BFP843F

SiGe:C Ultra Low Noise RF Transistor in Dual-Band 2.4 - 2.5 GHz & 5 - 6 GHz WLAN Application

(For 802.11a / b / g / n / ac Wireless LAN Applications)

Application Note AN315

Revision: Rev. 1.0
2014-04-01

RF and Protection Devices

Edition 2014-04-01

Published by
Infineon Technologies AG
81726 Munich, Germany

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Application Note AN315	
Revision History: 2014-04-01	
Previous Revision: No previous revision	
Page	Subjects (major changes since last revision)

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1 Introduction

1.1 About Wi-Fi® /Wireless LAN (WLAN)

The Wi-Fi® function is one of the most important connectivity functions in notebooks, smart phones and tablet PCs. Wi-Fi is a registered trademark made of the Wi-Fi Alliance created to certify devices for wireless LAN (WLAN) applications based on the IEEE 802.11 standard. The WLAN standard has evolved over the years from its legacy systems known as 802.11-1997, through 802.11a, b, g, and n, to the newest 802.11ac. Today the trend is rapidly changing where Wi-Fi is not only used for high data rate access to internet but also for content consumption such as streaming music and High Definition video on TVs, smart phones, tablets, game consoles etc.

With the requirements on wireless data quality becoming more stringent than ever, the new Wireless LAN standards are being developed by using higher order modulation schemes, wider channels and multiple data streams.

Wi-Fi according to IEEE802.11b/g/n at 2.4 GHz widely implemented over years suffers from interference from other devices such as cordless phones, microwave ovens, Bluetooth devices etc. in the 2.4 GHz space. 802.11a/n operating at 5 GHz has less interference and can transmit data at greater speeds (54 Mbps) but at the cost of reduced range. 802.11n provides enhanced performance and range over prior 802.11 technologies by operating in both the 2.4 GHz and 5 GHz. It adds two significant technologies: MIMO (Multiple input-Multiple output) and 40 MHz channels. With this, data rates up to 600Mbps (for 4 streams) can be achieved in the 5 GHz band. To cater to these high throughput requirements, major performance criteria have to be fulfilled: sensitivity, strong signal capability and interference immunity.

The **Figure 1** shows one example of general block diagram of a dual band WLAN system.

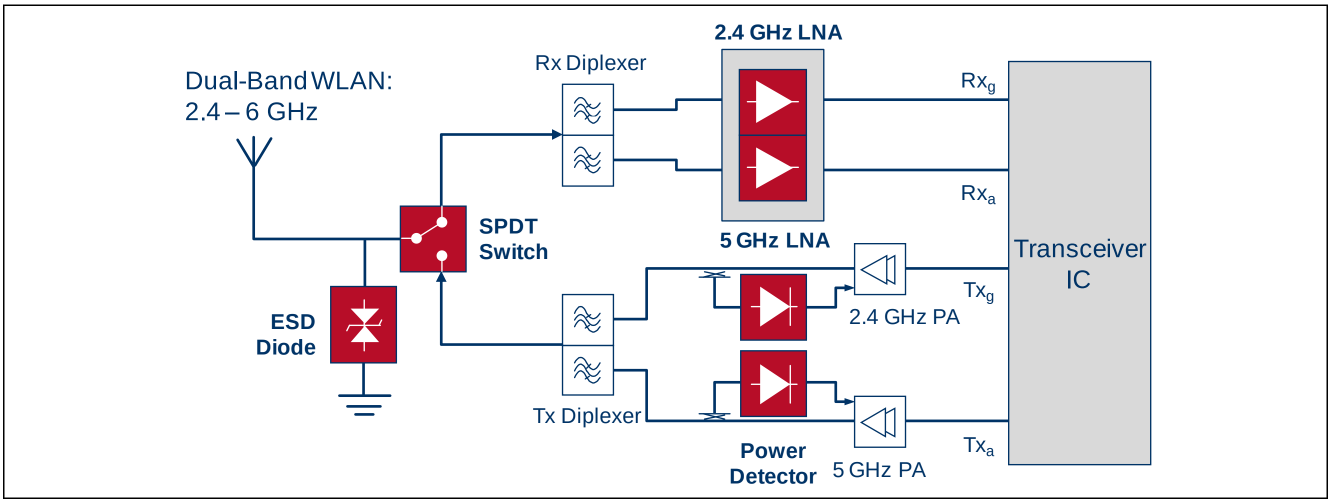

Figure 1 Dual-Band Wi-Fi® Wireless LAN at 2.4 - 2.5 GHz and 5 - 6 GHz

A Wi-Fi router has 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. We can improve the sensitivity of the receiver by using a low noise amplifier (LNA) as a first block of the receiver front end to improve the signal-to-noise ratio (SNR) of the overall system. As an example, an increase in the sensitivity by 5 dB corresponds to nearly double link distance.

WLAN systems are subject to co-channel interference and also interference from strong co-existing cellular signals. High linearity characteristics such as 3rd-order intercept point (IP3) and 1dB compression point (P1dB) are required to improve an application's ability to distinguish between desired signals and spurious signals received close together. This avoids saturation, degradation of the gain and increased noise figure.

