AN11223

Low Noise Fast Turn ON/OFF 2.4-2.5GHz WiFi LNA with BFU730LX

Rev. 2 — 16 November 2012 **Application note**

Document information

Info	Content
Keywords	BFU730LX, 2.4-2.5GHz LNA, WiFi (WLAN)
Abstract	This document provides circuit simulation, schematic, layout, BOM and typical EVB performance for a 2.4-2.5GHz WiFi (WLAN) LNA

Revision history

Rev	Date	Description
2	20121116	New publication
1	20120703	Initial Draft

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1. Introduction

The BFU730LX is a discrete HBT that is produced using NXP Semiconductors' advanced 110 GHz fT SiGe:C BiCmos process. SiGe:C is a normal 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. This allows a steeper and narrower SiGe HBT base and a heavier doped base. As a result, lower base resistance, lower noise and higher cut off frequency can be achieved.

The BFU730LX is one of a series of transistors made in SiGe:C.

BFU710F, BFU730F, BFU760F, BFU768F and BFU790F are the other types. BFU710F is intended for ultra low current applications. The BFU760F, BFU768F and BFU790F are high current types and are intended for application where linearity is key.

New 6th & 7th Generation Wideband transistors from NXP offer best RF noise figure / gain tradeoff at 12GHz drawing lowest current which means best signal reception at low power, enabling products to be more sensitive in noisy environments and friendlier to the environment.

Key Benefits:

- Application up to 18 GHz and higher
- Broad choice of parts for the perfect fit in the application
- Lowest current consumption meaning greener products
- SOT883C for BFU730LX and for the others SOT343F package for high performance and easy manufacturing

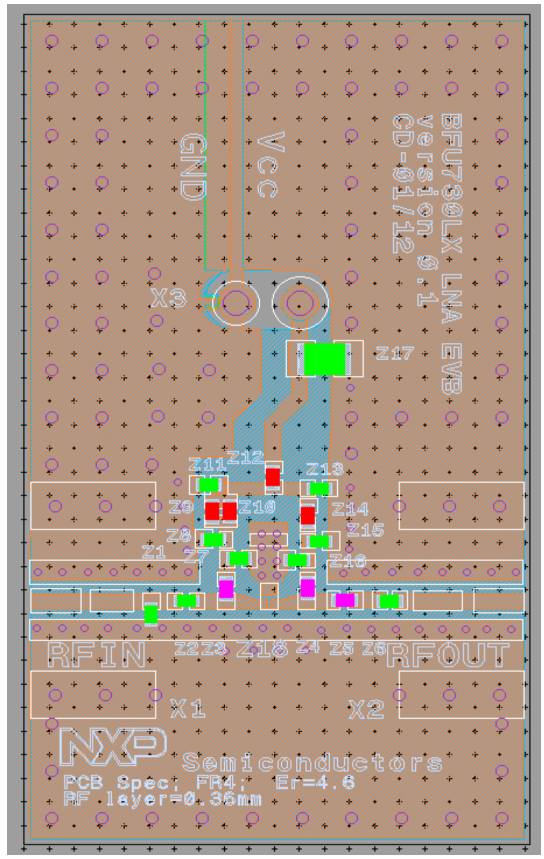


Fig 1. BFU730LX Universal Demo Board 2.4-2.5GHz WiFi LNA EVB Demo Board

2. Requirements and design of the 2.4-2.5GHz WiFi LNA

The circuit shown in this application note is intended to demonstrate the performance of the BFU730LX in a 2.4-2.5 GHz LNA for e.g. 802.11a/b/g/n & 802.11ac “MIMO” WiFi (WLAN) applications.

Key requirements for this application are:

- Frequency Band 2.4 – 2.5GHz
- Gain
- Input/output Match
- Linearity
- NF
- Turn ON/OFF Time

3. Design and Simulation

The 2.4-2.5 GHz WiFi LNA consists of one stage BFU730LX 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 10dB return loss and gain of 17 @2.45GHz with superior Noise Figure of 0.97dB.

With only 12.5mA it also shows a high input P1 dB compression of -9 dBm@2.45GHz, as well as high input IP3 of +2dBm.

The LNA Turn ON and OFF time are 380nS and 40 nS respectively.

The designed LNA is unconditionally stable at 10 MHz-15 GHz.

