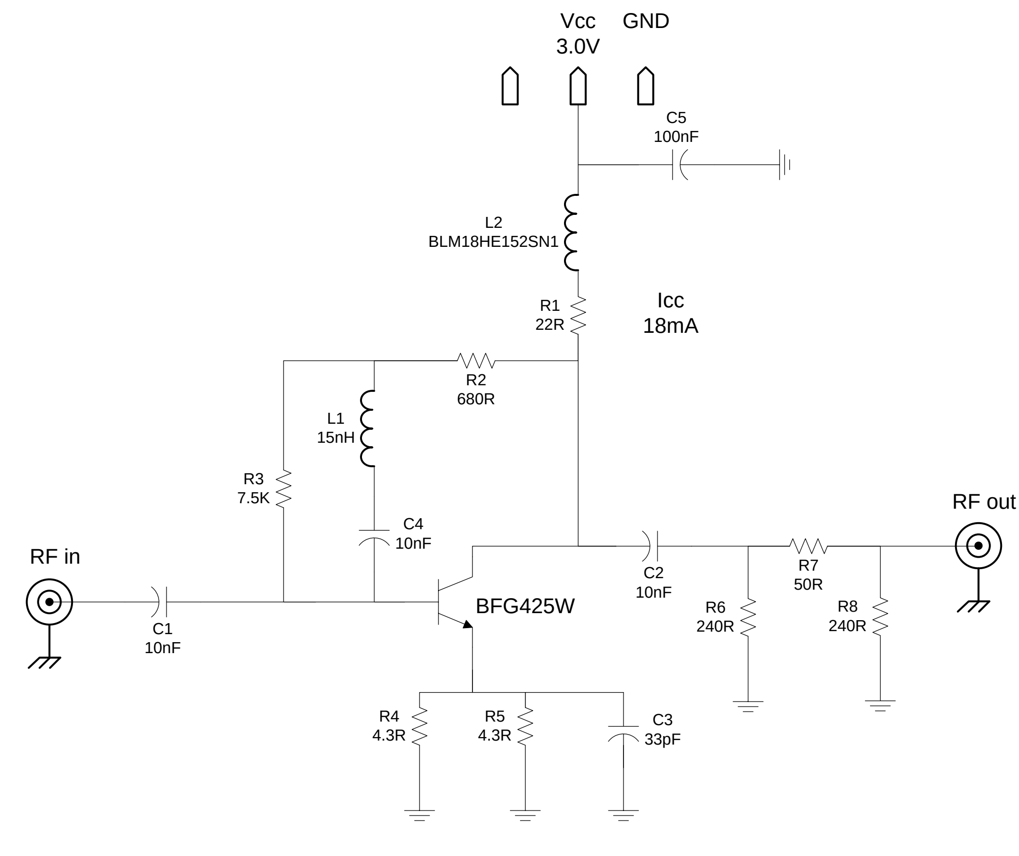


Fig 6. BFG425W 40M ~ 1GHz DVB-C LNA: Schematic

4.2 Application Board Bill-Of-Material

Table 1. BFG425W 40M ~ 1GHz DVB-C LNA Part List

Customer can choose their preferred vendor but should be aware that the performance could be affected.

Item	Reference (Fig 7)	Type	Vendor	Value
1	C1, C2, C4	GRM1555C1	Murata	10nF
2	C3	GRM1555C1	Murata	33pF
3	C5	GRM1555C1	Murata	100nF
4	L1	LQG15	Murata	15nH
5	L2	chip ferrite bead	Murata	BLM18HE152SN1
6	R1			22R
7	R2			680R
8	R3			7.5k
7	R4, R5			4.3R
8	R6, R8			240R
11	R7			50R