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 BFP843F Overview

2.1 Features

- Low noise broadband NPN RF transistor based on Infineon´s reliable, high volume SiGe:C bipolar technology
- High maximum RF input power and ESD robustness
- Unique combination of high RF performance, robustness and ease of use
- Low noise figure: NF_{min} = 0.95 dB at 2.4 GHz and 1.1 dB at 5.5 GHz, 1.8 V, 8 mA
- High gain $|S21|^2$ = 21.5 dB at 2.4 GHz and 16.5 dB at 5.5 GHz, 1.8 V, 15 mA
- *OIP*3 = 22 dBm at 2.4 GHz and 20 dBm at 5.5 GHz, 1.8 V, 15 mA
- Ideal for low voltage applications e.g. V_{CC} = 1.2 V and 1.8 V (2.85 V, 3.3 V, 3.6 V requires corresponding collector resistor)
- Low power consumption, ideal for mobile applications
- Thin small flat Pb-free (RoHS compliant) and halogen-free package
- Qualification report according to AEC-Q101 available

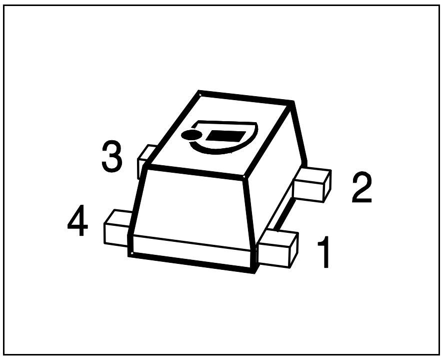

Figure 2 BFP843F in TSFP-4-1

2.2 Key Applications of BFP843F

As Low Noise Amplifier (LNA) in:

- Wireless Communications: 2.4 GHz Wireless LAN IEEE802.11b/g/n, 5 - 6 GHz Wireless LAN IEEE802.11a/n/ac, WiMAX
- Satellite navigation systems (e.g. GPS, GLONASS, COMPASS...) and satellite C-band LNB (1st and 2nd stage LNA)
- Broadband amplifiers: Dualband WLAN, multiband mobile phone, UWB up to 10 GHz
- ISM bands up to 10 GHz

Product Name	Package	Pin Configuration				Marking
BFP843F	TSFP-4-1	1 = B	2 = E	3 = C	4 = E	T2s

3 BFP843F as Dual-Band LNA for 2.4 - 2.5 GHz and 5.0 - 6.0 GHz Wireless LAN Applications

3.1 Description

BFP843F is a discrete SiGe:C hetero-junction bipolar transistor (HBT) specifically designed for high performance dual band 2 GHz - 6 GHz band low noise amplifier (LNA) solutions for Wi-Fi connectivity applications. This has been developed using Infineon's latest B9HFM technology. The key features of this technology are very high transition frequency (f_T = 80 GHz) and low parasitics, which enable to achieve higher gain and lower noise figure compared to the previous generation RF transistor BFP740FED. BFP843F features an integrated on-chip R-C feedback network. The negative feedback reduces the effects of performance variations of the amplifier. The design is therefore less sensitive to variations in PCB layout resulting in an amplifier with broader bandwidth, easier impedance matching and improved stability margin. However the price paid for using negative feedback is slight degradation of noise figure and decrease in gain.

The BFP843F is housed in flatlead TSFP-4-1 package. Other variants of this family are also available in other packages, e.g. BFP843 in the SOT343 package and BFR843EL3 in the leadless TSLP-3-9 package. **Figure 3** shows the pin assignment of package of BFP843F in the top view:

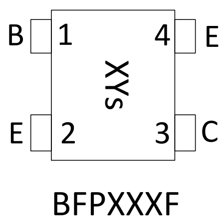

Figure 3 **Package and pin connections of BFP843F in Topview**

The BFP843F has an integrated 1.5 kV HBM ESD protection which makes the device robust against electrostatic discharge and extreme RF input power. The device offers its high performance at low current and voltage and is especially well-suited for portable battery powered applications in which energy efficiency is a key requirement.

In the 2.4 GHz to 2.5 GHz frequeny band, this circuit achieves noise figure of 1.1 dB. The gain ranges from 19.9 dB to 19.7 dB. The input return loss and output return loss is above 10 dB. At 2450MHz, the Input 1dB compression point (IP1dB) reaches -13.4 dBm. The input 3rd-order intercept point (IIP3) reaches -3.5 dBm.

As to the 5.0 GHz to 6.0 GHz frequeny band, this circuit achieves noise figure of 1.3 dB. The gain ranges from 16.4 dB to 15.5 dB. The input return loss and output return loss is above 10 dB. At 5500MHz, the input 1dB compression point (IP1dB) reaches -10.2 dBm. The input 3rd-order intercept point (IIP3) reaches -0.6 dBm.