3.1 BFU730LX 2.4-2.5GHz WiFi LNA Simulation

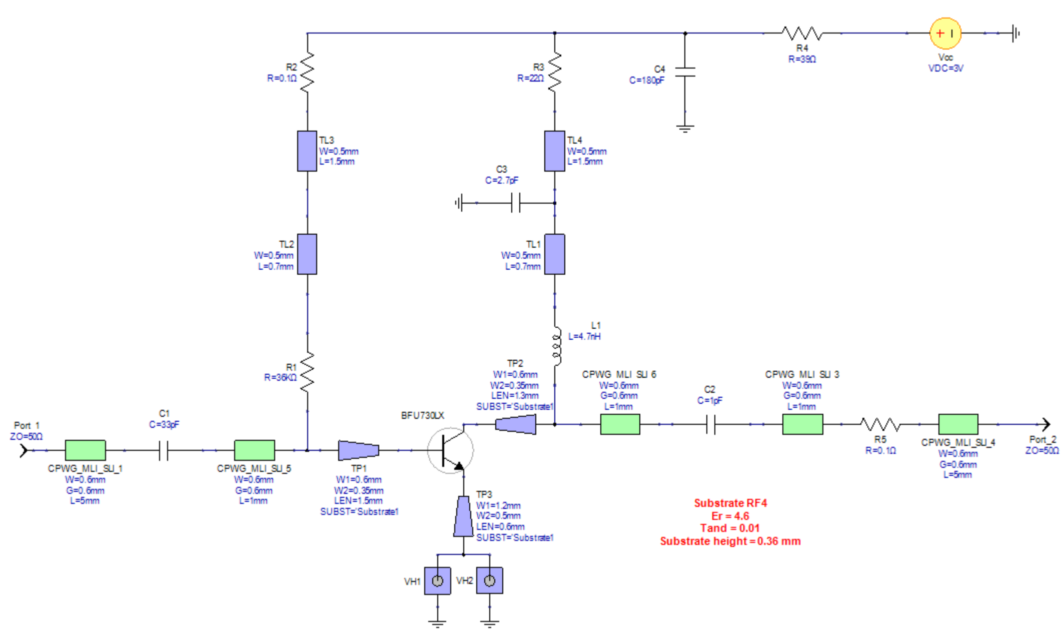


Fig 2. BFU730LX 2.4-2.5GHz WiFi LNA Simulation: Circuit (Capacitors GRM1555 & Inductors LQP15)

