BFP650

High Linearity Low Noise Amplifier using BFP650 for 2.4 GHz WLAN Application

Application Note AN329

Revision: Rev. 1.0
2013-06-21

RF and Protection Devices

Edition 2013-06-21

Published by
Infineon Technologies AG
81726 Munich, Germany

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Application Note AN329
Revision History: 2013-06-21

Previous Revision: No previous revision

Page	Subjects (major changes since last revision)

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Last Trademarks Update 2011-11-11

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1 Introduction

1.1 About Wi-Fi® /Wireless LAN (WLAN)

Wireless Fidelity (Wi-Fi®) or the well-known Wireless LAN (WLAN) plays a major role in today's communications by enabling constant connection in the 2.4 GHz and broadband Internet access for users with laptops or devices equipped with wireless network interface while roaming within the range of fixed Access Points (AP) or a public hotspot. Different applications like home entertainment with wireless high-quality multimedia signal transmission, home networking notebooks, mass data storages and printers implement 2.4 GHz wireless data transfer functions into their system for the connectivity convinience. For this kind of high-speed and high data rate wireless communication standards, it is essential to ensure the data transfer quality of the link path. Major performance criteria of these equipments have to be fulfilled: sensitivity, strong signal capability and interference immunity. Fig.1 presents a general block diagram of the WLAN system.

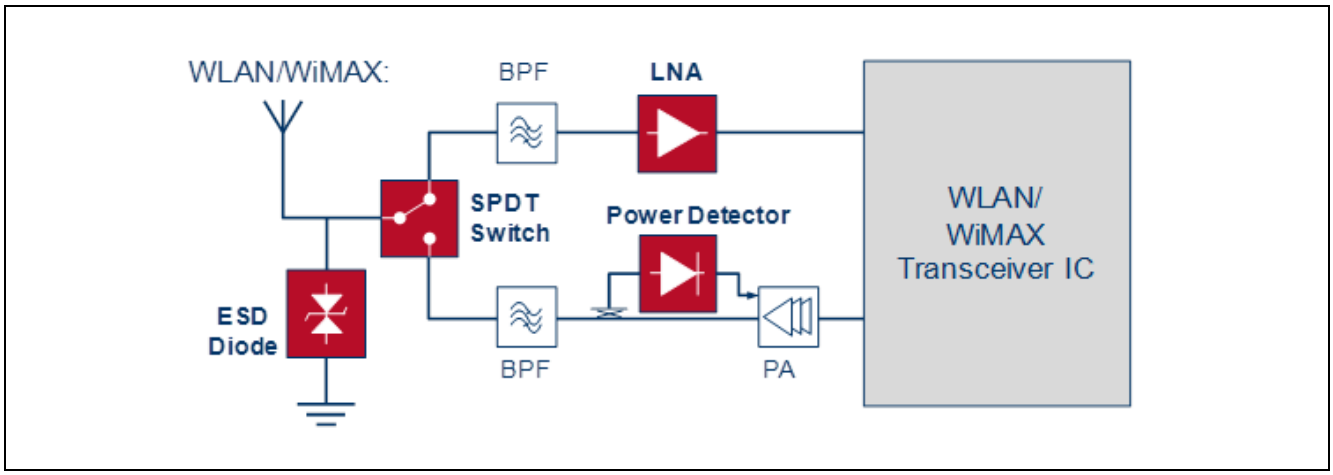

Figure 1 The 2.4 GHz WLAN (IEEE802.11b/g/n/a/c/ac) Front-End System Block Diagram.

The Wi-Fi router provides the ability to receive relatively weak signals from Wi-Fi enabled devices such as mobile phones. Therefore, it should have high sensitivity to detect a weak signal in the presence of strong interfering signals. The sensitivity of the receiver can be improved by using a low noise amplifier (LNA) as a first block of the receiver front-end to increase the signal-to-noise ratio (SNR) of the overall system, especially in an environment with very weak signal strength. Due to the insertion loss of the single-pole-double-throw (SPDT) switch and the Bandpass Filter (BPF) or diplexer, the typical allowed receiver chain Noise Figure (NF) of approx. 2 dB can only be achieved by using a high-gain LNA. In addition, the WLAN systems are subject to co-channel interference and the interference from strong co-existing cellular signals. High linearity

characteristics of the LNA, such as the 3rd order intercept point (IP_3) and 1dB compression point (P_{1dB}), are required to improve the ability to distinguish between desired signals and interference signals received close together.

This application note is focusing on the LNA block, but Infineon does also support with RF-switches, TVS-diodes for ESD protection and RF Schottky diodes for power detection for WLAN.

2 BFP650 Overview

2.1 Features

- Linear low noise driver amplifier for RF front-end up to 5 GHz, based on Infineon´s reliable, high volume SiGe:C wafer technology
- High Output compression point OP_{1dB}=17 dBm at 70 mA, 3 V, 2.4 GHz, 50 Ω system
- High Output 3rd order intermodulation point OIP_3=30 dBm at 70 mA, 3 V, 2.4 GHz, 50 Ω system
- Maximum available gain G_{max}=17.5 dB at 70 mA, 3 V, 2.4 GHz
- Minimum noise figure NF_{min}=1 dB at 30 mA, 3 V, 2.4 GHz
- Easy to use Pb-free (RoHS compliant) and halogen-free standard package with visible leads

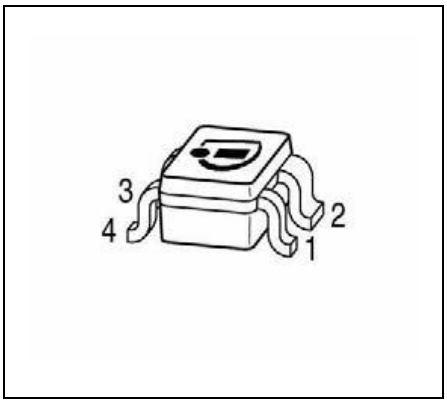

Figure 2 BFP650 in SOT343

2.2 Key Applications of BFP650

Driver amplifier:

