AN11118

BFU725F/N1 1.5 GHz LNA evaluation board

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Document information

Info	Content
Keywords	LNA, 1.5 GHz, BFU725F, GPS
Abstract	This document explains the BFU725F 1.5 GHz LNA evaluation board

Revision history

Rev	Date	Description
1.1	20111017	Modified BOM for better stability.
1.0	20110921	Initial document.

Contact information

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1. Introduction

The BFU725F/N1 is a wideband Silicon Germanium Amplifier transistor for high speed, low noise applications. It is designed to be used for LNA applications up to 15 GHz like GPS, Satellite radio, Cordless Phone, Wireless LAN and satellite LNB. The BFU725F/N1 comes in a SOT343F package that has 2-emitter pins to reduce emitter inductance (for maximum gain).

The BFU725F/N1 is ideal in all kind of applications where cost matters. It also gives the designer flexibility in his design work, like bias current, frequency of operation; optimize for the parameter of interest e.g. noise; gain; IP3 etc

The 1.5GHz LNA evaluation board (EVB) is designed to evaluate the performance of the BFU725F/N1 applied as a general ISM band LNA in the 1.5GHz range. In this document, the application diagram, board layout, bill of material, and some typical results are given.

Fig 1 shows the evaluation board.

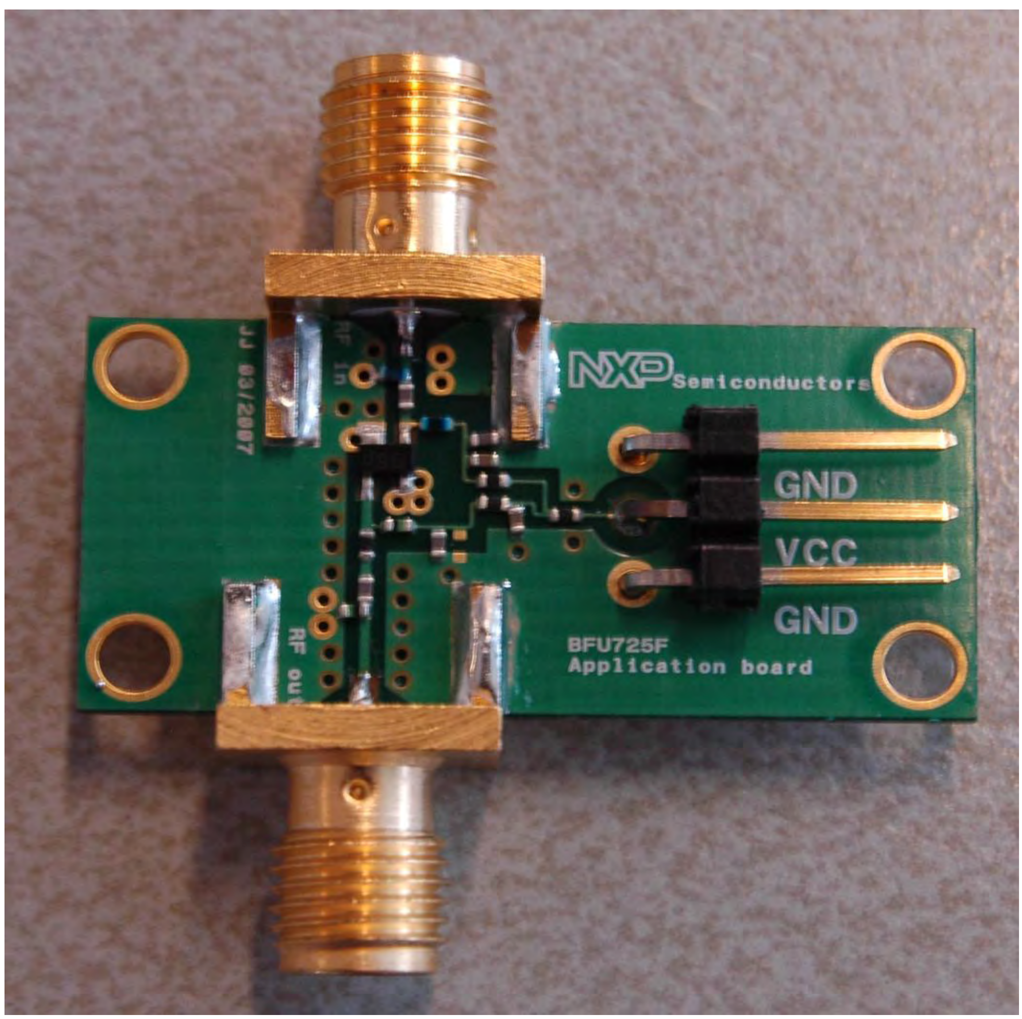


Fig 1. BFU725F/N1 1.5GHz LNA evaluation board

2. General Description

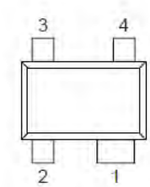
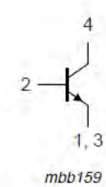
