UM10483

BFU725F/N1 2.4 GHz to 6.0 GHz LNA demonstration board

Rev. 1 — 16 September 2011 User manual

Document information

Info	Content
Keywords	LNA, 2.4 GHz to 6.0 GHz, BFU725F/N1, WiFi, 802.11, WiMax, 802.16
Abstract	This document describes how to use the BFU725F/N1 2.4 GHz to 6.0 GHz LNA demonstration board.

Revision history

Rev	Date	Description
v 1.0	20110916	first issue

Contact information

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1. Introduction

The BFU725F/N1 is a wideband silicon germanium amplifier transistor for high speed, low-noise applications. The transistor is designed to be used for LNA applications up to 15 GHz such as GPS, satellite radio, cordless phone, wireless LAN and satellite LNB. The BFU725F/N1 is packaged in a SOT343F that has 2 emitter pins to reduce emitter inductance (for maximum gain).
The BFU725F/N1 is ideal for applications where cost is a concern. It also gives the designer flexibility in his design work, for bias current, frequency of operation, noise-figure, gain and P1dB.

The 2.4 GHz to 6.0 GHz LNA demonstration (demo) board is designed to evaluate the performance of the BFU725F/N1 applied as a LNA in the 2.4 GHz to 6 GHz range. In this document, the application diagram, board layout, bill of materials, and some typical results are given.

Figure 1 shows the demonstration board.

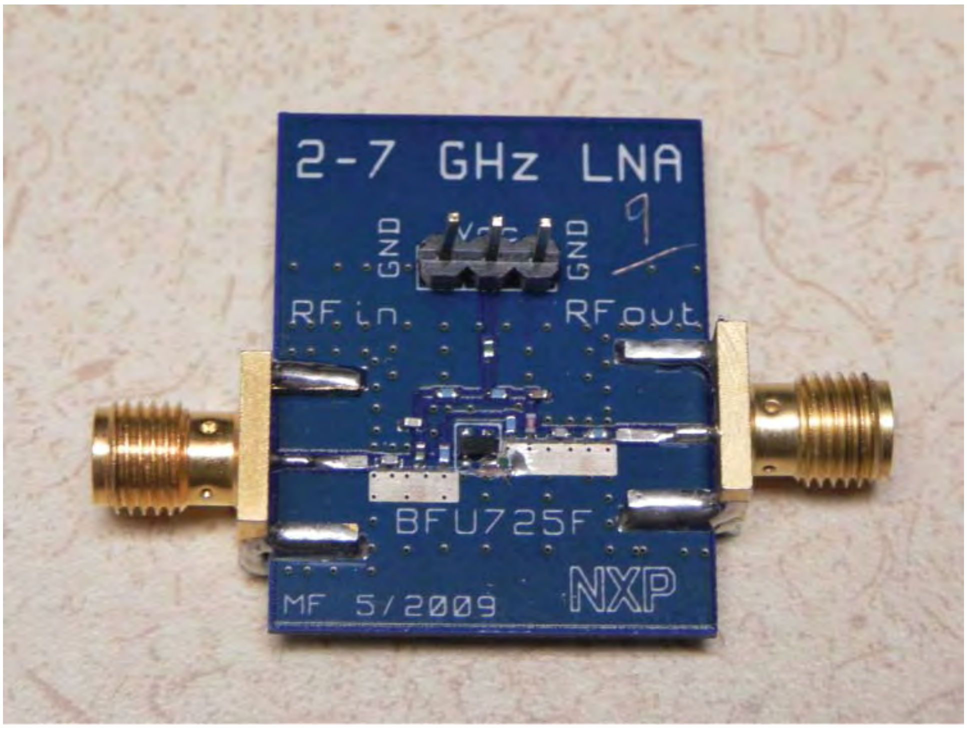

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Fig 1. BFU725F/N1 2.4 GHz to 6.0 GHz LNA demonstration board

2. General description

The BFU725F/N1 is the first discrete HBT produced using NXP Semiconductor's SiGeC QuBIC4x BiCMOS process. SiGe:C is a silicon germanium process with the addition of carbon in the base layer of the NPN-transistor. The presence of carbon in the base layer suppresses the diffusion of boron during wafer processing allowing steeper and narrower

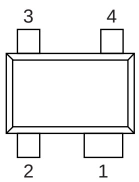
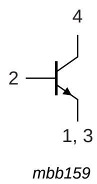
SiGe HBT base and a heavier doped base. This results in lower base resistance, hence lower noise and higher cut-off frequency (higher gain). Table 1 shows a summary of the transistor performance in terms of noise and gain.