- ISM bands 434 and 868 MHz
- 1.9 GHz cordless phones
- CATV LNA amplifiers
- ISM bands up to 10 GHz

Transmitter driver amplifier

- 2.4 GHz WLAN / Bluetooth, 2.4 / 3.5 GHz WiMAX

Output stage LNA for active antennas

- TV, GPS, SDARS
- 2.4 / 5 GHz WLAN
- 2.4 / 3.5 / 5 GHz WiMAX, etc

Suitable for 5-10.5 GHz oscillators

3 BFP650 as Low Noise Amplifier for 2.4–2.5 GHz Wireless LAN Applications

3.1 Description

BFP650 from Infineon Technologies is a low cost discrete SiGe:C hetero-junction bipolar transistor (HBT) specifically designed for WLAN LNA with high power applications.

This report presents the application circuit with the low-cost SiGe BFP650 RF transistor as LNA for 2.4 GHz WLAN application. The circuit requires 11 external SMDs (0402 case size).

The LNA provides gain from 11.7 dB to 12.1 dB over the WLAN band from 2.4 GHz to 2.5 GHz, and the noise figure (NF) varies from 0.92 dB to 0.97 dB (SMA and PCB losses are subtracted) over the complete frequency band.

Furthermore, the circuit provides unconditional stability from 10 MHz to 15 GHz. The circuit is matched at input and output, and presents an input return loss more than 11.9 dB, and an output return loss more than 10.8 dB.

At the frequency of 2.4 GHz, using two tones spaced of 1MHz, the output 3rd intercept point reaches +20.9 dBm. Besides, the measured input 1 dB compression point at 2.4 GHz is -3.4 dBm.

3.2 Performance Overview

Device: BFP650
Application: High Linearity LNA for 2.4 GHz WLAN Application
PCB Marking: BFP740 SOT343, 740-080704 Rev A

Table 1 Summary of Measurement Results

Parameter	Symbol	Value		Unit	Note/Test Condition
DC Voltage	Vcc	3.0		V	
DC Current	Icc	14.2		mA	
Frequency Range	Freq	2400	2500	MHz	
Gain	G	12.1	11.7	dB	
Noise Figure	NF	0.92	0.97	dB	SMA and PCB losses (~0.08 dB) are subtracted
Input Return Loss	RLin	11.9	12.1	dB	
Output Return Loss	RLout	12.0	10.8	dB	
Reverse Isolation	IRev	17.2	16.9	dB	
Input P1dB	IP1dB	-3.4	-3.2	dBm	
Output P1dB	OP1dB	7.7	7.5	dBm	
Input IP3	IIP3	8.8		dBm	
Output IP3	OIP3	20.9		dBm	f=2400 MHz, Δf=1 MHz, Pin= -25 dBm
Stability	k	>1		--	Stability measured from 10 MHz to 15 GHz