The BFU725F/N1 is the first discrete HBT produced in NXPs SiGeC QuBIC4x BiCmos process. SiGeC is a silicon germanium process with the addition of Carbon in the base layer of the NPN transistor. The presence of carbon in the base layer suppresses the boron diffusion during wafer processing that allows 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). In Table 1 a summary of the transistor performance in terms of noise and gain is shown.

Table 1. BFU725F/N1 figures

Measured at 2V Vce and 5mA Ic

Frequency [GHz]	Noise Figure [dB]	Associated gain [dB]
1.5	0.42	24
1.8	0.43	22
2.4	0.47	20
5.8	0.7	13.5
12	1.1	10

Table 2. Pinning information of the BFU725F/N1

Pin	Description	Simplified outline	Graphic symbol
1	Emitter		
2	Base		
3	Emitter		
4	Collector		

3. Application Board

The BFU725F/N1 1.5GHz EVB simplifies the evaluation of the BFU725F/N1 wideband transistor, for this frequency range. The EVB enables testing of the device performance and requires no additional support circuitry. The board is fully assembled with BFU725F/N1, including input- and output matching, to optimize the performance. For input matching a compromise has to be made for optimum noise/maximum gain/RL/usable bandwidth on the application and customer requirements. To prevent unwanted oscillations the stability factor (K) must be greater than 1. The stability factor can be increased at the cost of gain. The board is mounted with signal input and output SMA connectors for connection to RF test equipment.

3.1 Application Circuit

In Fig 2 the application diagram as supplied on the evaluation board is given.

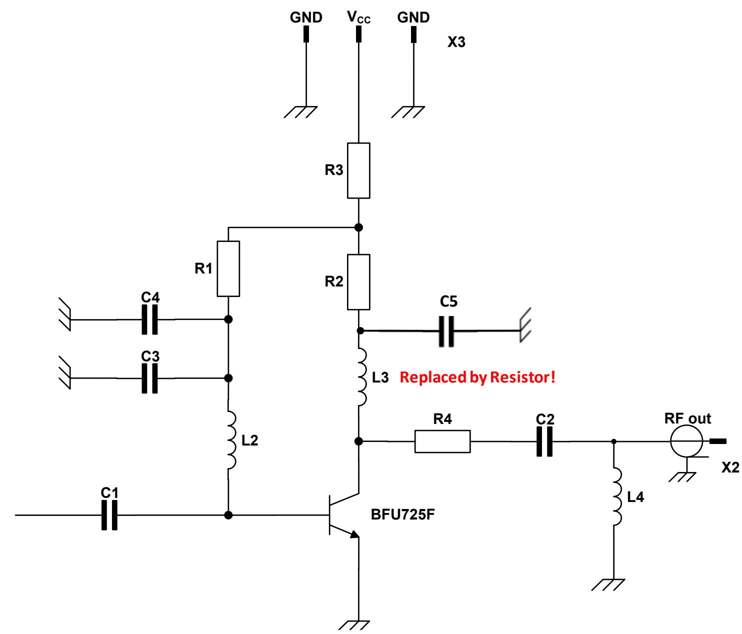


Fig 2. Circuit diagram of the evaluation board

3.2 Board Layout

Fig 3 shows the board layout with the components.