8	BFG425W	NXP SEMICONDUCTORS	BFG425W
7	Vcc	Molex	CON-3PIN
12	RF_IN, RF_OUT	Amphenol	CON-SMA-1

4.3 Typical Application Board Test Result

4.3.1 S-Parameter – Gain

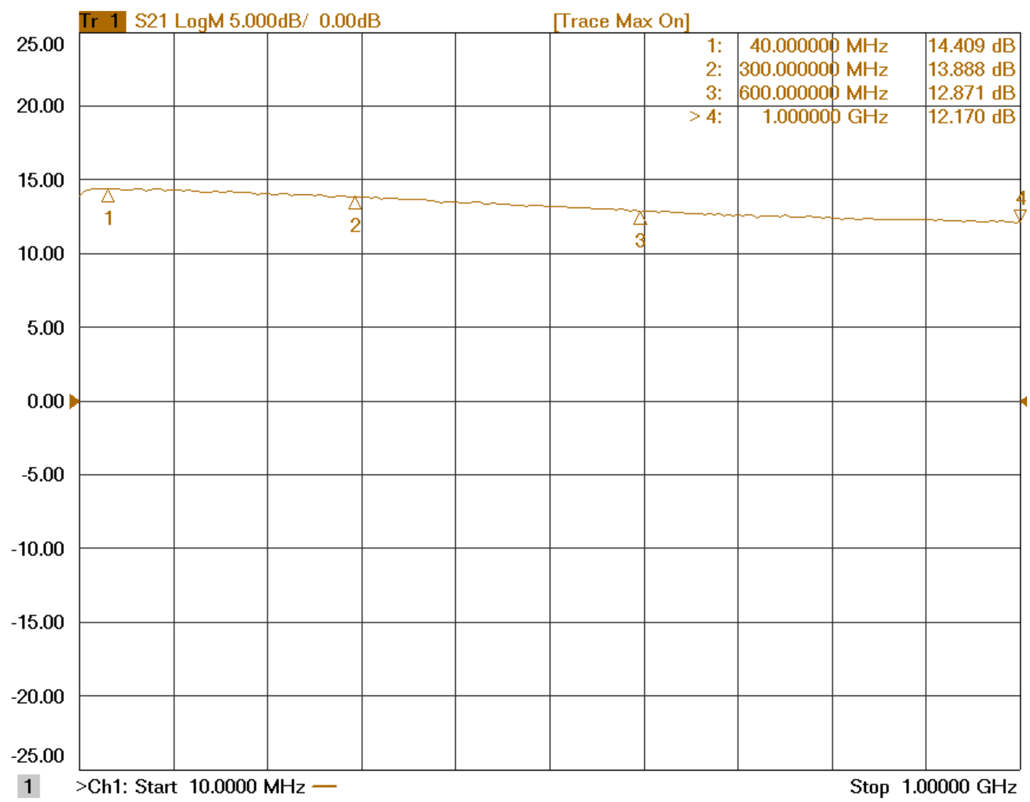