3.3 Schematics and Bill-of-Materials

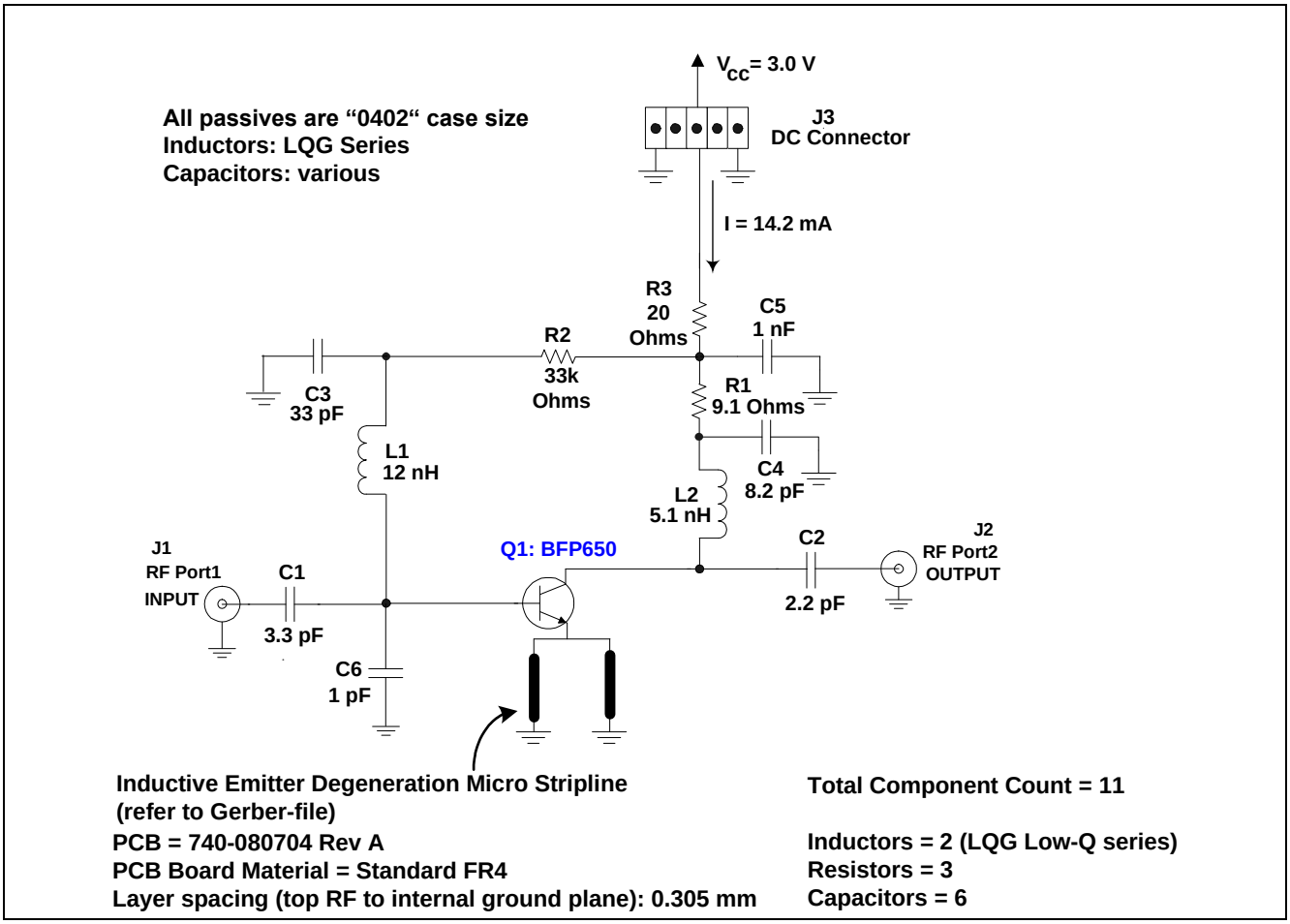

Figure 3 Schematic Diagram of the Application Circuit

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	3.3	pF	0402	Various	DC block & input matching
C2	2.2	pF	0402	Various	DC block & output matching
C3	33	pF	0402	Various	RF decoupling
C4	8.2	pF	0402	Various	Output matching
C5	1.0	nF	0402	Various	RF decoupling
C6	1.0	pF	0402	Various	Input matching
L1	12	nH	0402	LQG series	input matching and bias to the Base
L2	5.1	nH	0402	LQG series	Output matching and bias to the Collector
R1	9.1	Ω	0402	Various	Inband stability improvement
R2	33	kΩ	0402	Various	Base biasing
R3	20	Ω	0402	Various	DC biasing (provides DC negative

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
					feedback to stabilize DC operating point over temperature variation, transistor h_{FE} variation, etc.)
Q1			SOT343	Infineon Technologies	BFP650 low-cost SiGe:C RF transistor