4 Application Circuit and Performance Overview

Device: BFP843F

Application: Dual-Band LNA for 2.4 GHz & 5 GHz WLAN Applications

PCB Marking: **M12051302** BFP840FESD

4.1 Performance Overview

Table 1 Summary of Measurement Results (at room temperature)

Parameter	Symbol	Value					Unit	Note/Test Condition
DC Voltage	V_{CC}	3.0					V	
DC Current	I_{CC}	13.5					mA	
Frequency Range	Freq	2400	2500	5100	5500	5900	MHz	
Gain (On Mode)	G_{ON}	19.9	19.7	16.4	16.0	15.5	dB	
Gain (Off Mode)	G_{OFF}	-21.1	-21.5	-21.0	-21.0	-21.6	dB	
Noise Figure	NF	1.1	1.1	1.3	1.3	1.3	dB	SMA and PCB losses (0.04 dB @ 2.4 GHz, 0.14 dB @ 5 GHz) are subtracted
Input Return Loss	RL_{in}	14.3	14.5	23.3	21.1	16.0	dB	
Output Return Loss	RL_{out}	10.9	10.5	13.0	16.3	21.4	dB	
Reverse Isolation	IRev	27.4	27.5	27.7	27.5	27.3	dB	
Input P1dB (On Mode)	$IP1dB_{ON}$	-13.4[1)]		-	-10.2	-	dBm	[1)] f=2450MHz
Output P1dB (On Mode)	$OP1dB_{ON}$	+5.3[1)]		-	+4.8	-	dBm	[1)] f=2450MHz
Input IP3	IIP3	-3.5[2)]		-	-0.6[3)]	-	dBm	Power @ Input: -25 dBm each tone [2)] f1=2450MHz, f2=2451MHz [3)] f1=5500MHz, f2=5501MHz
Output IP3	OIP3	+16.2[2)]			+15.5[3)]	-	dBm	Power @ Input: -25 dBm each tone [2)] f1=2450MHz, f2=2451MHz [3)] f1=5500MHz, f2=5501MHz
Stability	k	> 1					--	Stability measured from 10 MHz to 15 GHz