Table 1. BFU725F/N1

V_{CE} = 2 V, I_C = 5 mA, T_{amb} = 25 °C

Frequency (GHz)	Noise figure (dB)	Associated gain (dB)
1.5	0.42	24
2.4	0.47	20
5.8	0.7	13.5
12	1.1	10

Table 2. Pinning information BFU725/N1

Pin	Description	Simplified outline	Symbol
1	emitter		
2	base		
3	emitter		
4	collector		

3. Application board

The BFU725F/N1 2.4 GHz to 6 GHz demonstration board simplifies the evaluation of the BFU725F/N1 wideband transistor, for this frequency range. The demonstration board enables testing of the device performance and requires no additional support circuitry. The board is fully assembled with the BFU725F/N1, including input- and output-matching, to optimize the performance. For input matching, a compromise must be made between optimum noise/maximum gain/RL/usable bandwidth of the application and customer requirements. The board is mounted with signal input and output SMA connectors for connection to RF test equipment.

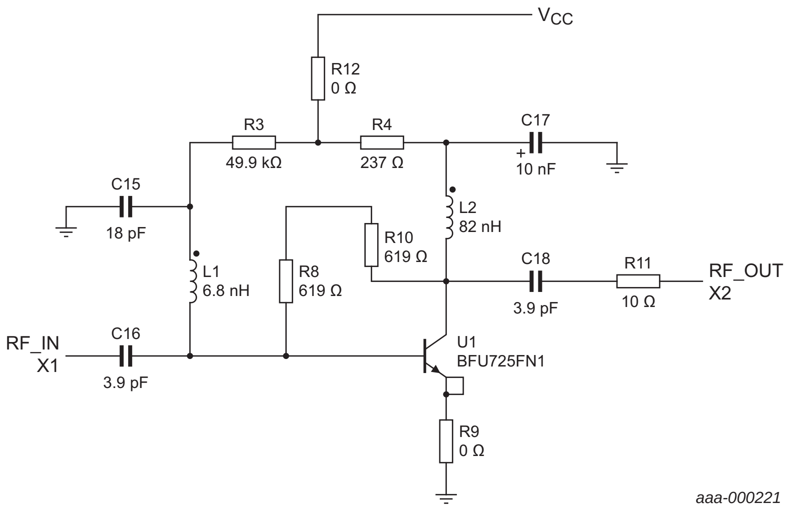
Table 3. Design targets

Symbol	Parameter	Value	Unit
NF	noise figure	<1.3	dB
G_p	power gain	>14	dB
$\|s_{11}\|^2$	input return loss	>10	dB
$\|s_{22}\|^2$	output return loss	>10	dB

3.1 Schematic

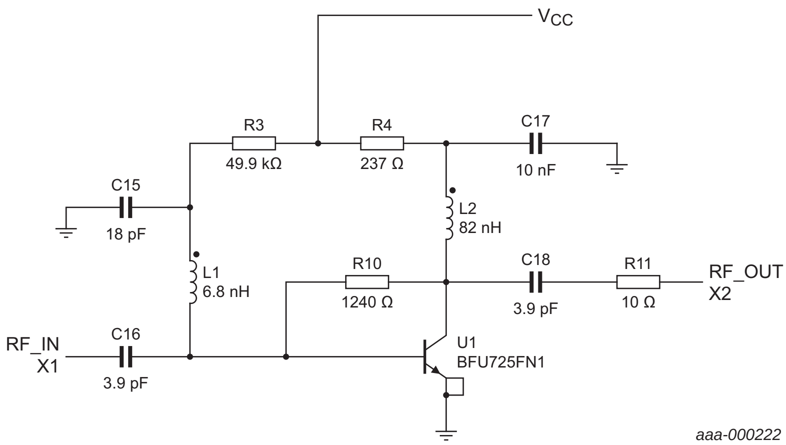
Figure 2 shows the demonstration board schematic.