4 Measurement Graphs

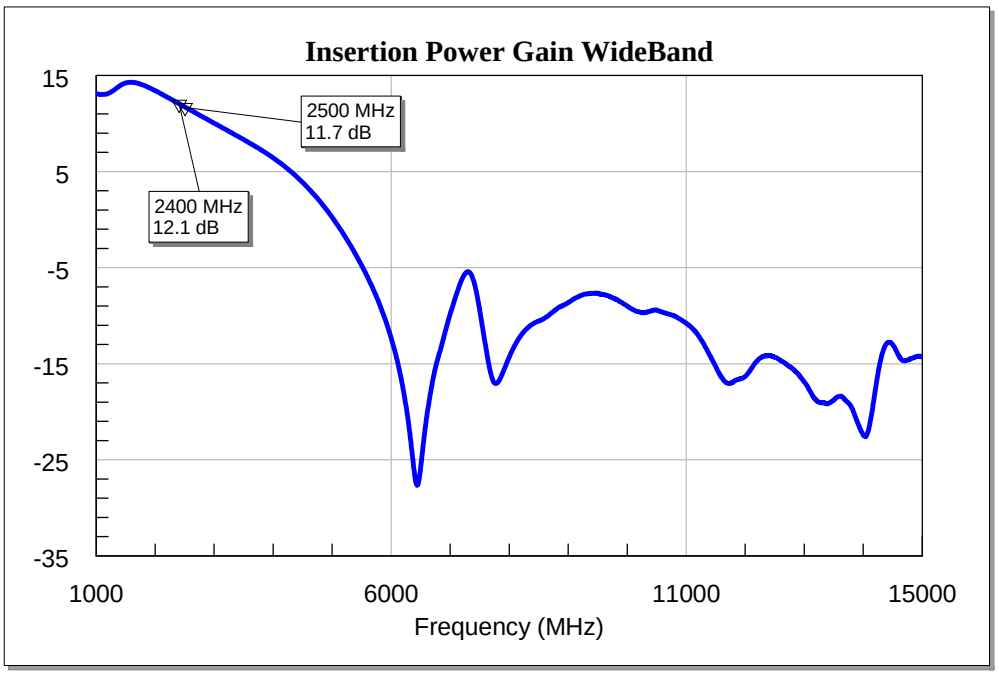

Figure 4 Insertion Power Gain Wideband of the 2400-2500 MHz WLAN LNA with BFP650

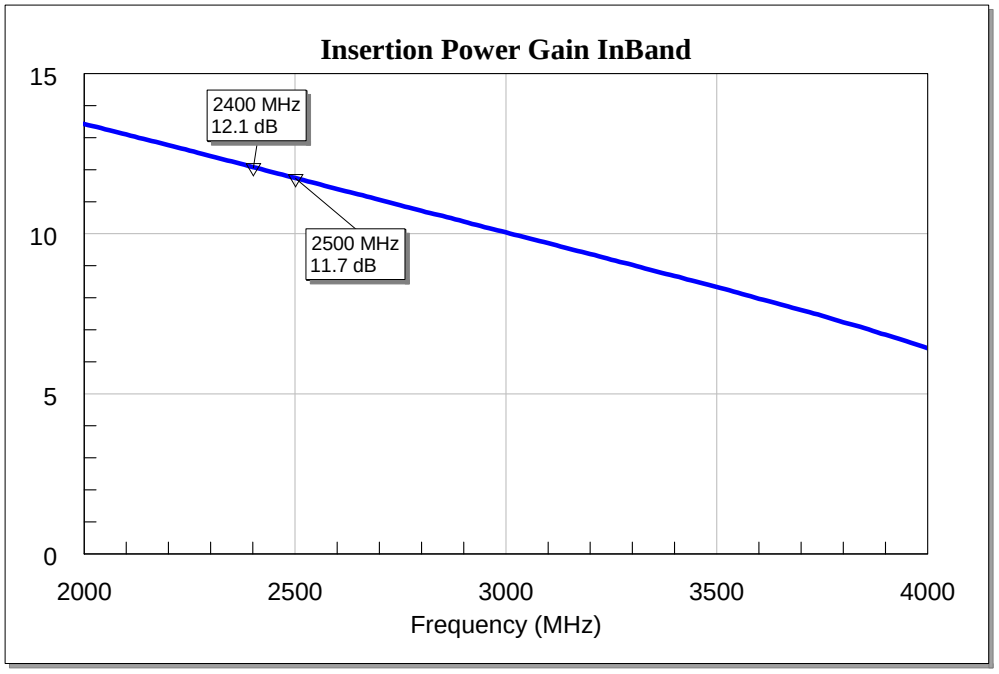

Figure 5 Insertion Power Gain Inband of the 2400-2500 MHz WLAN LNA with BFP650

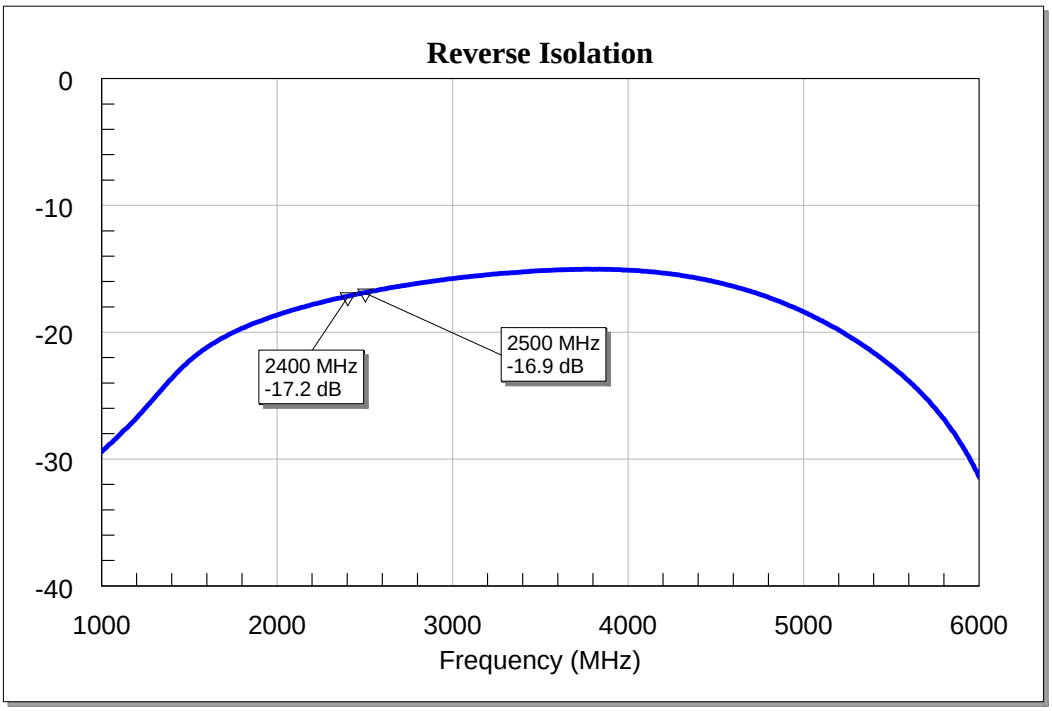

Figure 6 Reverse Isolation of the 2400-2500 MHz WLAN LNA with BFP650