3.2 BFU730LX 2.4-2.5GHz WiFi LNA Simulation Result

3.2.1 Gain and Match in 2.4-2.5GHz Band

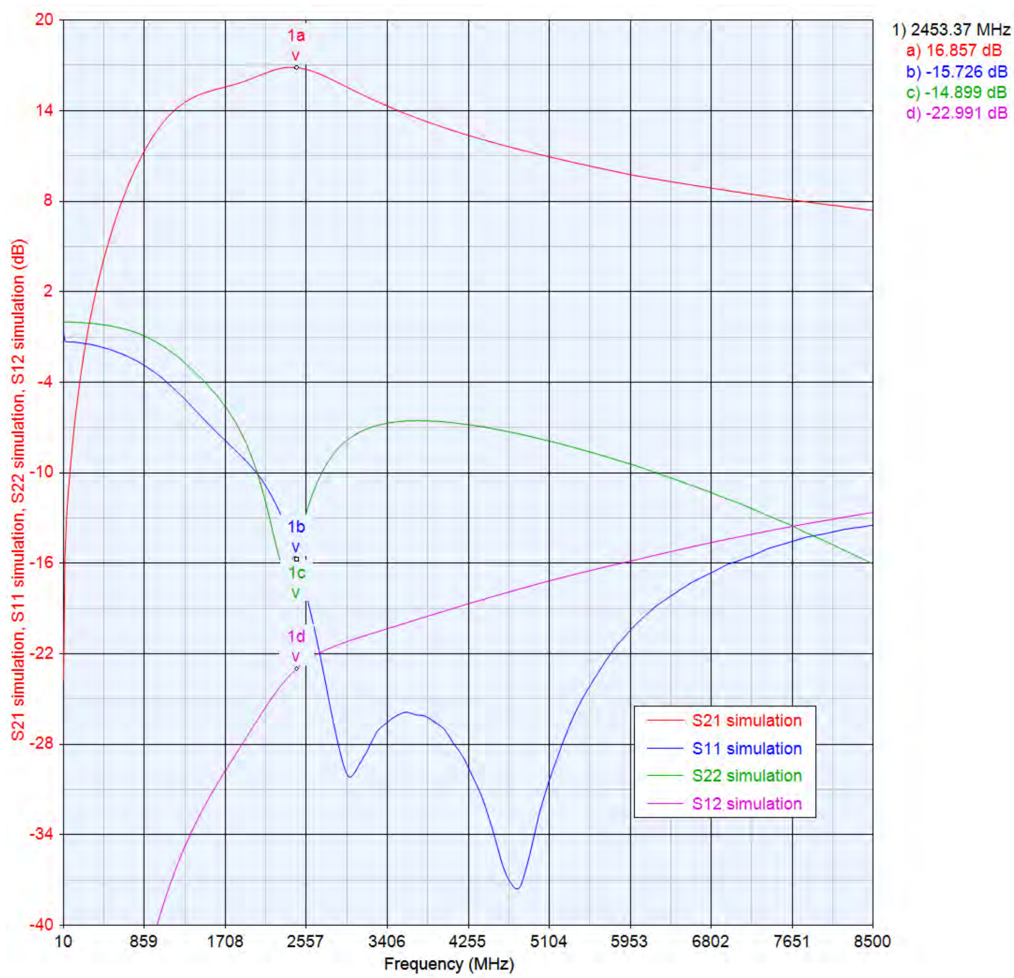


Fig 3. BFU730LX 2.4-2.5GHz WiFi LNA Simulation: Gain and Match

3.2.2 Noise Figure in 2.4-2.5GHz Band

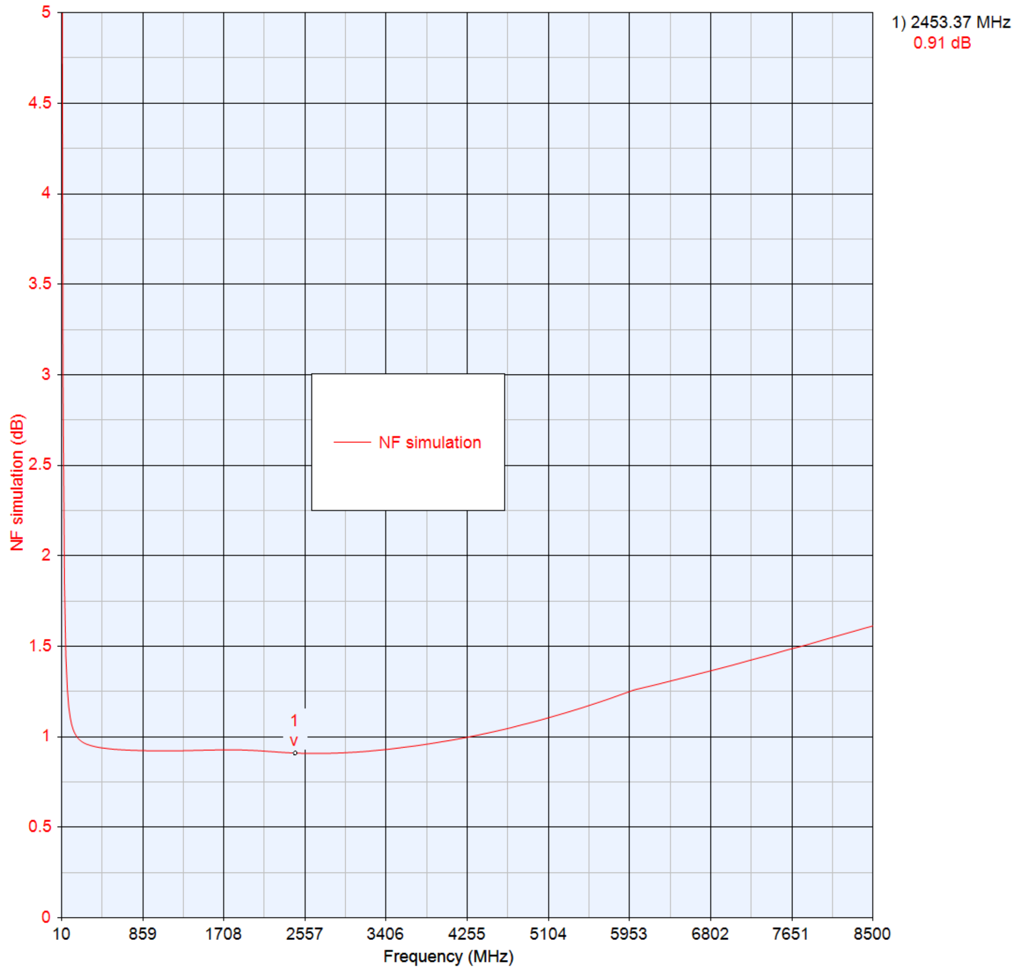


Fig 4. BFU730LX 2.4-2.5GHz WiFi LNA Simulation: Noise Figure

3.2.3 Stability

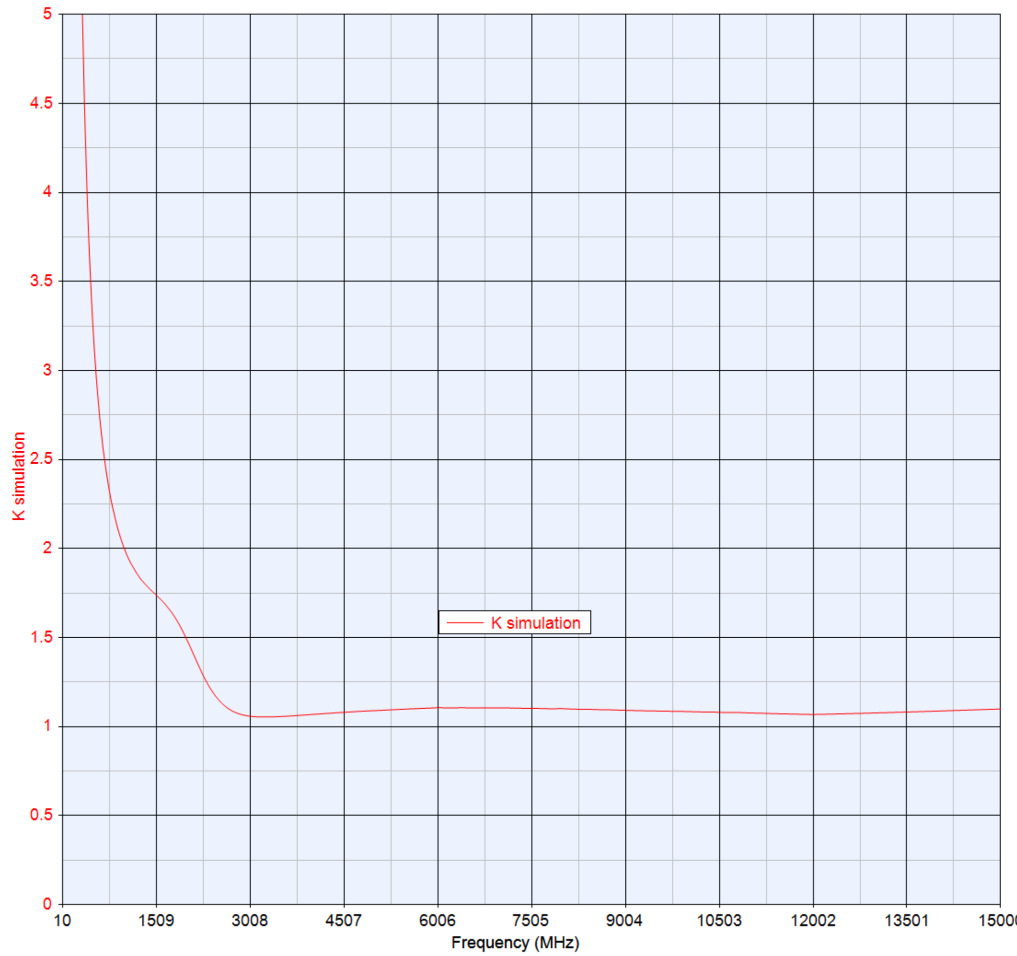


Fig 5. BFU730LX 2.4-2.5GHz WiFi LNA Simulation: Stability

4. Application Board

The 2.4-2.5GHz WiFi LNA evaluation board simplifies the evaluation of the BFU730LX application. The evaluation board enables testing of the device performance and requires no additional support