Figure 3 shows the required end-users application board schematic optimized for BOM count compared to the demonstration board schematic which is optimized for tuning flexibility.



(1) Output series resistance (R_{OS}) is set for V_O = 1.2 V; reference voltage = 0.7 V.

Fig 2. Demo board schematic



(1) R_{OS} is set for V_O = 1.2 V; reference voltage = 0.7 V.

Fig 3. Circuit diagram of the end-user application circuit (minimized BOM) demo board schematic

3.2 PCB layout

Figure 4 shows the board layout.

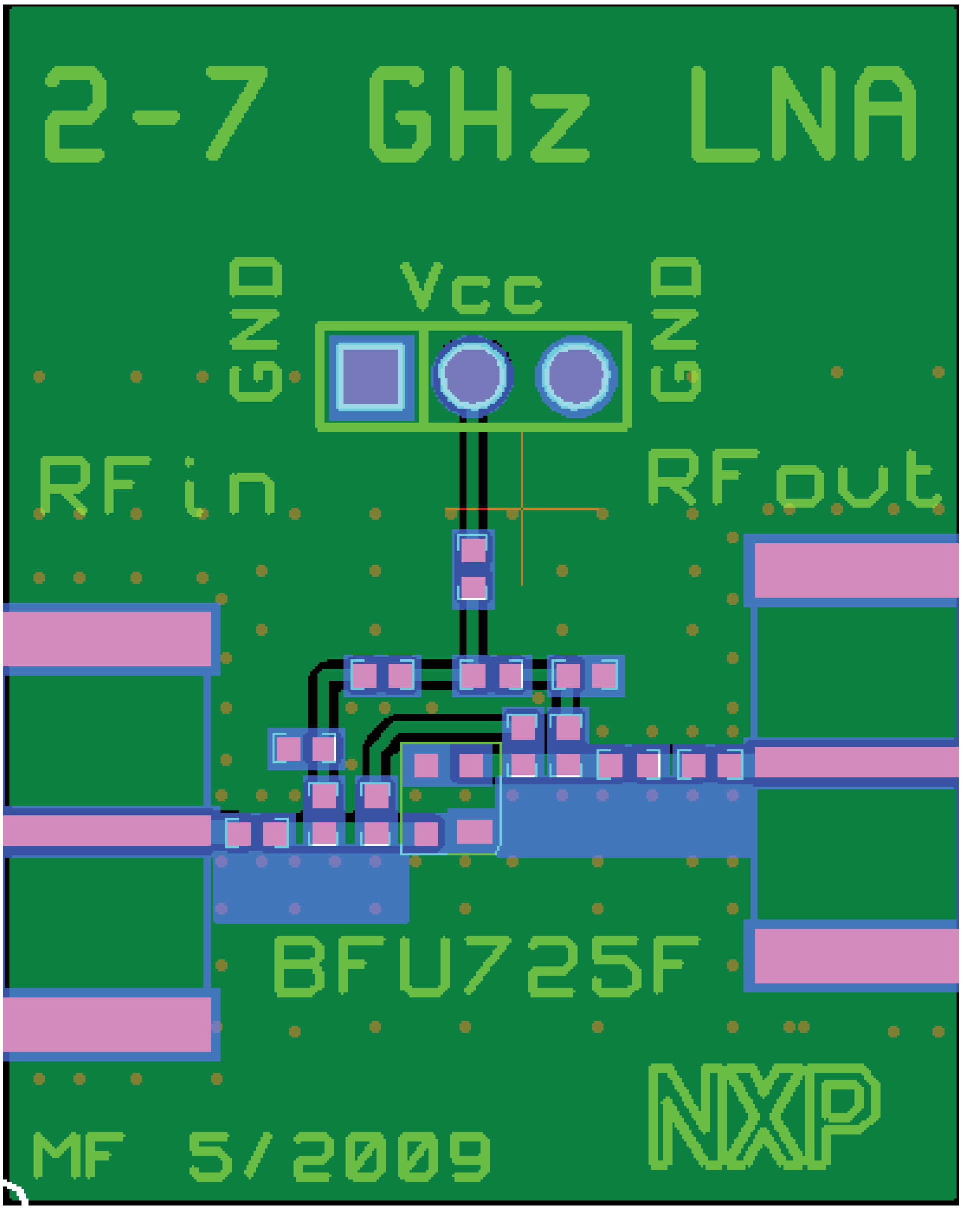


Fig 4. Printed-circuit board of the BFU725F/N1 2.4 GHz to 6 GHz demo board

The PCB layout is an essential part of an RF circuit design. The demonstration of the BFU725F/N1 can serve as a guideline for laying out a board using the BFU725F/N1. Use controlled impedance lines for all high frequency inputs and outputs. Bypass V_{CC} with decoupling capacitors, preferably located as close as possible to the device. For long bias lines it may be necessary to add decoupling capacitors to the line away from the device. Correctly grounding the emitters is also essential for the performance. Connect the emitters either directly to the ground plane or through vias, or do both.

The demonstration board is constructed from Rogers 4003C using the stack shown in Figure 5.

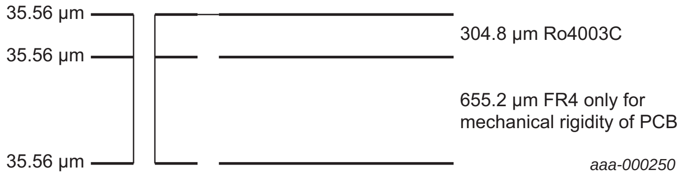


Fig 5. PCB material stack

3.3 Bill of materials

Table 4. Demonstration board BOM

Reference	Value	Package	Manufacturer / part number	Comment
C15	18 pF	0402	Murata GRM1555C1H180JZ01	decoupling
C16	3.9 pF	0402	Murata GRM1555C1H3R9CZ01	DC blocking, input matching