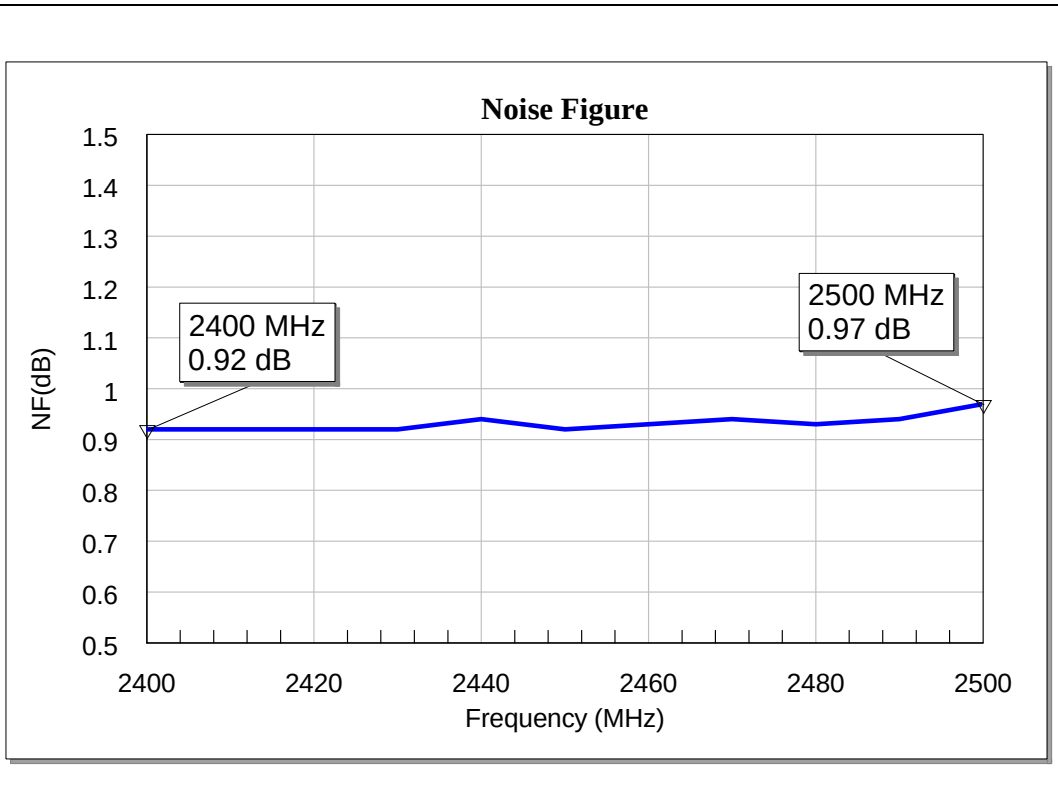

Figure 7 Noise figure of the 2400-2500 MHz WLAN LNA with BFP650

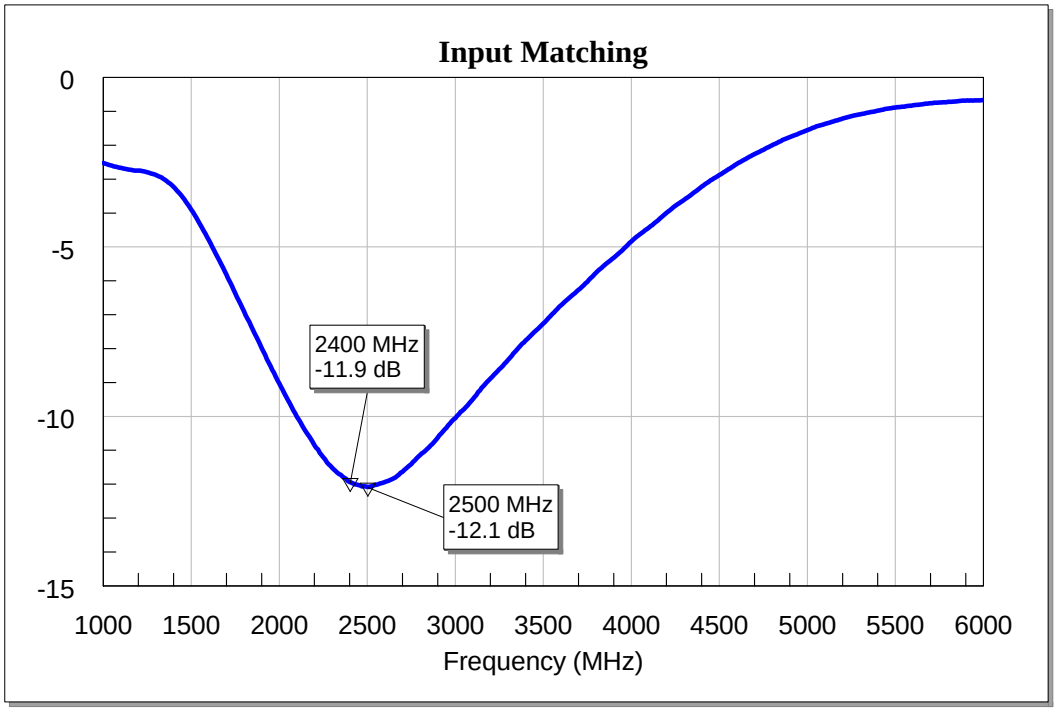

Figure 8 Input Matching of the 2400-2500 MHz WLAN LNA with BFP650

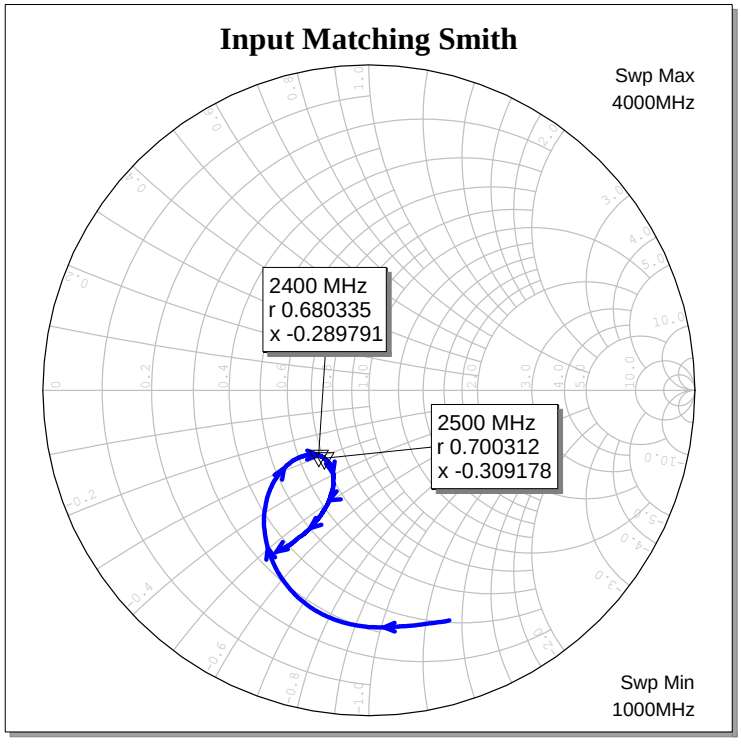

Figure 9 Input Matching of the 2400-2500 MHz WLAN LNA with BFP650 (Smith Chart)