Fig 7. BFG425W 40M ~ 1GHz DVB-C LNA: S-Parameter Gain

4.3.2 S-Parameter – Input Return Loss

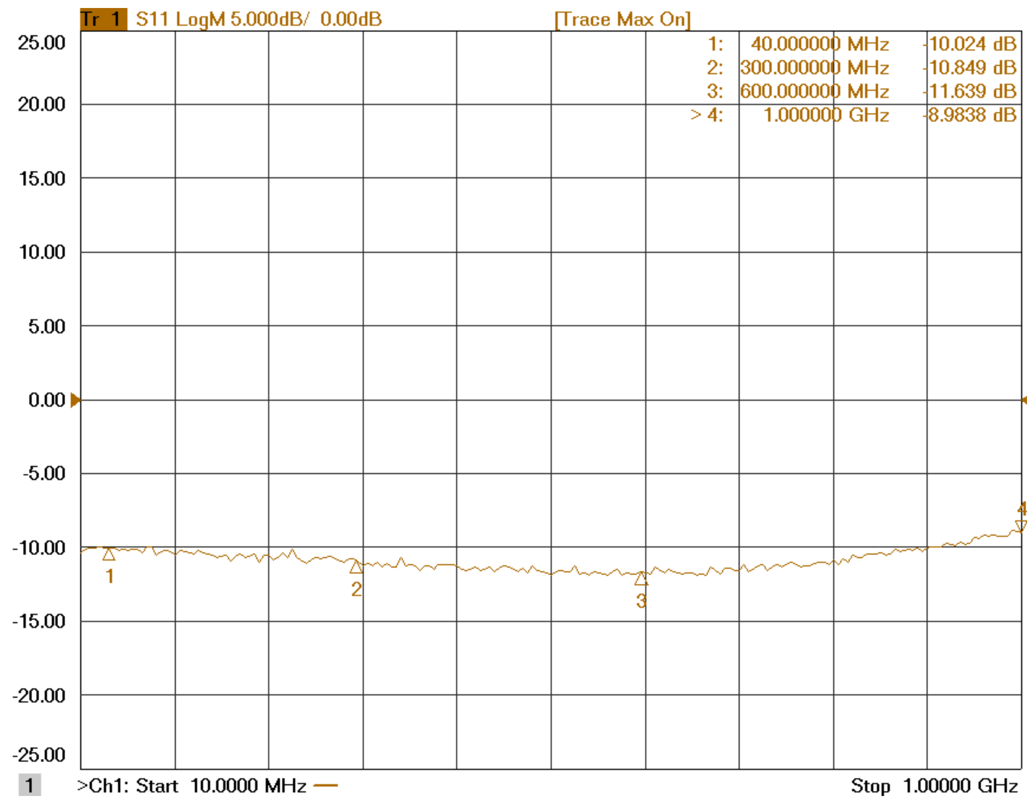


Fig 8. BFG425W 40M ~ 1GHz DVB-C LNA: S-Parameter Input Return Loss

4.3.3 S-Parameter – Output Return Loss