C17	10 nF	0402	Murata GRM155R71C104KA88	decoupling
C18	3.9 pF	0402	Murata GRM1555C1H3R9CZ01	DC blocking, output matching
L1	6.8 nH	0402	Murata LQG15HN6N8J02	input matching
L2	82 nH	0402	CoilCraft 06CS82N	output matching, DC bias
R3	49.9 kΩ	0402	various	bias setting temperature stability
R4	237 Ω	0402	various	bias setting temperature stability
R9	0 Ω	0402	various	emitter degenerating resistor, used to set gain
R11	10 Ω	0402	various	stability
R12	0 Ω	0402	various	not required
U1	BFU725F/N1	SOT343	NXP Semiconductors	transistor
X1, X2	SMA RF connector		Johnson, end-launch SMA 142-0701-841	RF input, RF output
X3	DC header		Molex, PCB-header, 1 row, 3 way	bias connector

4. Required equipment

The following equipment is required to perform measurements on the demonstration board:

- DC power supply up to 30 mA at 3.3 V
- An RF signal generator capable of generating an RF signal over the operating frequency range of 2.4 GHz to 6.0 GHz (preferably up to 12 GHz)
- An RF spectrum analyzer that covers at least the operating frequency range of 2.4 GHz to 6.0 GHz plus a few harmonics, (up to 18 GHz should be sufficient). Optionally, a version with the capability of measuring noise figure would be convenient
- Current meter to measure the supply current (optional)
- A network analyzer for measuring gain, return loss, reverse isolation, stability and P1dB
- Noise figure analyzer

4.1 Connections and setup

The BFU725F/N1 2.4 GHz to 6.0 GHz demonstration board is fully assembled and tested. Please follow the steps below for a step-by-step guide to operate the demonstration board and testing the device functions.