circuitry. The board is fully assembled with the BFU730LX transistor, including input and output matching components, to optimize performance.

The board is supplied with two SMA connectors for input and output connection to RF test equipment.

4.1 Application Circuit Schematic

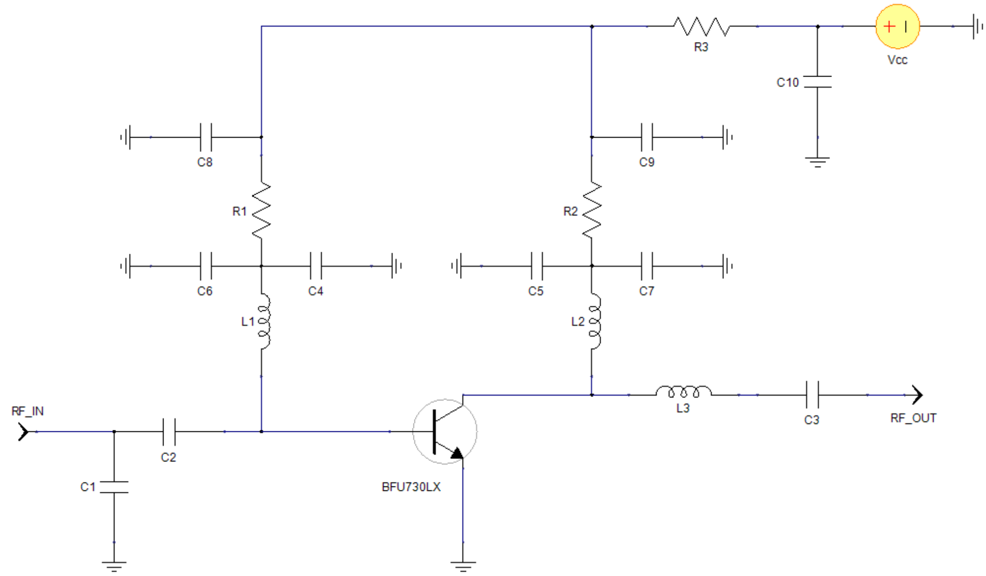


Fig 6. BFU730LX Universal Demo Board: Schematic

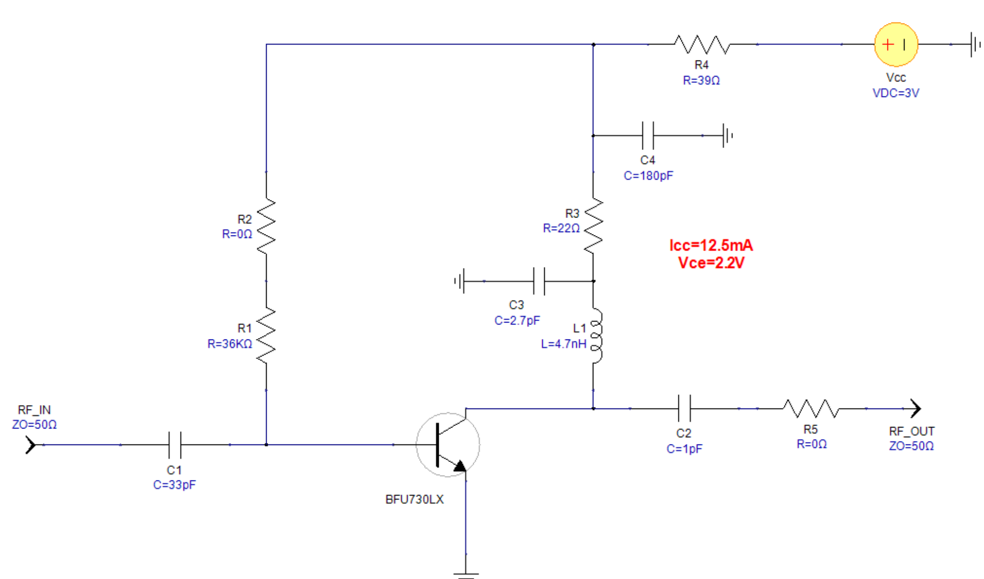


Fig 7. BFU730LX 2.4-2.5GHz WiFi LNA: Schematic

Note: Figure 6 is the schematic for BFU730LX universal demo board, some assembly changes are made to accommodate this simplified design, the revised schematic is shown in figure 7, and the changes in figure 6 are as following:

1. C1, C4, C6, C7, C8, C10: not populated
2. Move R1 (36K) to L1 location, short two solder pads of R1 or put a 0 ohm jumper
3. Move C3 (1pF) to L3 location, short two solder pads of C3 or put a 0 ohm jumper

4.2 Application Board Bill-Of-Material

Table 1. BFU730LX 2.4-2.5GHz WiFi LNA Part List

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

Item	Position on Layout	Reference (Fig 7)	Type	Vendor	Value
1	Z2	C1	GRM1555C1	Murata	33pF
2	Z5	C2	GRM1555C1	Murata	1.0pF
3	Z16	C3	GRM1555C1	Murata	2.7pF
4	Z13	C4	GRM1555C1	Murata	180pF
5	Z4	L1	LQP15	Murata	4.7nH
6	Z3	R1			36K
7	Z10	R2			0R
8	Z14	R3			22R
9	Z12	R4			39R
10	Z6	R5			0R
11	Z18	BFU730LX		NXP SEMICONDUCTORS	BFU730LX
12	X1, X2	RF_IN, RF_OUT		Amphenol	CON-SMA-1
13	X3	Vcc		Molex	CON-2PIN

4.3 Typical Application Board Test Result

4.3.1 S-Parameter – Gain and Match

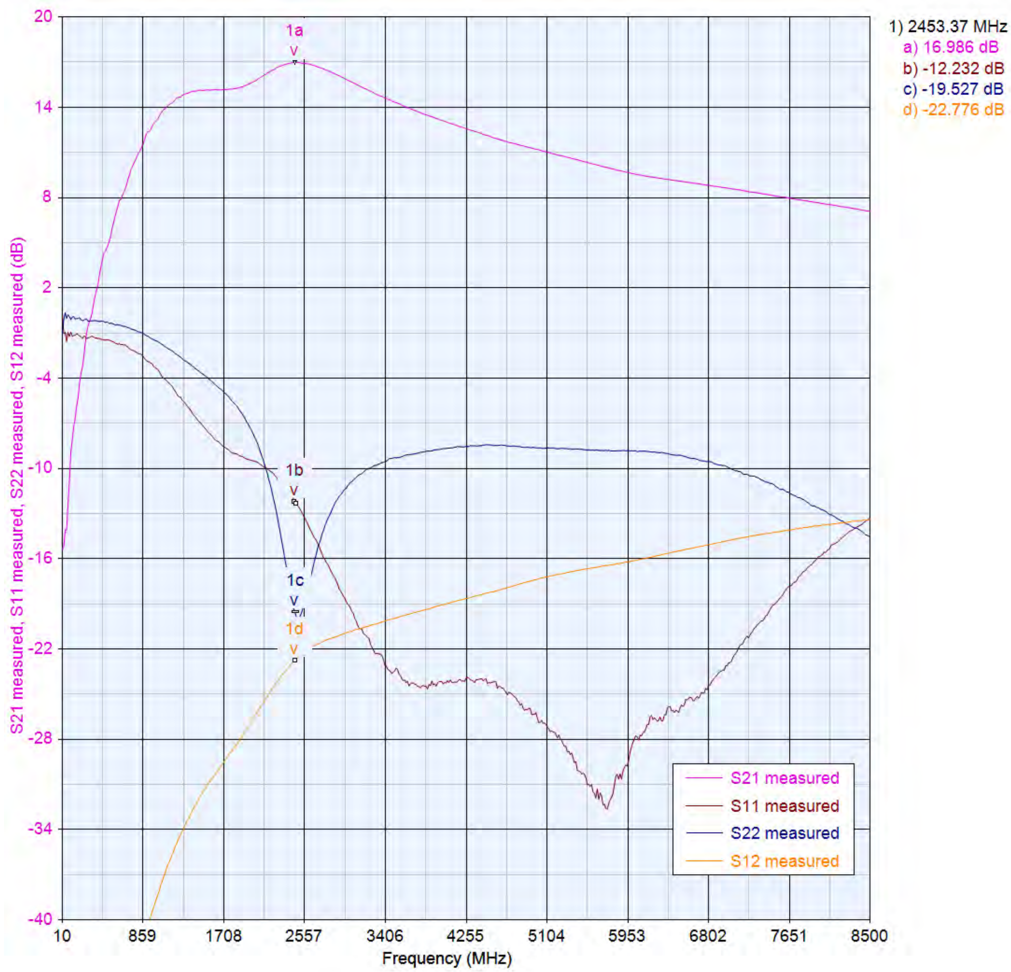
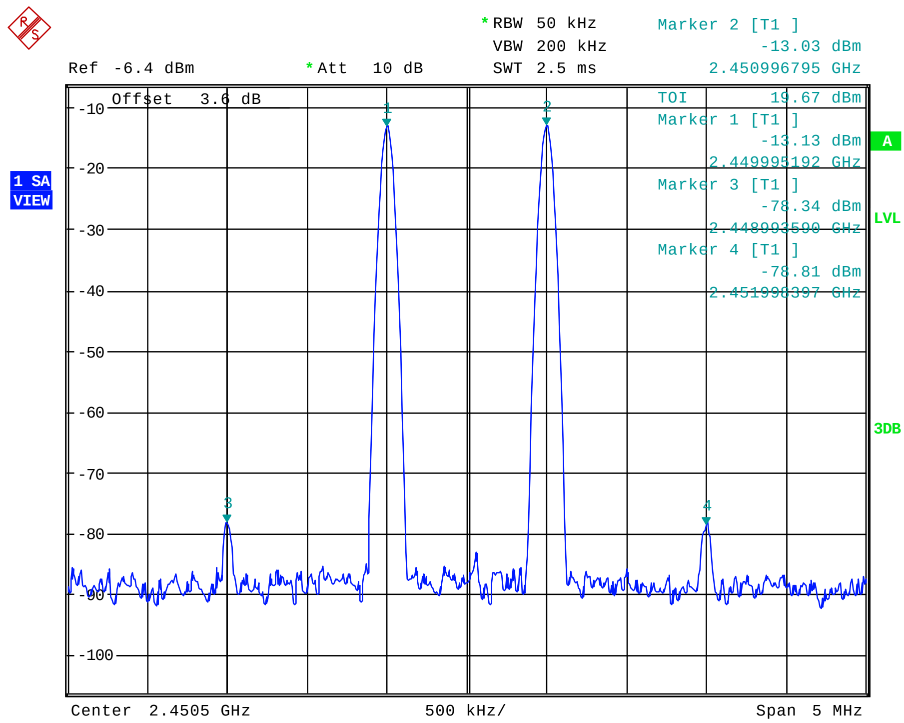