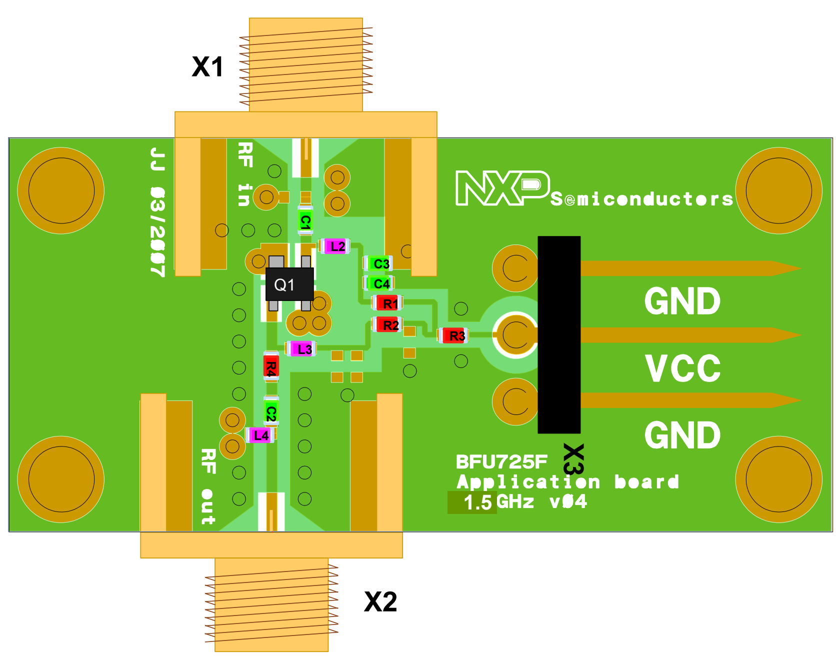
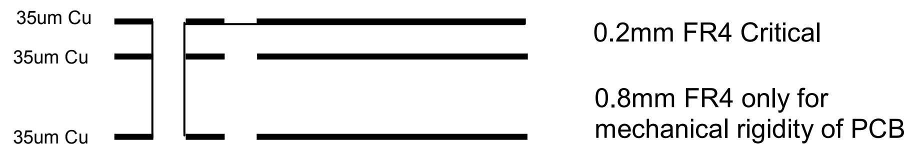


Fig 3. Printed Circuit Board of BFU725F/N1 1.5GHz Evaluation Board

3.3 PCB Layout

A good PCB Layout is an essential part of an RF circuit design. The EVB of the BFU725F/N1 can serve as a guideline for laying out a board using either the BFU725F/N1. 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 emitters is also essential for the performance. Either connect the emitters 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 4.



(1) Material supplier is ISOLA DURVAVER; εr=4.6-4.9: Tδ=0.02

Fig 4. Stack of PCB material

3.4 Bill of Materials

Table 3. Bill of Materials

Designator	Description	Footprint	Value	Supplier Name/type	Comment
C1	Capacitor	0402	1.5 pF	MurataGRM1555	DC blocking/ matching
C2	Capacitor	0402	6.8 pF	MurataGRM1555	DC blocking/ matching
C3,C5	Capacitor	0402	120 pF	MurataGRM1555	LF decoupling
C4	Capacitor	0402	100 nF	MurataGRM1555	LF decoupling
L2	Inductor	0402	5.1 nH	Murata/LQW15A High Q low Rs	Input matching
L3	Resistor	0402	100 Ω	Various	Output matching
L4	NOT MOUNTED				
R1	Resistor	0402	22 kΩ	Various	Bias setting
R2	Resistor	0402	0 Ω	Various	Stability
R3	Resistor	0402	390 Ω	Various	Bias setting
R4	Resistor	0402	33 Ω	Various	Stability
X1, X2	SMA RF 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

4. Required Equipment

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

- ✓ DC Power Supply up to 30 mA at 3V.
- ✓ An RF Signal generator capable of generating an RF signal at the operating frequency of 1.575 GHz.
- ✓ An RF spectrum analyzer that covers at least the operating frequency of 1.575 GHz 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.

5. Connections and Setup

The BFU725F/N1 1.5GHz EVB is fully assembled and tested. Please follow the steps below for a step-by-step guide to operate the EVB and testing the device functions.