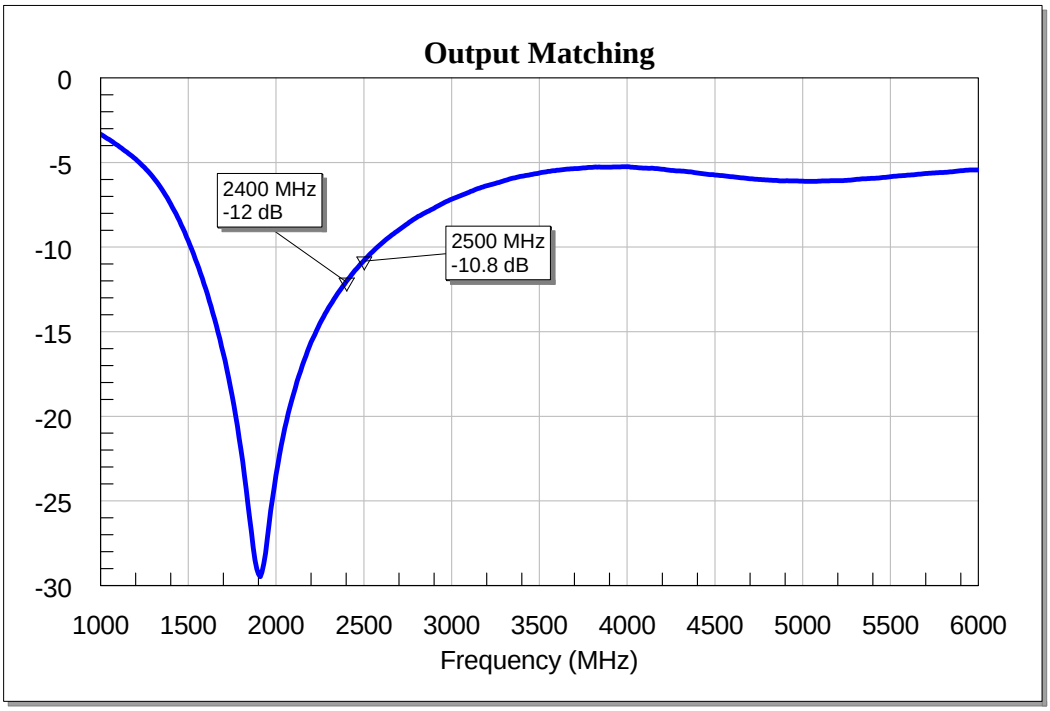

Figure 10 Output Matching of the 2400-2500 MHz WLAN LNA with BFP650

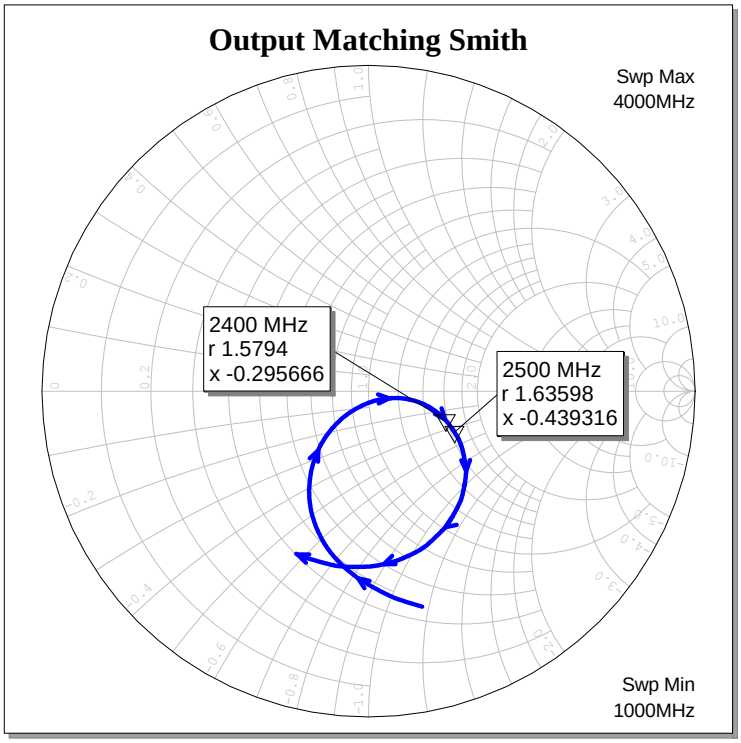

Figure 11 Output Matching of the 2400-2500 MHz WLAN LNA with BFP650 (Smith Chart)