Fig 8. BFU730F 2.4-2.5GHz WiFi LNA: S-Parameter

4.3.2 Linearity/IP3



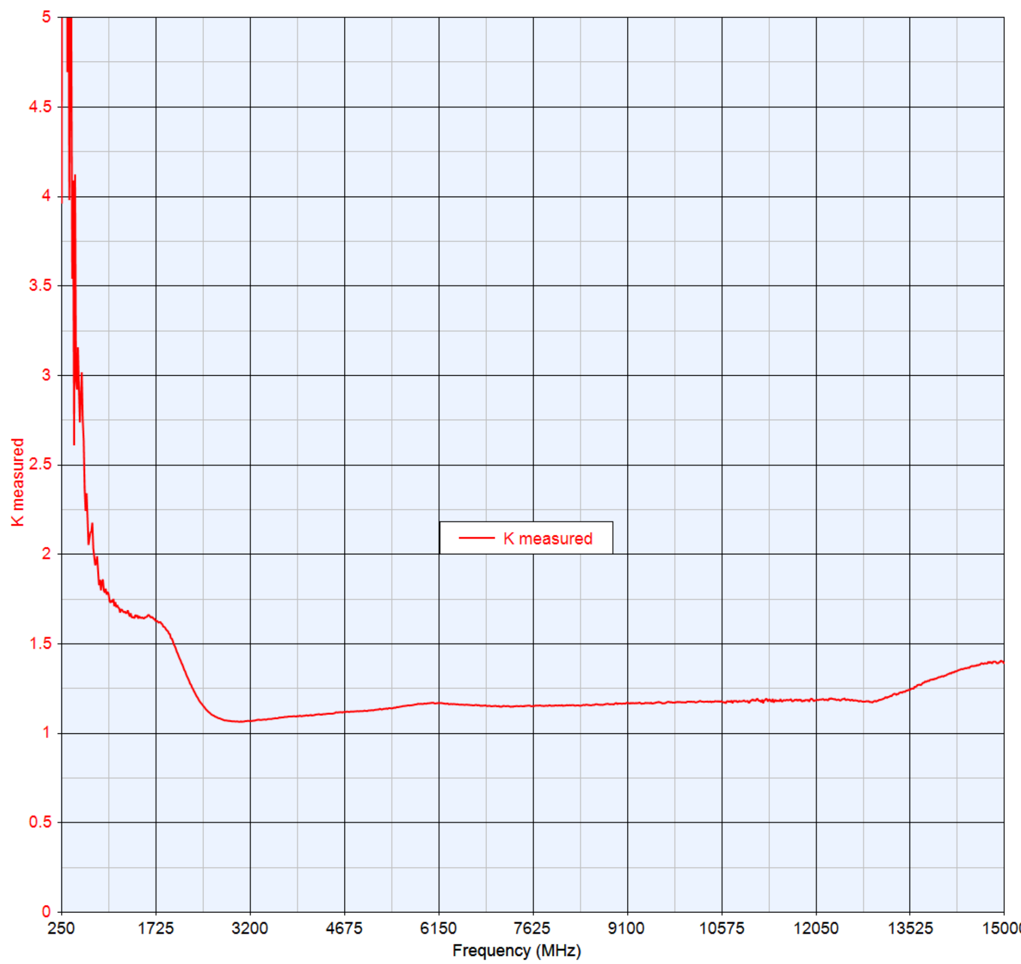
Two tones: f1: 2450MHz, f2: 2451MHz, -30dBm each tone, tone spacing: 1MHz

OIP3 = 19.5dBm

IIP3 = OIP3 - Gain = 19.5 -17 = 2.5dBm

Fig 9. BFU730LX 2.4-2.5GHz WiFi LNA: IP3

4.3.3 Stability



K Factor

Fig 10. BFU730LX 2.4-2.5GHz WiFi LNA: Stability

4.3.4 Noise Figure Measurement

The noise figure is measured at the SMA connectors of the evaluation board. The losses of the connectors and the pcb are around 0.36dB @ 2.45GHz (RF_IN to RF_OUT).