4.2 Schematics and Bill-of-Materials

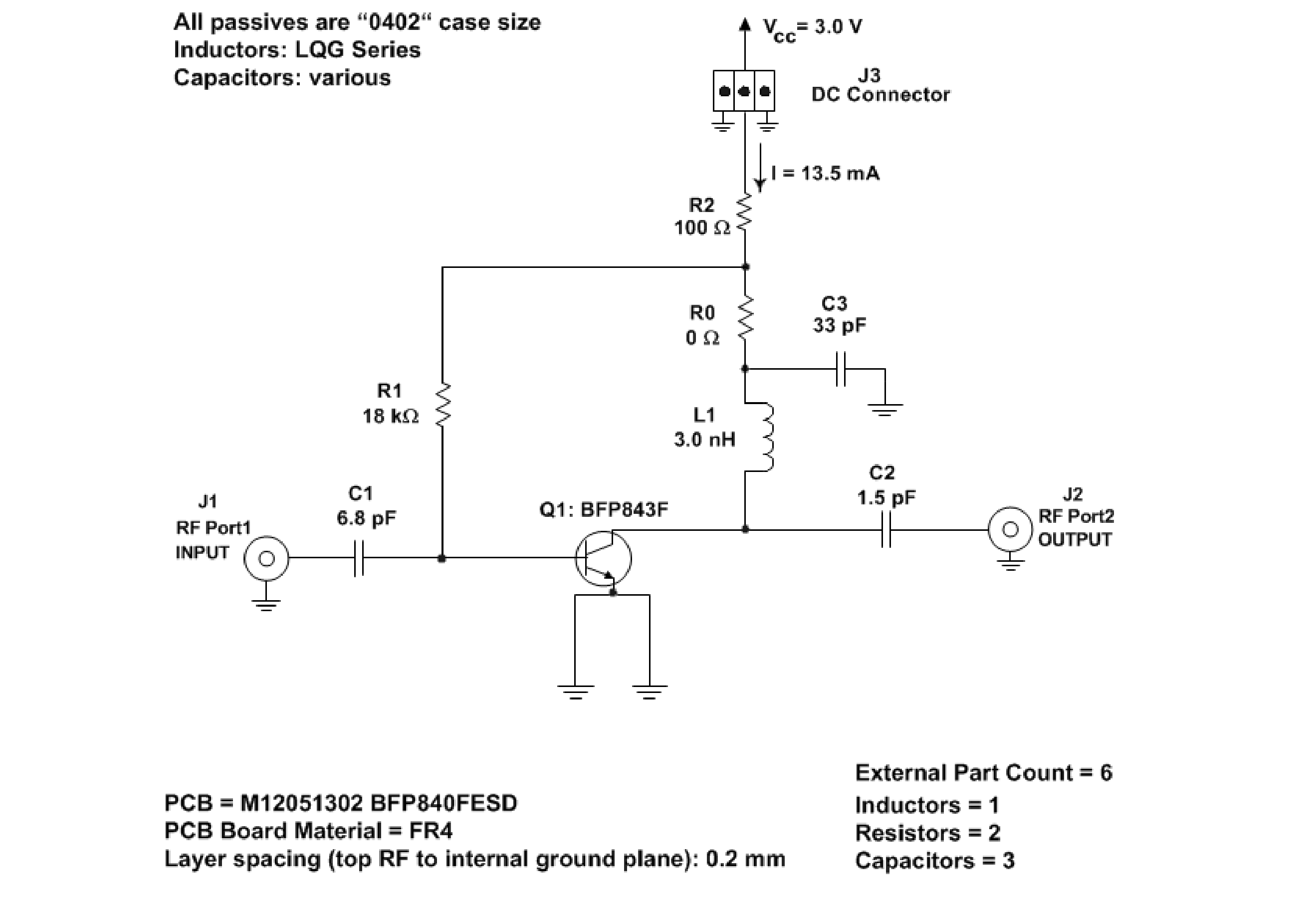

Figure 4 Schematic of the BFP843F Application Circuit

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	6.8	pF	0402	Various	Input matching / DC blocking
C2	1.5	pF	0402	Various	Output matching / DC blocking
C3	33	pF	0402	Various	RF decoupling / blocking cap
L1	3.0	nH	0402	LQG Series	RF decoupling / output matching
R1	18	kΩ	0402	Various	DC biasing for base current