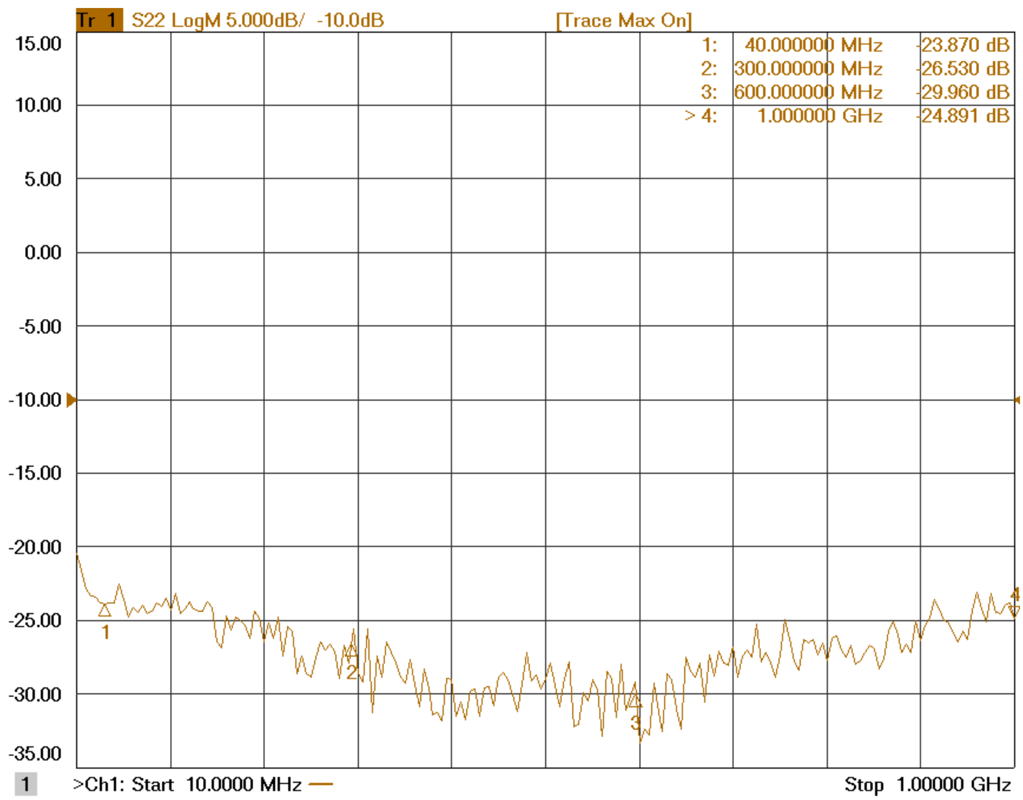


Fig 9. BFG425W 40M ~ 1GHz DVB-C LNA: S-Parameter Output Return Loss

4.3.4 S-Parameter – Isolation

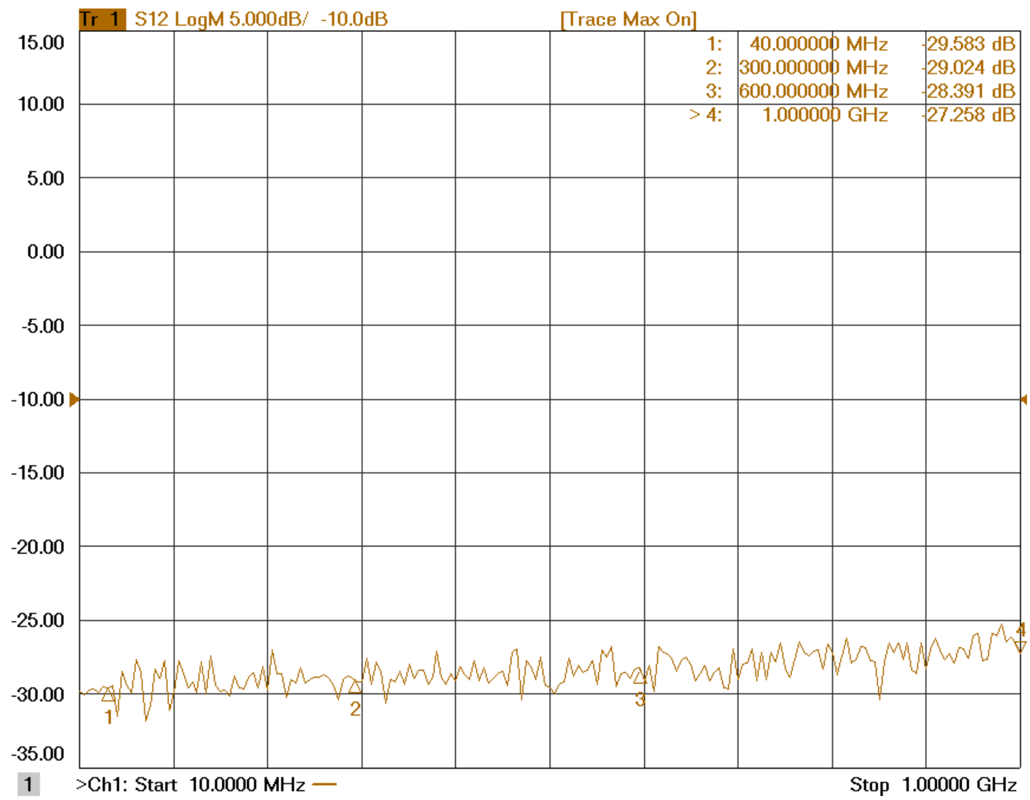
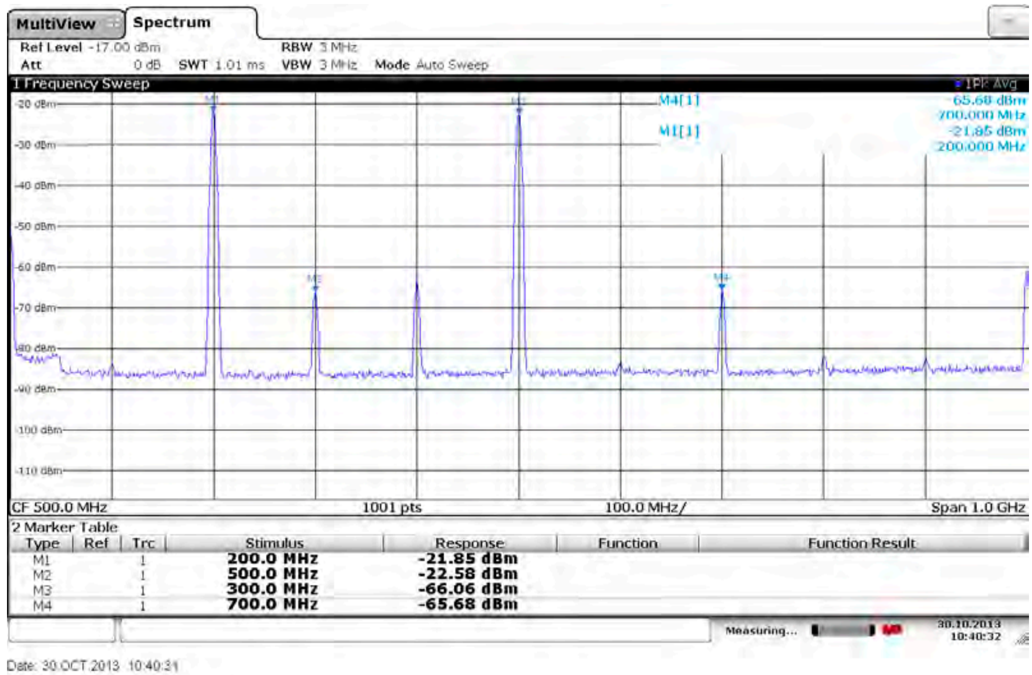