1. Connect the DC power supply, set to 3.3 V, to the V_{CC} and GND terminals.
2. Connect the RF signal generator and the spectrum analyzer; to the RF input and the RF output of the demonstration board respectively. Do not turn on the RF output of the signal generator yet, set it to –30 dBm output power at 2.4 GHz, and set the spectrum analyzer on 2.4 GHz center frequency and a reference level of –10 dBm.
3. Turn on the DC power supply and it should read approximately 11 mA.
4. Enable the RF output of the generator; the spectrum analyzer displays a tone of 2.4 GHz at around –10 dBm.
5. Instead of using a signal generator and spectrum analyzer one can also use a network analyzer in order to measure gain, return loss, stability and P1dB.
6. 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, such as the Agilent 346B is recommended. When measuring the noise figure of the demonstration board, avoid connecting adaptors and cables between the noise source and the demonstration board, or de-embedded.

5. Typical results

5.1 2.4 GHz data (de-embedded)

Table 5. BFU725F/N1 demonstration board at 2.4 GHz

Symbol	Parameter	Value	Unit
NF	noise figure	0.8	dB
G_p	power gain	>19	dB
$\|s_{11}\|^2$	Input return loss	<–11	dB
$\|s_{22}\|^2$	output return loss	<–12	dB
$\|s_{12}\|^2$	isolation	>21	dB
$P_{L(1dB)}$	output power at 1 dB gain compression	>0.8	dBm
$P_{i(1dB)}$	input power at 1 dB gain compression	>–17.3	dBm
I_C	collector current	>10.5	mA

5.2 5.9 GHz data (de-embedded)

Table 6. BFU725F/N1 demonstration board at 5.9 GHz

Symbol	Parameter	Value	Unit
NF	noise figure	1.37	dB
G_p	power gain	>11.6	dB
$\|s_{11}\|^2$	Input return loss	<–9.0	dB
$\|s_{22}\|^2$	output return loss	<–12.0	dB
$\|s_{12}\|^2$	isolation	>21.0	dB
$P_{L(1dB)}$	output power at 1 dB gain compression	>0.7	dBm
$P_{i(1dB)}$	input power at 1 dB gain compression	>–10.2	dBm
I_C	collector current	>10.5	mA