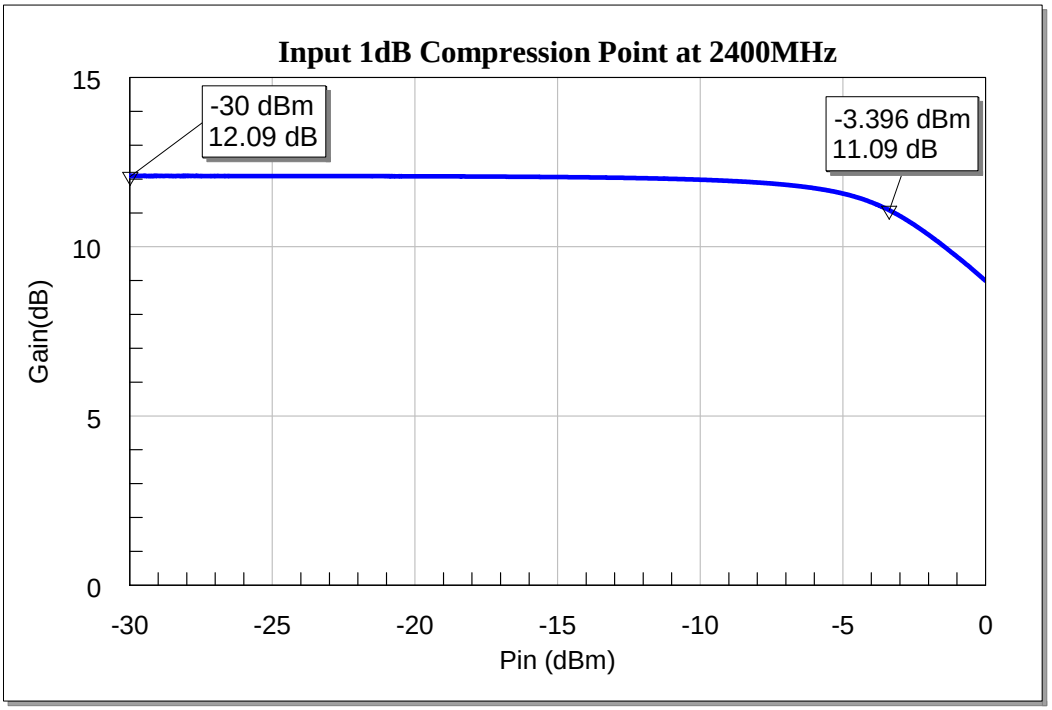

Figure 12 Input 1dB compression point of the BFP650 LNA at 2400 MHz

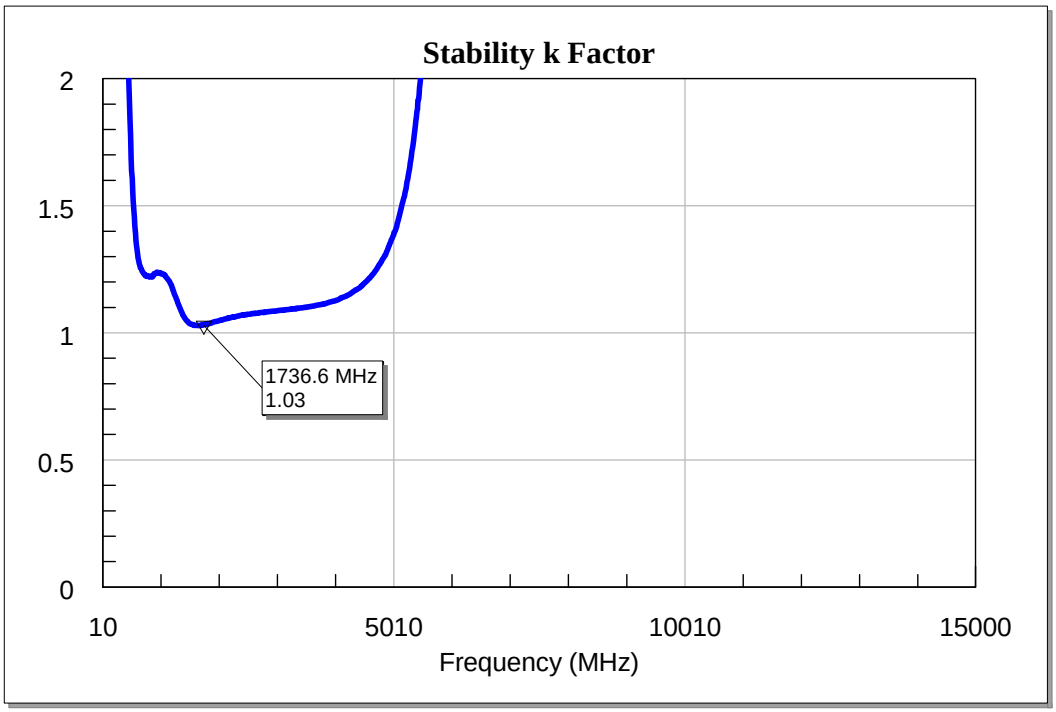

Figure 13 Wideband Stability K Factor of the 2400-2500 MHz WLAN LNA with BFP650

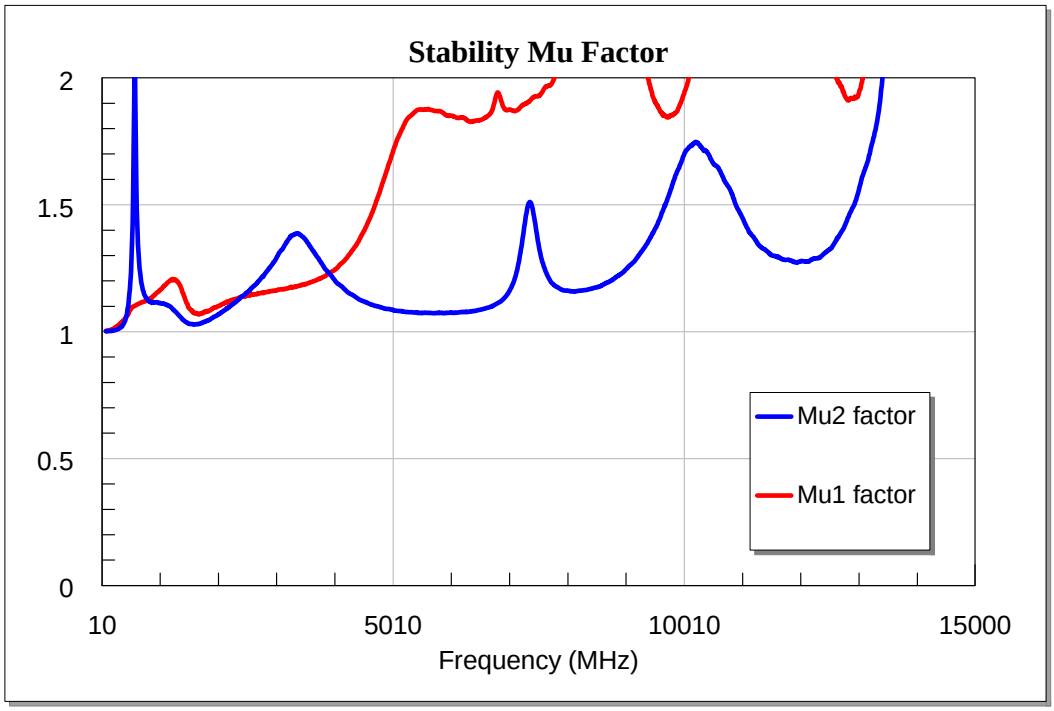

Figure 14 Wideband Stability Mu Factor of the 2400-2500 MHz WLAN LNA with BFP650

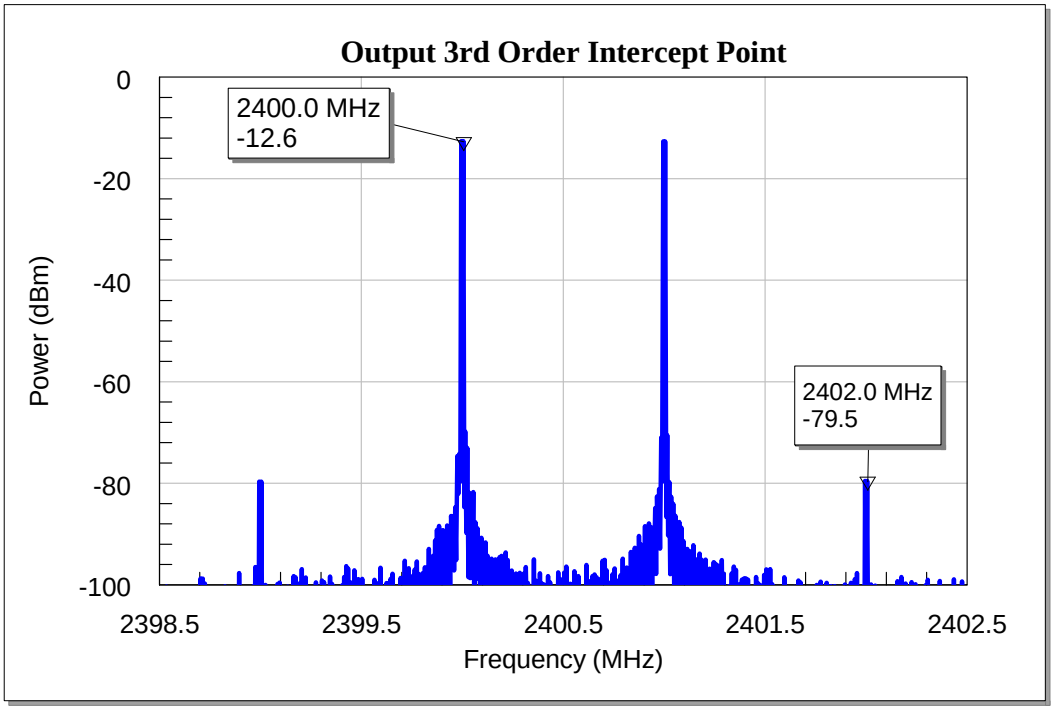

Figure 15 Output 3rd Order Intercept Point of BFP650 LNA at 2400 MHz