Fig 10. BFG425W 40M ~ 1GHz DVB-C LNA: S-Parameter Isolation

4.3.5 Linearity/IP2



OIP2 = -21.9dBm +(65.7-22.6)dB+5.7dB = 26.9dBm

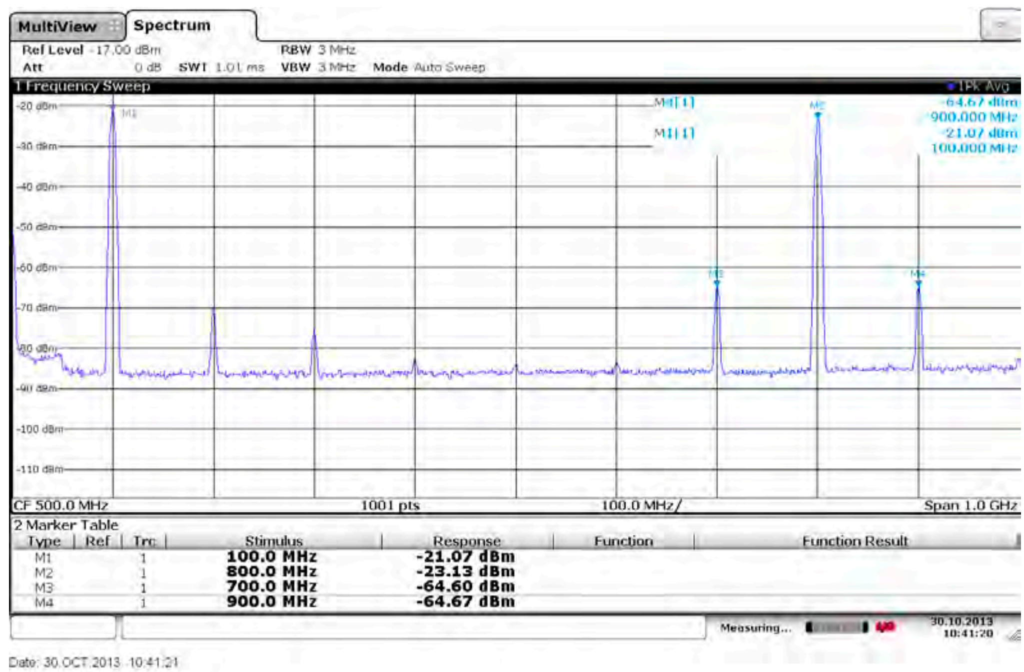
IIP2 = 26.9dBm-13.1dB = 13.8dBm

Note1, Input Power = -30dBm, f1 = 200MHz, f2 = 500MHz

Note2, 75-to-50 ohm adaptor Insertion Loss = 5.7dB

Note3, Gain @ 500MHz = 13.1dB

Fig 11. BFG425W 40M ~ 1GHz DVB-C LNA: IP2 @ f1=200MHz, f2=500MHz



OIP2 = -21.1dBm +(64.6-23.1)dB+5.7dB = 26.1dBm

IIP2 = 26.1dBm-12.6dB = 13.5dBm

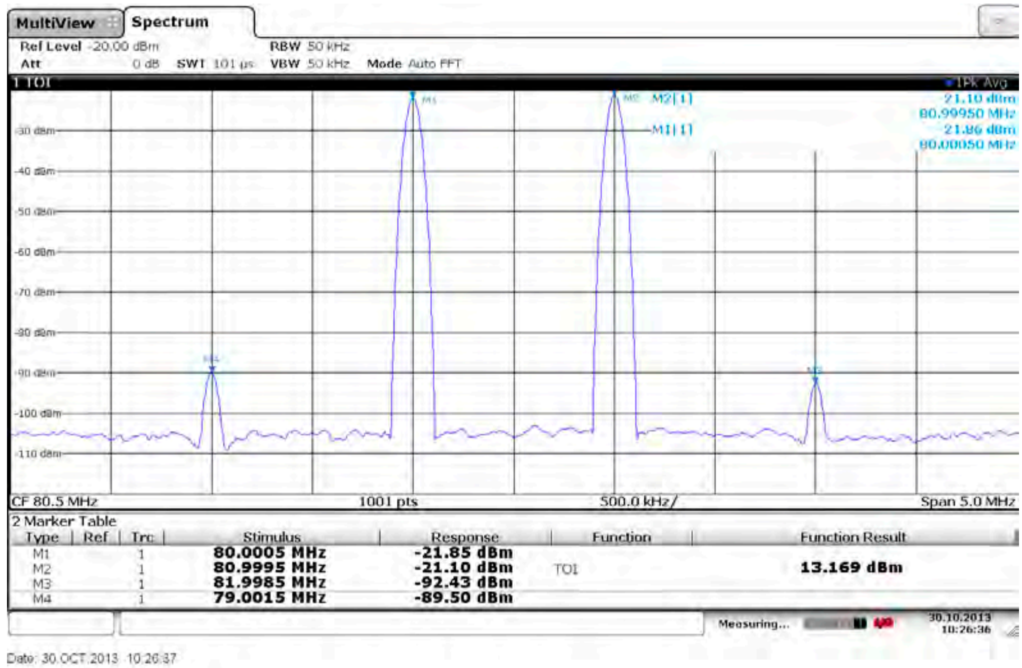
Note1, Input Power = -30dBm, f1 = 100MHz, f2 = 800MHz