After de-embedding the connector and pcb losses (0.18dB @ 2.45GHz) up to the transistor input, the noise figure is 0.79dB @ 2.45GHz.

4.3.5 LNA Turn ON/OFF Time

The following diagram shows the setup to test LNA Turn ON and Turn OFF time. The LNA Turn ON and Turn OFF time are mainly determined by the R-C time constant of the biasing circuitries: R4*C4…Reducing the C4 can improve switching time speed.

Set the waveform generator to square mode and the output amplitude at 3Vrms with high output impedance. The waveform generator has adequate output current to drive the LNA therefore no extra DC power supply is required which simplifies the test setup.

Set the RF signal generator output level to -25dBm at 2.4GHz and increase its level until the output DC on the oscilloscope is at 25mV on 5mV/division, the signal generator RF output level is approximately -12dBm.

It is very important to keep the cables as short as possible at input and output of the LNA so the propagation delay difference on cables between the two channels is minimized.

It is also critical to set the oscilloscope input impedance to 50ohm on channel 2 so the diode detector can discharge quickly to avoid a false result on the Turn OFF time testing.

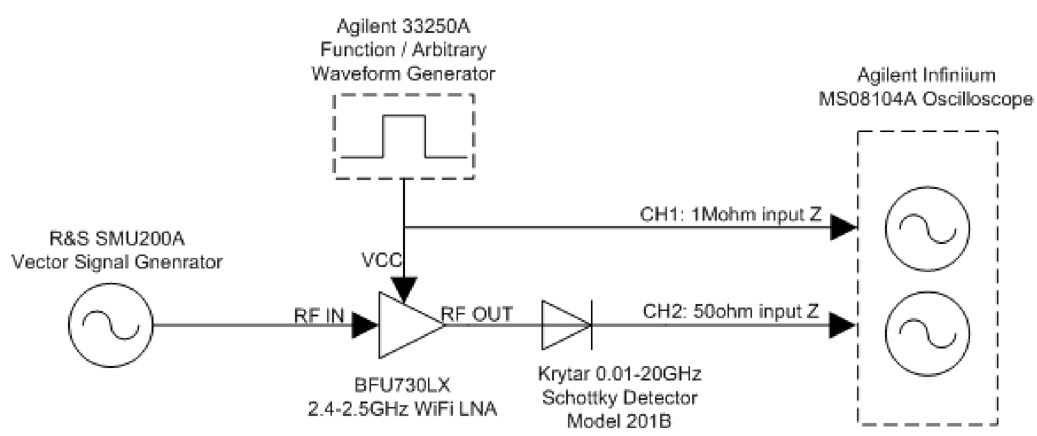
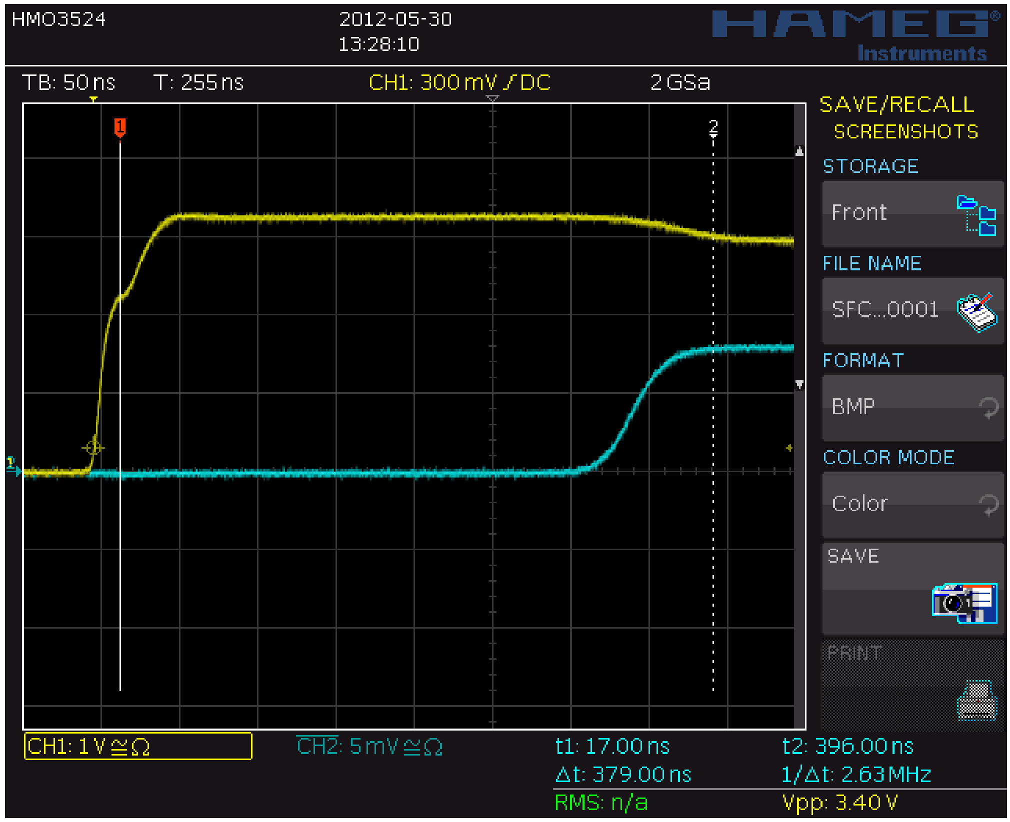