R2	100	Ω	0402	Various	DC biasing, to stabilize the DC current against hfe variation
R0	0	Ω	0402	Various	Jumper
Q1			TSFP-4-1	Infineon Technologies	BFP843F SiGe:C Heterojunction Bipolar RF Transistor

5 Measurement Graphs

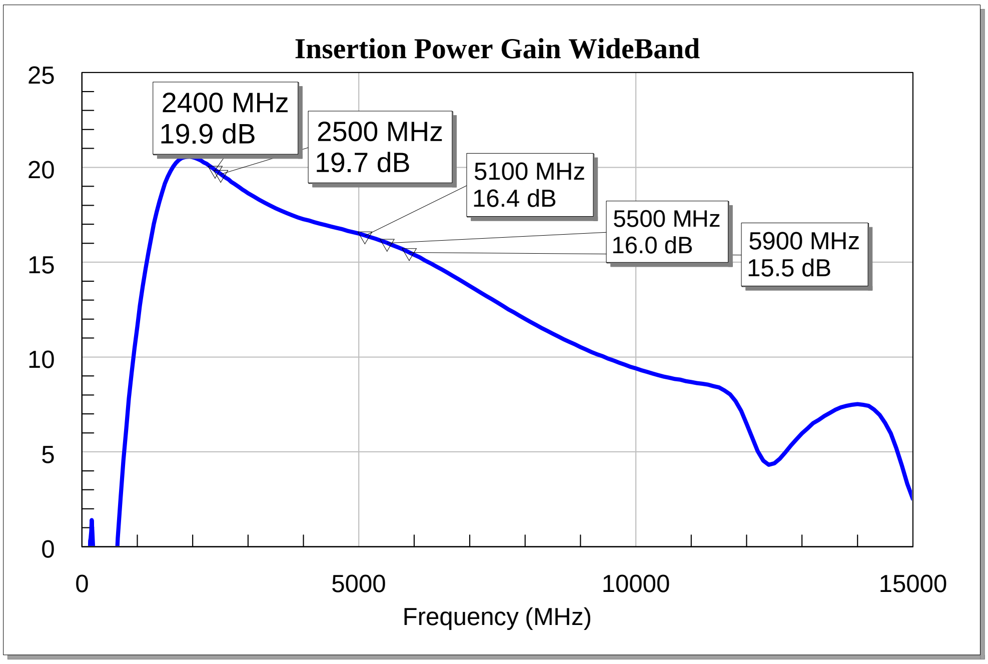

Figure 5 Wideband Insertion Power Gain of the 2.4 - 2.5 GHz & 5 - 6 GHz WLAN LNA with BFP843F

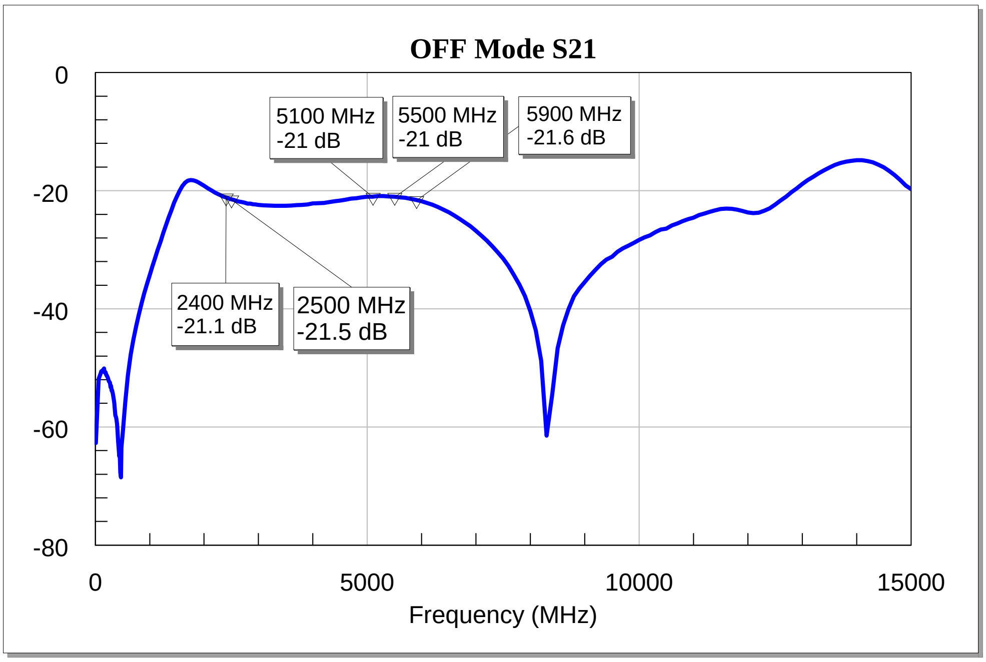

Figure 6 Off-Mode Insertion Power Gain of the 2.4 - 2.5 GHz & 5 - 6 GHz WLAN LNA with BFP843F