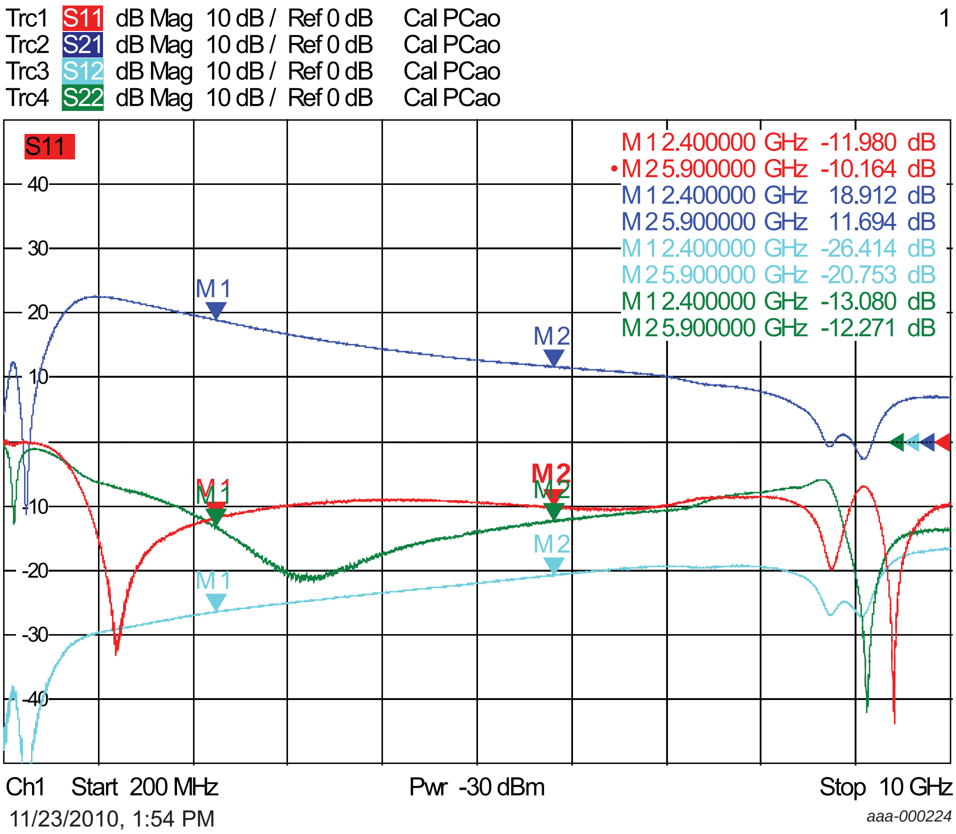


Fig 6. S parameters