Note2, 75-to-50 ohm adaptor Insertion Loss = 5.7dB

Note3, Gain @ 800MHz = 12.6dB

Fig 12. BFG425W 40M ~ 1GHz DVB-C LNA: IP2 @ f1=100MHz, f2=800MHz

4.3.6 Linearity/IP3



OIP3 = 13.2dBm+5.7dB = 18.9dBm

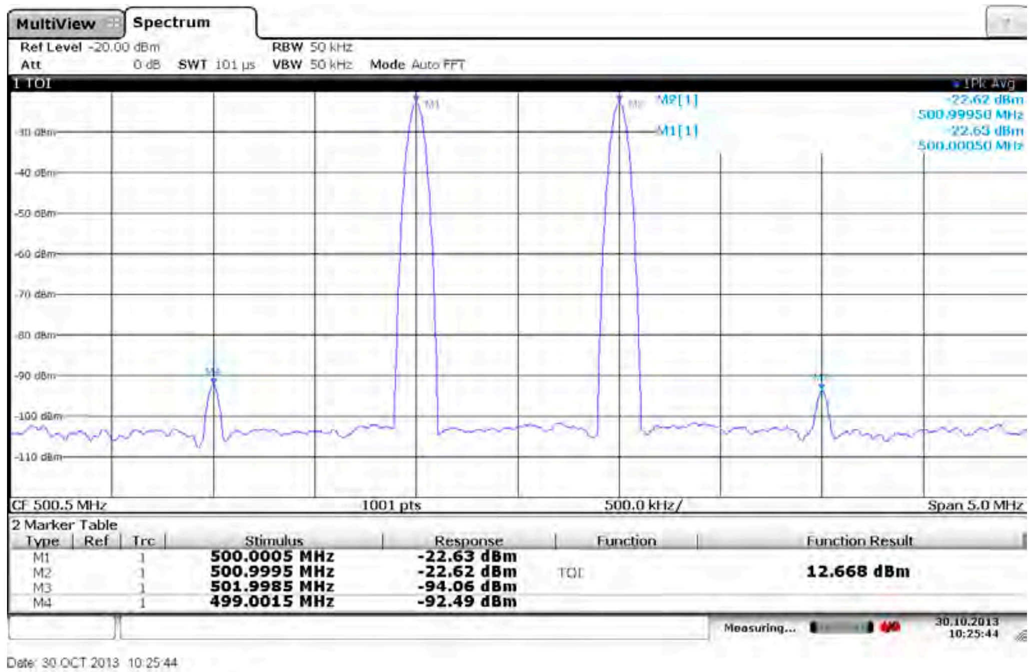
IIP3 = OIP3 - Gain = 18.9 -13.9 = 5.0dBm