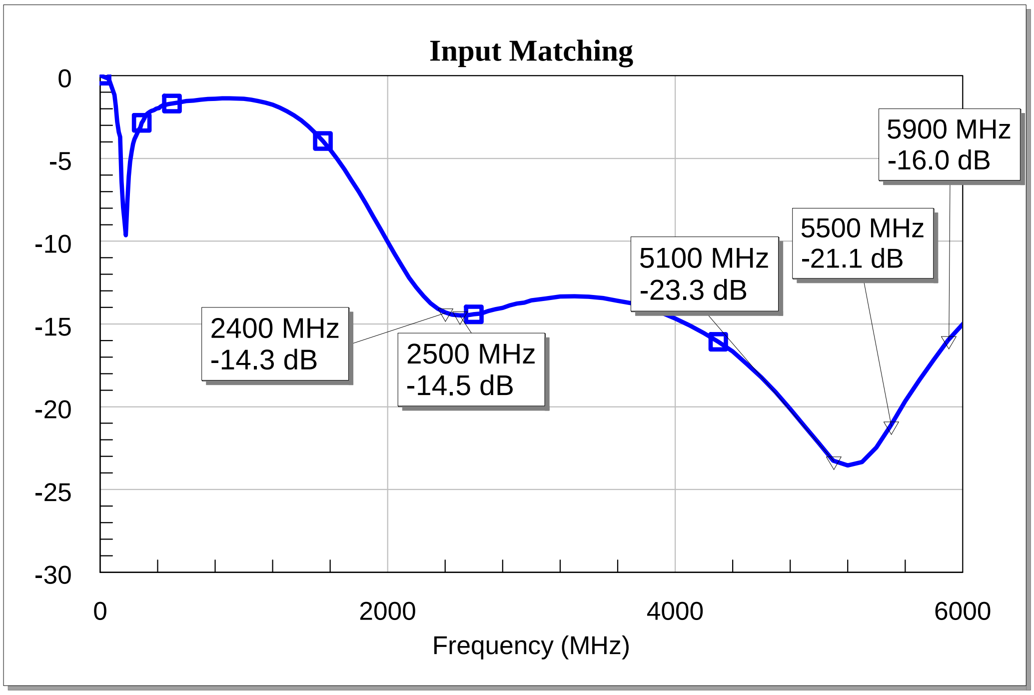

Figure 7 Input Matching of the WLAN LNA with BFP843F at 2.4 – 2.5 GHz

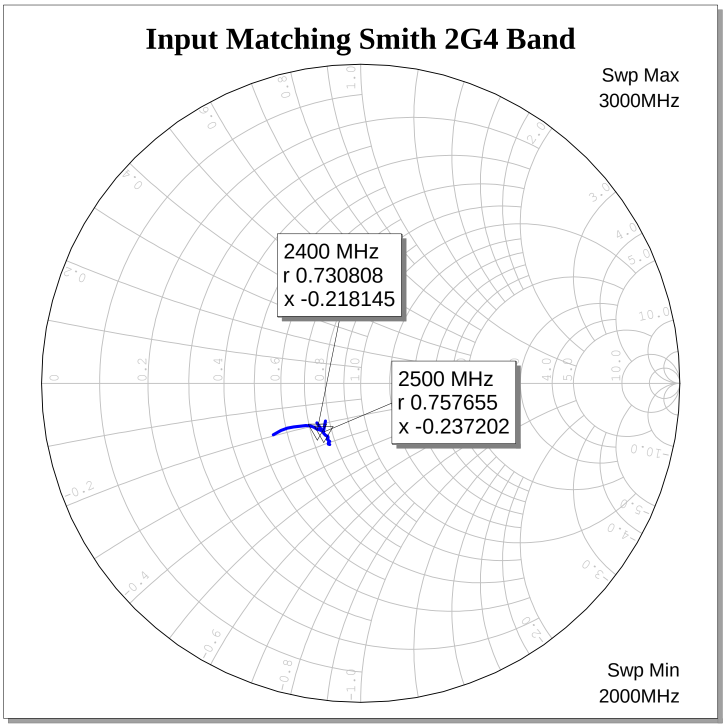

Figure 8 Input Matching at 2.4 – 2.5 GHz (Smith Chart, Port-Deembedded)