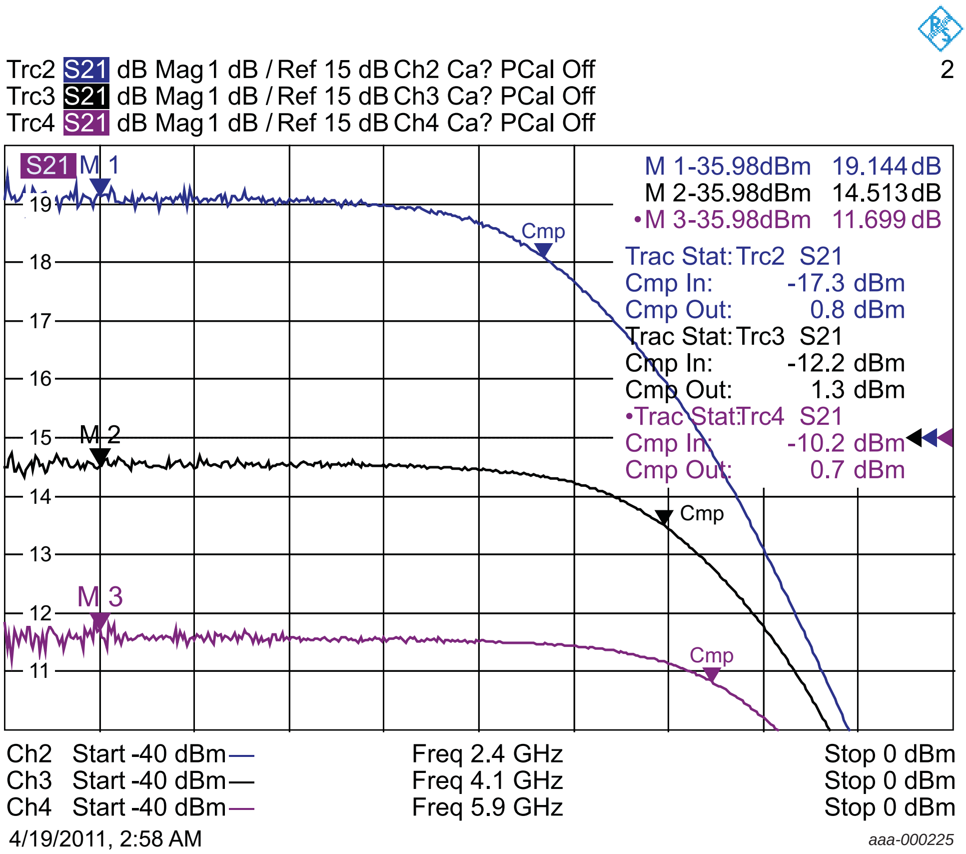
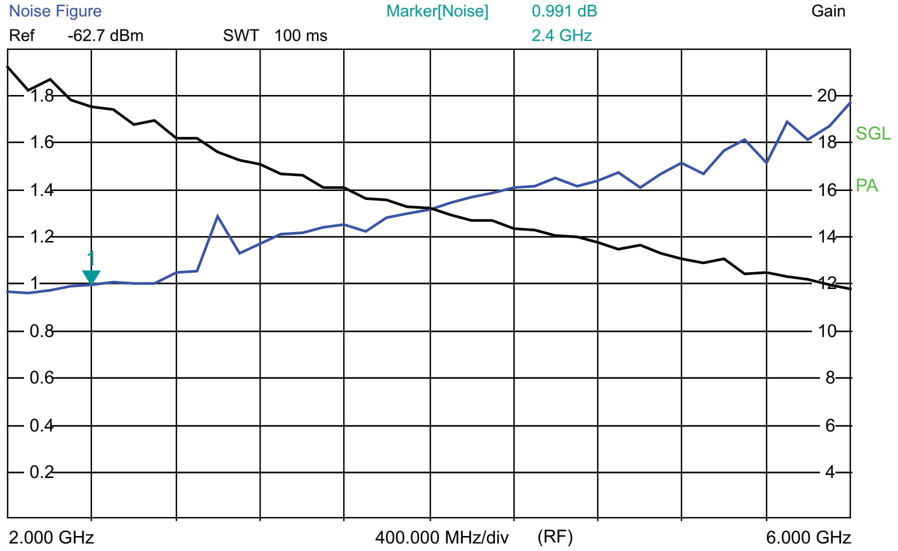