Note1, Two tones: f1: 80MHz, f2: 81MHz, -30dBm each tone, tone spacing: 1MHz

Note2, 75-to-50 ohm adaptor Insertion Loss = 5.7dB

Note3, Gain @ 80MHz = 13.9dB

Fig 13. BFG425W 40M ~ 1GHz DVB-C LNA: IP3 @ f1=80MHz, f1=81MHz



OIP3 = 12.7dBm+5.7dB = 18.4dBm

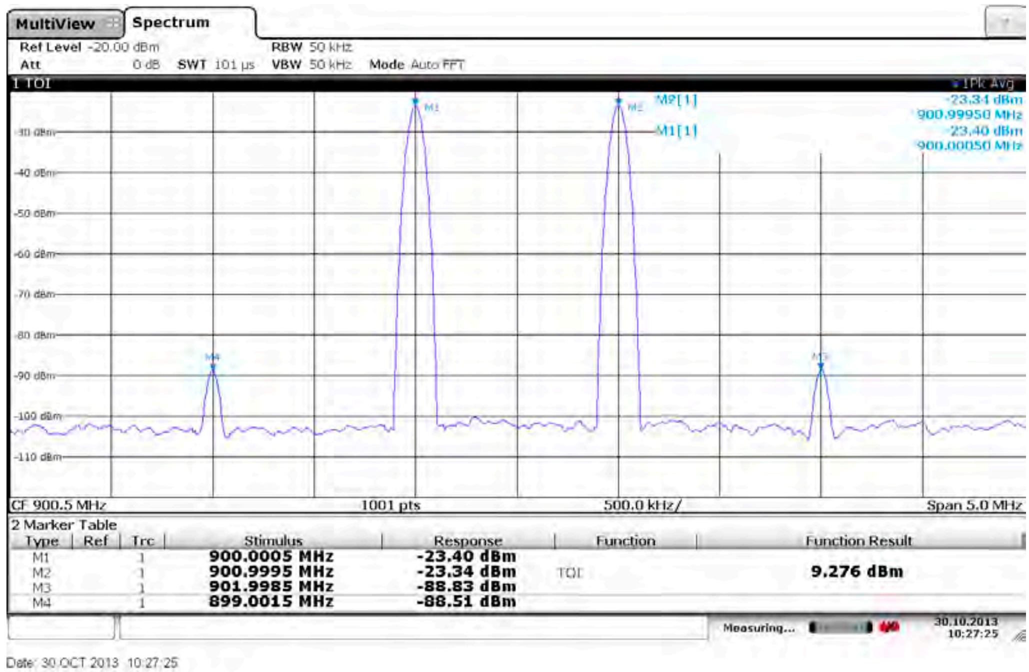
IIP3 = OIP3 - Gain = 18.9 -13.1 = 5.8dBm

Note1, Two tones: f1: 500MHz, f2: 501MHz, -30dBm each tone, tone spacing: 1MHz

Note2, 75-to-50 ohm adaptor Insertion Loss = 5.7dB

Note3, Gain @ 500MHz = 13.1dB

Fig 14. BFG425W 40M ~ 1GHz DVB-C LNA: IP3 @ f1=500MHz, f1=501MHz



OIP3 = 9.3dBm+5.7dB = 15.0dBm

IIP3 = OIP3 - Gain = 15.0 -12.3 = 2.7dBm

Note1, Two tones: f1: 900MHz, f2: 901MHz, -30dBm each tone, tone spacing: 1MHz

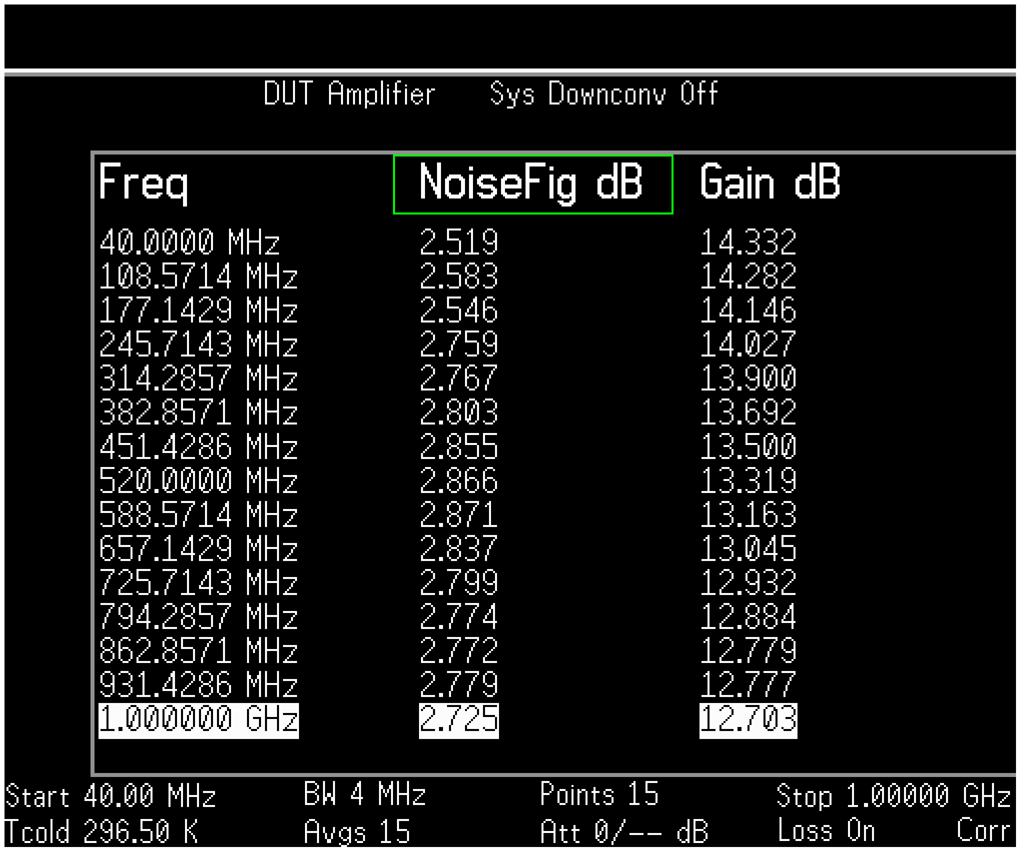
Note2, 75-to-50 ohm adaptor Insertion Loss = 5.7dB