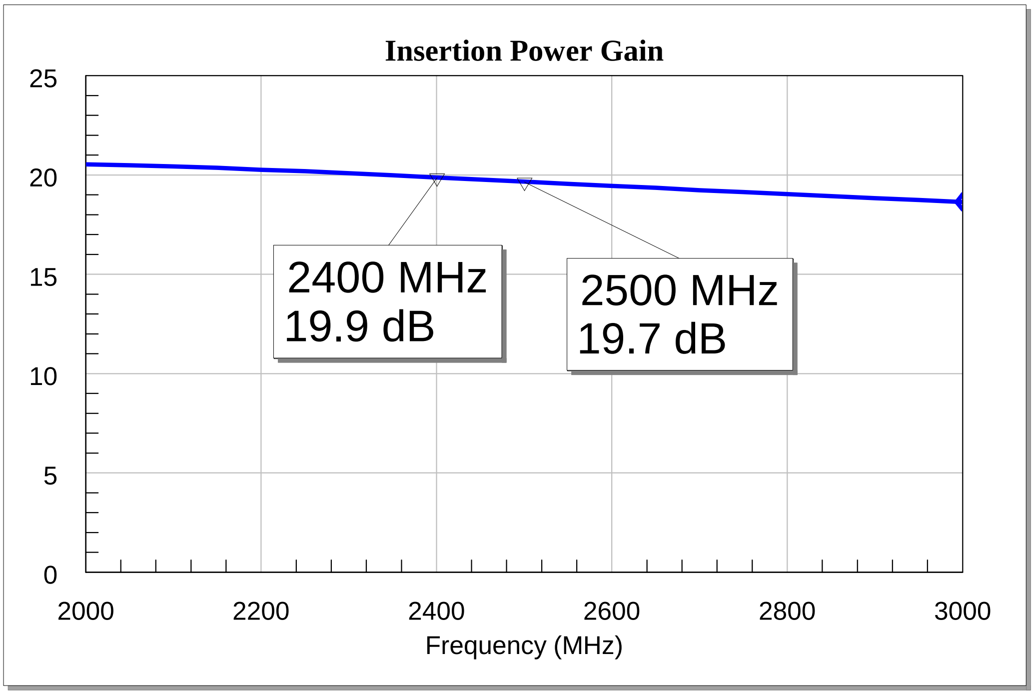

Figure 9 Insertion Power Gain of the WLAN LNA with BFP843F at 2.4 – 2.5 GHz

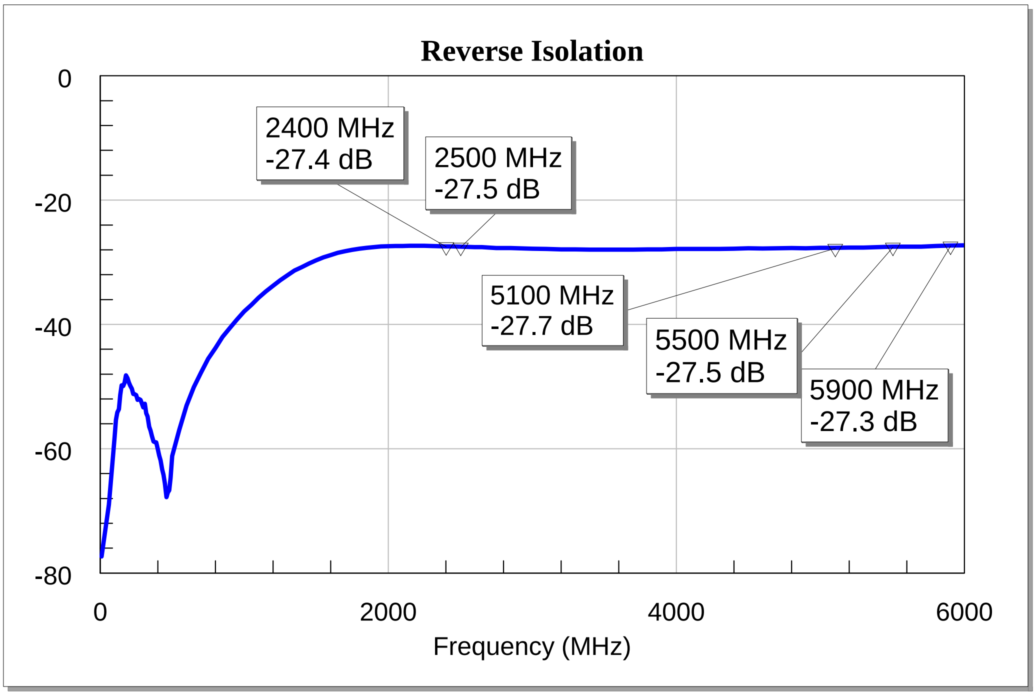

Figure 10 Reverse Isolation of the WLAN LNA with BFP843F at 2.4 – 2.5 GHz

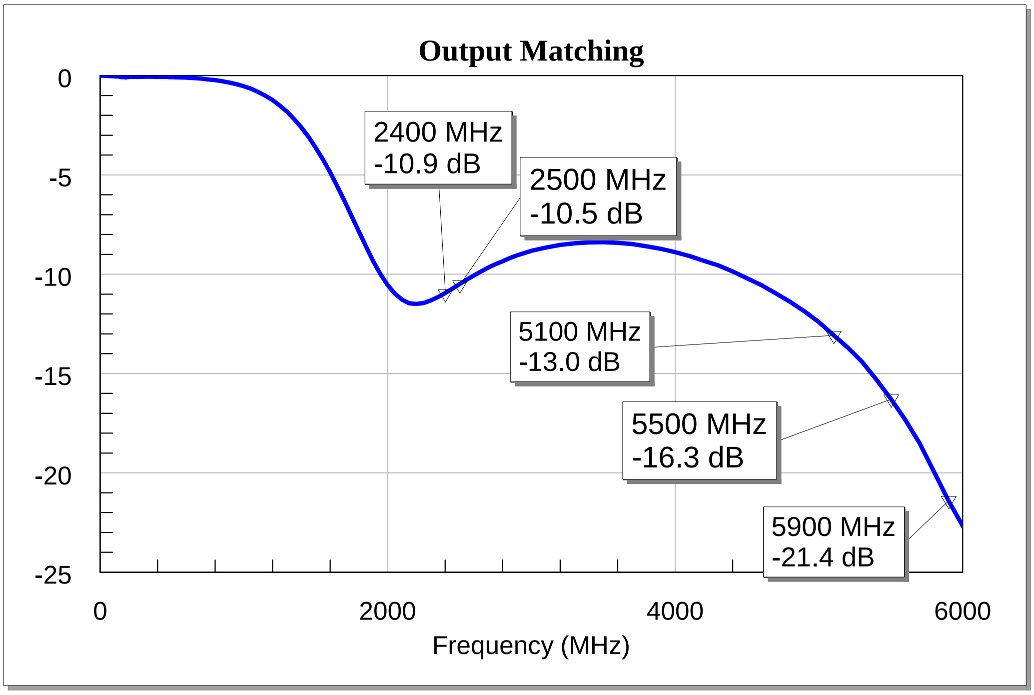

Figure 11 Output Matching of the WLAN LNA with BFP843F at 2.4 – 2.5 GHz

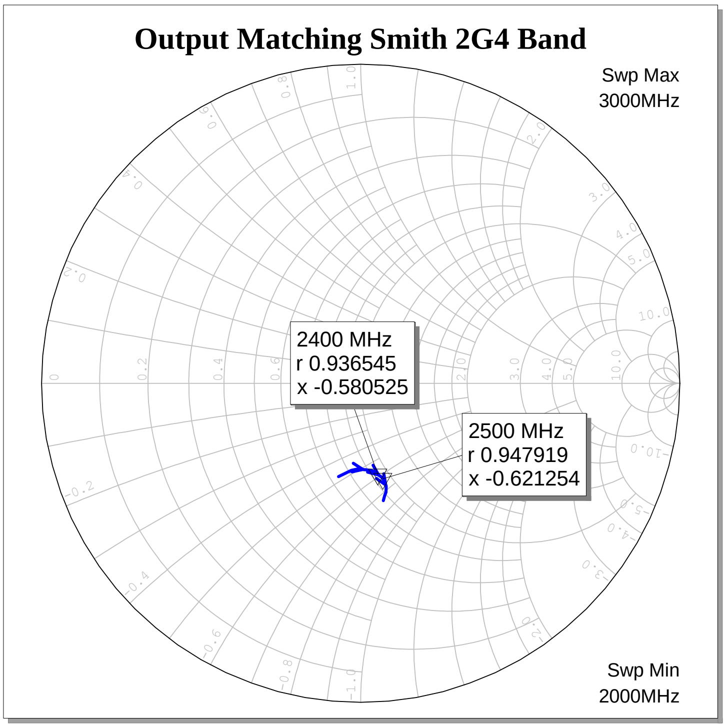

Figure 12 Output Matching at 2.4 – 2.5 GHz (Smith Chart, Port-Deembedded)