5 Evaluation Board and Layout Information

Figure 16 Photo of the BFP650 2400-2500 MHz LNA Evaluation Board

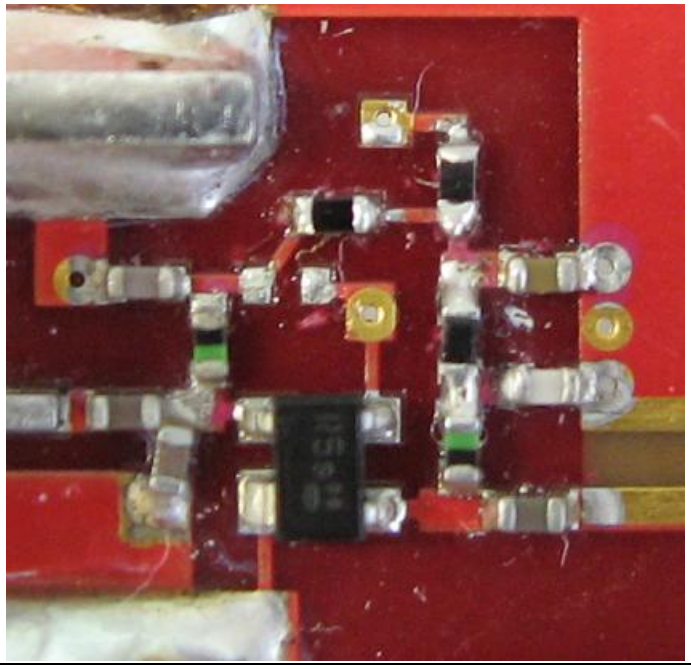

Figure 17 Zoom-in Pictutre of the BFP650 2400-2500 MHz LNA Evaluation Board

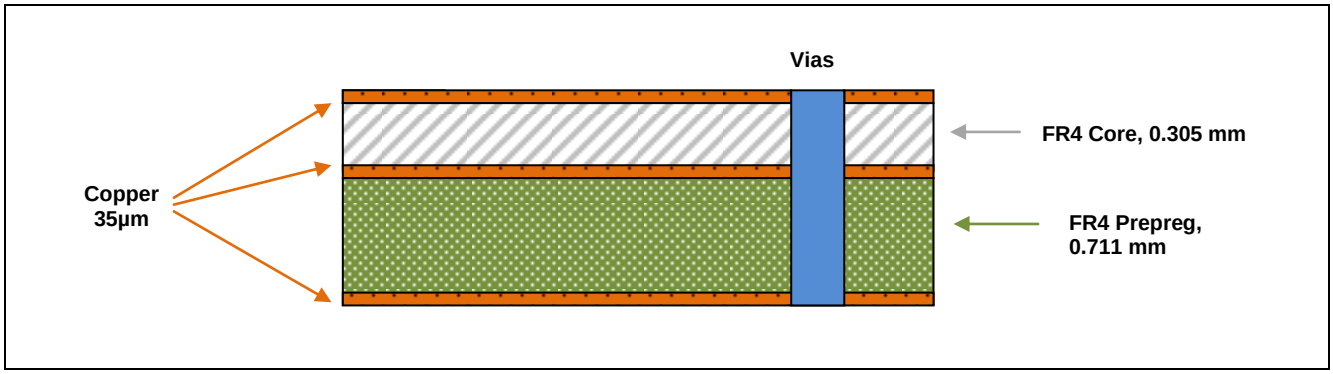

Figure 18 PCB Layer Information

6 Authors

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7 Remark

The graphs are generated with the simulation program AWR Microwave Office®.

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