1. Connect the DC power supply set to 3V 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 EVB respectively. Do not turn on the RF output of the Signal generator yet, set it to -45dBm output power at 1.575 GHz, set the spectrum analyzer on 1.575 GHz center frequency and a reference level of 0dBm.
3. Turn on the DC power supply and it should read approximately 5 mA.
4. Enable the RF output of the generator; the Spectrum analyzer displays a tone of 1.575 GHz at around –28.5 dBm.
5. Instead of using a signal generator and spectrum analyzer one can also use a Network Analyzer NWA in order to measure Gain as well as in- and output return loss
6. For Noise figure evaluation, either a Noise-figure analyzer or a spectrum analyzer with noise option can be used. The use of a 6 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 EVB should be avoided, since this affects the noise performance.

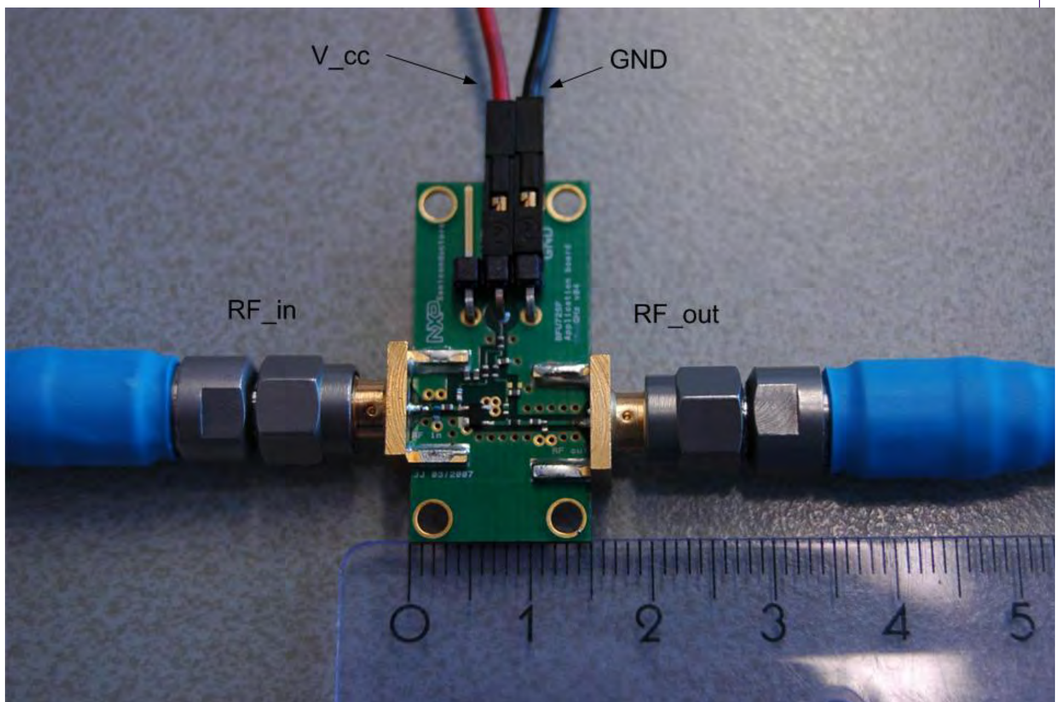


Fig 5. Evaluation board including its connections

6. Typical EVB Results

Table 4. Typical results measured on the evaluation board
Operating Frequency is f = 1575.42 MHz unless otherwise specified; Vcc = 3 V

Parameter	Symbol	BFU725F/N1 EVB	Unit	Comment
Supply Current	Isup	4.8	mA	[1]
Noise Figure	NF	0.95	dB	[1]
Power Gain	Gp	15.7	dB	
Input Return Loss	IRL	4.7	dB	
Output Return Loss	ORL	9.5	dB	
Reverse Isolation	ISO_{rev}	27.8	dB	
Input 1dB Gain Compression	IP1dB	-22.8	dBm	
Output 1dB Gain Compression	OP1dB	-8.1	dBm	
Input third order intercept point	IIP3	-9.1	dBm	[2]
Output third order intercept point	OIP3	6.6	dBm	[2]

[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 0.1 dB are not subtracted.

[2] Jammers at f_1=f+138MHz and f_2=f+276MHz, where f=1575.42MHz. $P_{in}(f_1)=P_{in}(f_2)$=-30dBm

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