Fig 11. LNA Turn ON and Turn OFF time test setup

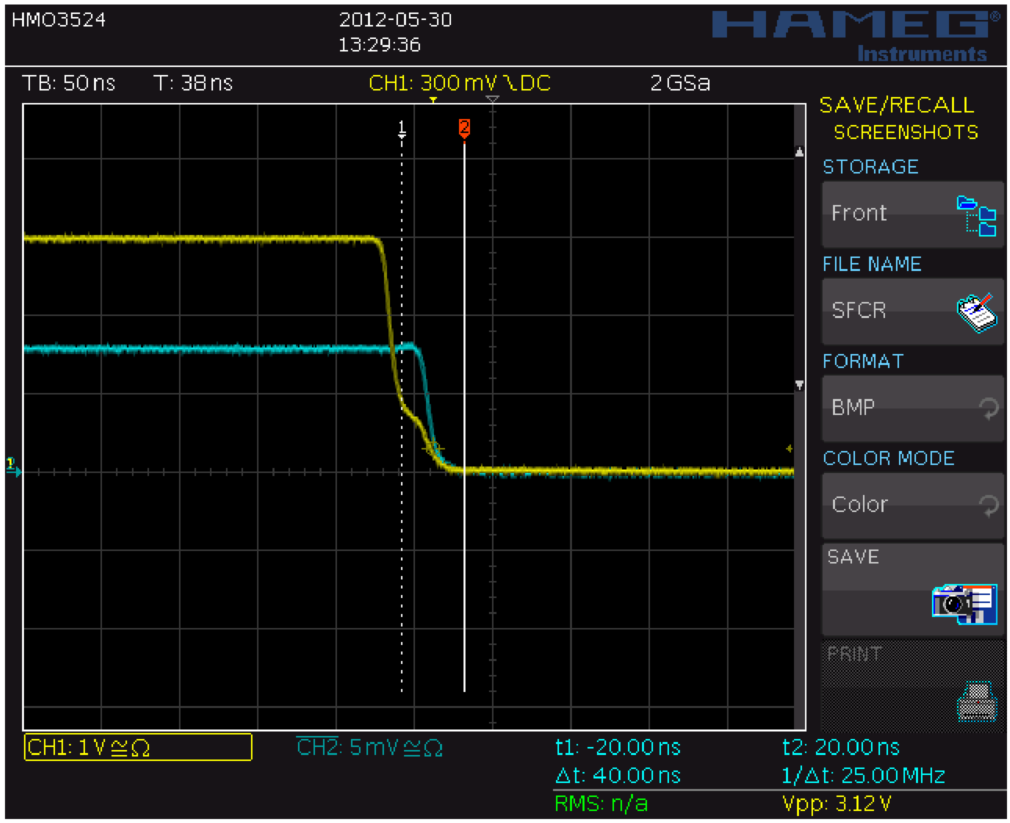
4.3.5.1 LNA Turn ON Time



3.0Vrms, 1kHz and 50% duty cycle pulse applied on VCC pin, measured from 50% of input pulse to 100% of max. output power

Fig 12. BFU730LX 2.4-2.5GHz WiFi LNA: Turn ON time

4.3.5.2 LNA Turn OFF Time



3.0Vrms, 1kHz and 50% duty cycle pulse applied on VCC pin, measured from 50% of input pulse to 0% of max. output power

Fig 13. BFU730LX 2.4-2.5GHz WiFi LNA: Turn OFF time

4.3.6 Summary Of the Typical Evaluation Board Test Result

Table 2. Typical results measured on the BFU730LX 2.4-2.5GHz WiFi LNA Evaluation Board

Operating frequency 2.4-2.5GHz, testing at 2.4GHz and 2.5GHz unless otherwise specified, Temp = 25°C. ***All measurements are done with SMA-connectors as reference plane.***

Parameter		Symbol	Value	Unit
Supply Voltage		Vcc	3.0	V
Supply Current		Icc	12.5	mA
Noise Figure [1]	@2.4GHz	NF	0.79	dB
	@2.5GHz	NF	0.79	dB
Power Gain	@2.4GHz	Gp	16.9	dB
	@2.5GHz	Gp	17.0	dB
Input Return Loss	@2.4GHz	IRL	11.5	dB
	@2.5GHz	IRL	12.6	dB

Parameter		Symbol	Value	Unit
Output Return Loss	@2.4GHz	ORL	17.6	dB
	@2.5GHz	ORL	19.9	dB
Reverse Isolation	@2.4GHz	ISLrev	23.2	dB
	@2.5GHz	ISLrev	22.5	dB
Input 1dB Gain Compression Point	@2.4GHz	Pi1dB	-8.9	dBm
	@2.5GHz	Pi1dB	-8.9	dBm
Output 1dB Gain Compression Point	@2.4GHz	PL1dB	7.2	dBm
	@2.5GHz	PL1dB	7.2	dBm
Input Third Order Intercept Point Two Tones: f1: 2450MHz, f2: 2451MHz, power: -30dBm	@2.4GHz	IIP3	2.5	dBm
Output Third Order Intercept Point Two Tones: f1: 2450MHz, f2: 2451MHz, power: -30dBm	@2.4GHz	OIP3	19.5	dBm
Stability (0- 15GHz)		K	>1	
LNA Turn ON/OFF Time		Ton	380	nS
		Toff	40	nS

[1] PCB and connector losses excluded.

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