Fig 7. 1 dB compression point (input and output)

Direct		NOISE & GAIN			CALIBRATED
RBW:	1 MHz	RF Atten.	0 dB	2nd Stage Corr.	On
Average:	10	Auto Ref Level	On	Image Rejection	...
		Current Value			
RF:	6 GHz	ENR	15 dB	NF.	1.77 dB
LO:	...	Loss In	6 dB	Noise Temp.	145.88 K
IF:	...	Loss Out	0.3 dB	Gain	11.75 dB



Measurement Complete

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Fig 8. Demonstration board noise figure 2.4 GHz (not de-embedded to de-embedded subtract 0.1 dB)

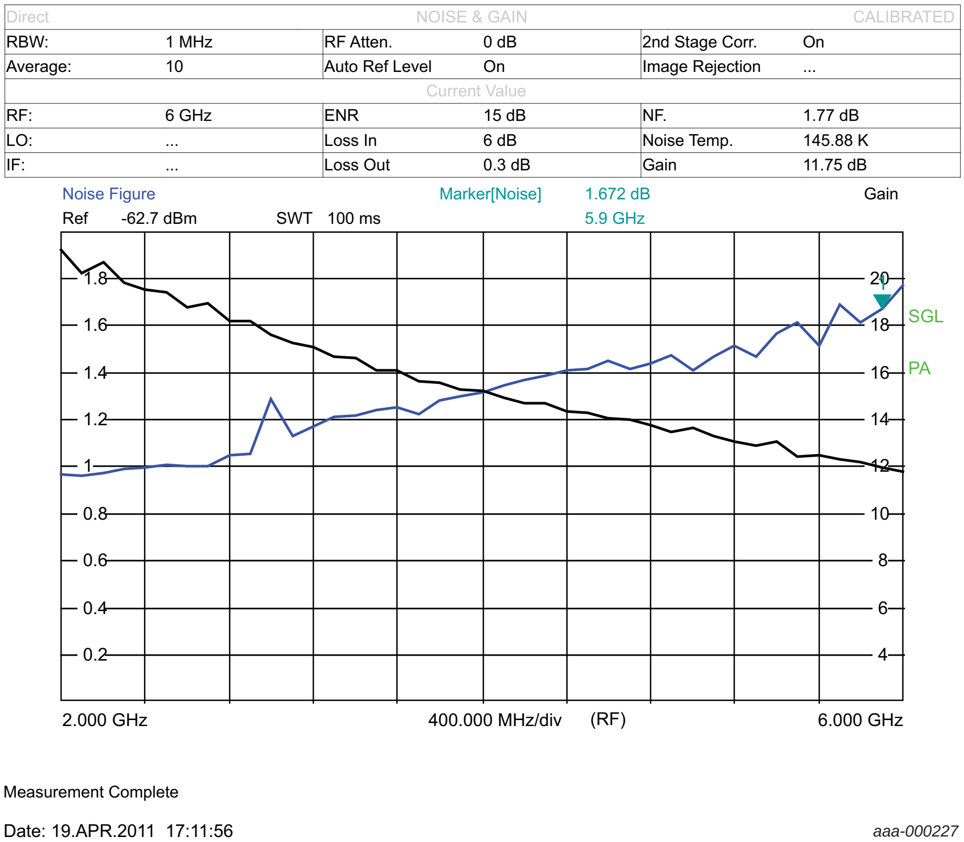

Fig 9. Demonstration board noise figure 5.9 GHz (not de-embedded to de-embedded subtract 0.3 dB)

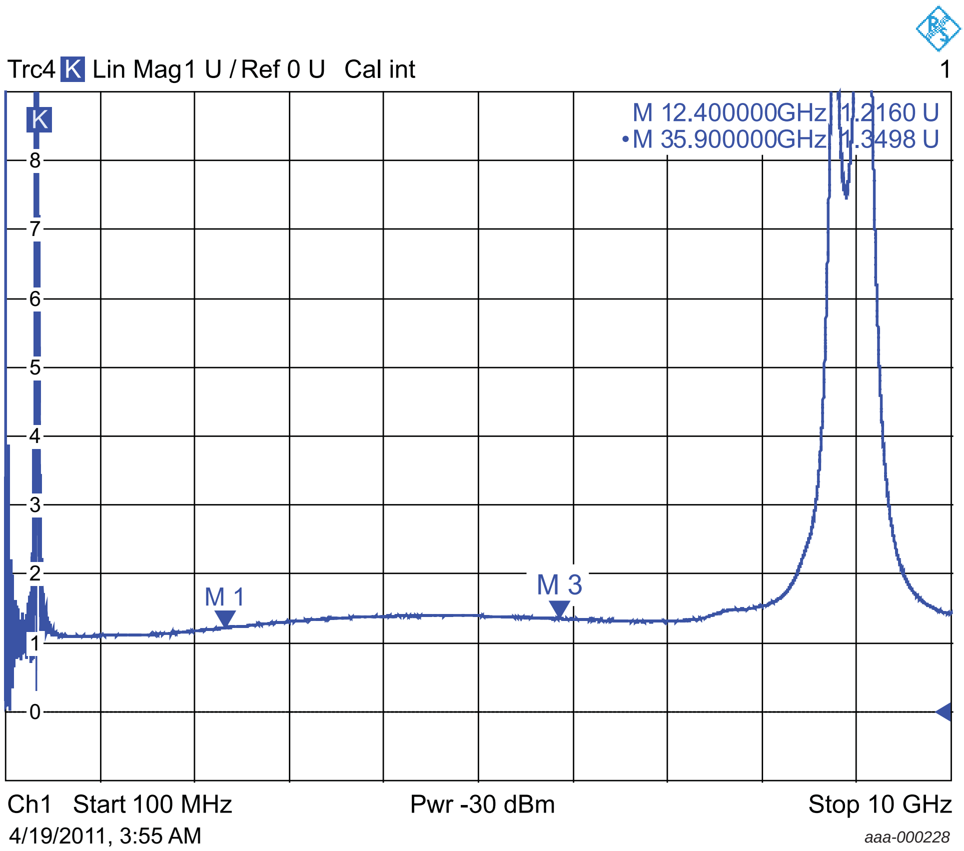

Fig 10. Stability factor

6. Abbreviations

Table 7. Abbreviations

Acronym	Description
BOM	Bill Of Materials
DCR	Direct Current Resistance
GPS	Global Positioning System
HBT	Heterojunction Bipolar Transistor
LFM	Linear Feet per Minute
LNA	Low-Noise Amplifier
RL	Return Loss
SMA	SubMiniature version A

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8. Contents

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