Note3, Gain @ 900MHz = 12.3dB

Fig 15. BFG425W 40M ~ 1GHz DVB-C LNA: IP3 @ f1=900MHz, f1=901MHz

4.3.7 Noise Figure Measurement

The noise figure is measured under F-to-SMA adaptors connecting with the evaluation board, this 75-to-50ohm adaptor has 5.7dB insertion loss from 40MHz to 1GHz. The adaptor losses (RF_IN and RF_OUT loss = 5.7dB @ 40M~1GHz) of the connectors are subtracted.



Noise Figure

Fig 16. BFG425W 40M ~ 1GHz DVB-C LNA: NF

4.3.8 Summary of the Typical Evaluation Board Test Result

Table 2. Typical results measured on the BFG425W 40M ~ 1GHz DVB-C LNA Evaluation Board

Operating frequency 40M ~ 1GHz, testing at 40MHz and 1GHz unless otherwise specified, Temp = 25°C.

All measurements are done with F-to-SMA adaptor connectors as reference plane.

Parameter		Symbol	Value	Unit
Supply Voltage		Vcc	3.0	V
Supply Current		Icc	18	mA
Noise Figure	@40MHz	NF	2.5	dB
	@520MHz	NF	2.8	dB
	@1GHz	NF	2.7	dB
Power Gain	@40MHz	Gp	14.4	dB
	@1GHz	Gp	12.2	dB
Gain Flatness	40M ~ 1GHz	Gf	+/- 1.1	dB
Input Return Loss	@40MHz	IRL	10	dB
	@1GHz	IRL	9.0	dB

Parameter		Symbol	Value	Unit
Output Return Loss	@40MHz	ORL	23.9	dB
	@1GHz	ORL	24.9	dB
Reverse Isolation	@40MHz	ISLrev	29.6	dB
	@1GHz	ISLrev	27.3	dB
Input Second Order Intercept Point	f1: 200MHz, f2: 500MHz,	IIP2	13.8	dBm
	f1: 100MHz, f2: 800MHz,	IIP2	13.5	dBm
Output Second Order Intercept Point	f1: 200MHz, f2: 500MHz,	OIP2	26.9	dBm
	f1: 100MHz, f2: 800MHz,	OIP2	26.1	dBm
Input Third Order Intercept Point Two Tones: Input power: -30dBm	f1: 80MHz, f2: 81MHz,	IIP3	5.0	dBm
	f1: 500MHz, f2: 501MHz,	IIP3	5.8	dBm
	f1: 900MHz, f2: 901MHz,	IIP3	2.7	dBm
Output Third Order Intercept Point Two Tones: Input power: -30dBm	f1: 80MHz, f2: 81MHz,	OIP3	18.9	dBm
	f1: 500MHz, f2: 501MHz,	OIP3	18.4	dBm
	f1: 900MHz, f2: 901MHz,	OIP3	15.0	dBm

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6. List of figures

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