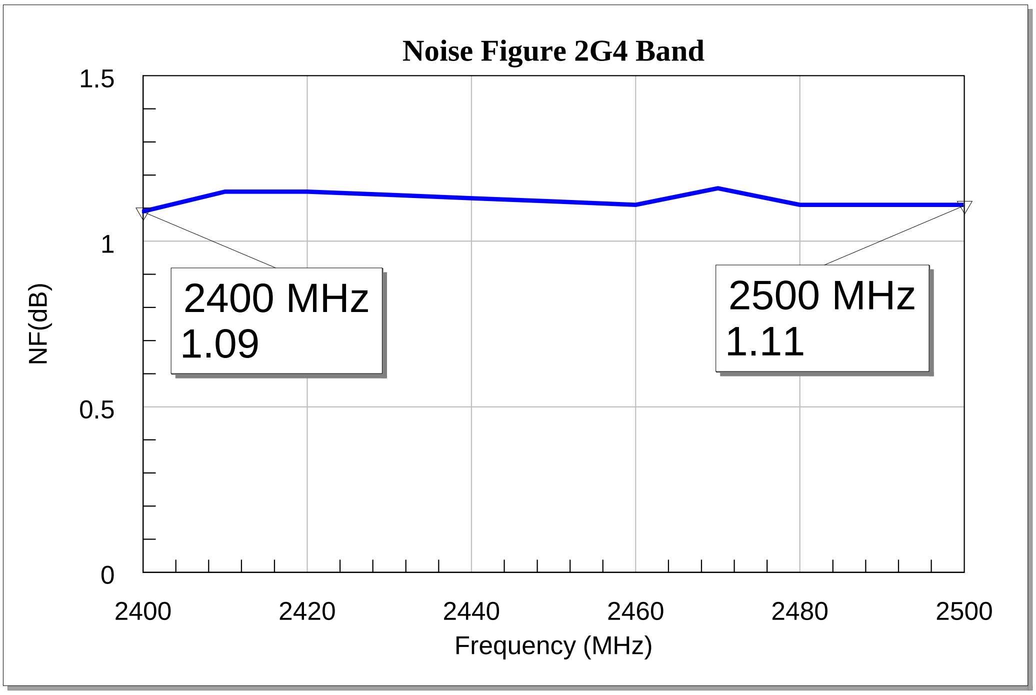

Figure 13 Noise Figure of the WLAN LNA with BFP843F at 2.4 – 2.5 GHz

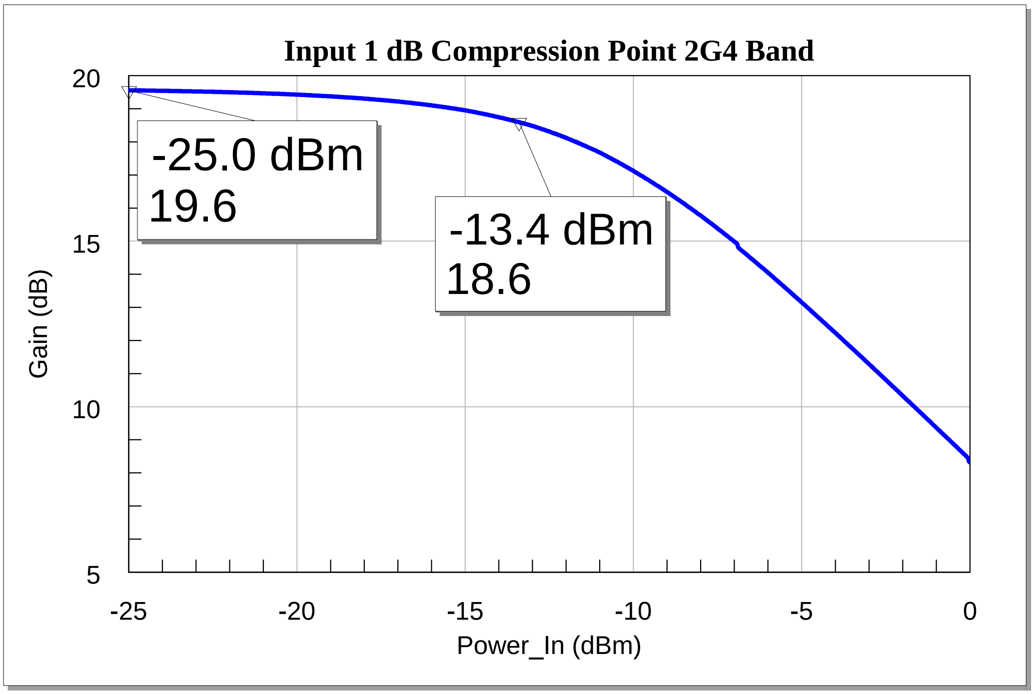

Figure 14 Input 1dB Compression Point (IP1dB) of the WLAN LNA with BFP843F at 2450 MHz

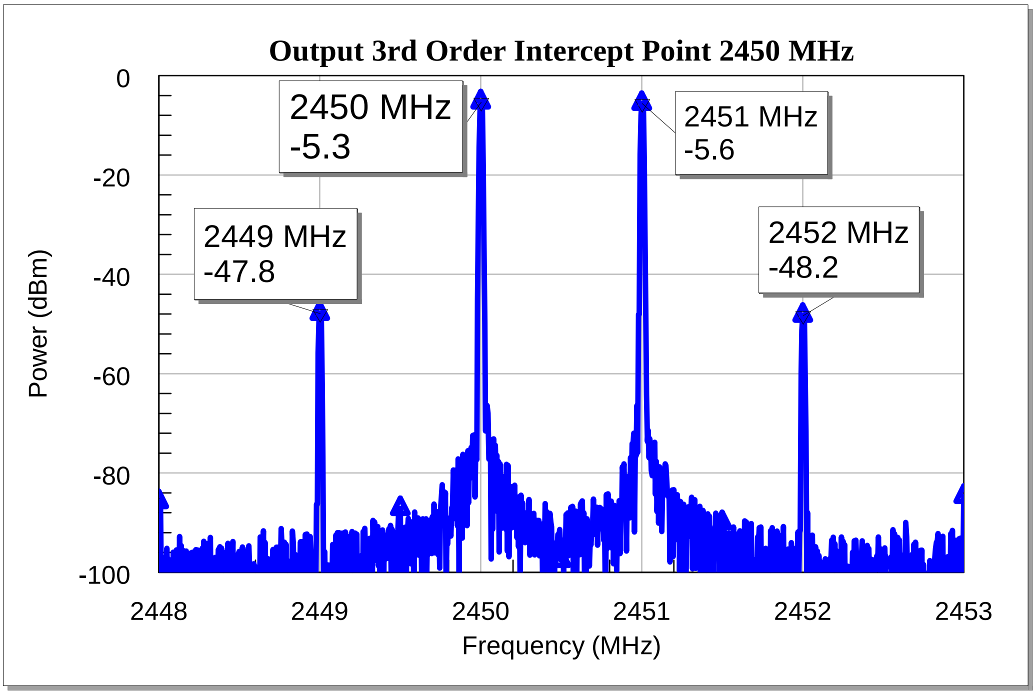

Figure 15 Output Third Order Intercept Point (OIP3) of the WLAN LNA with BFP843F at 2450 MHz

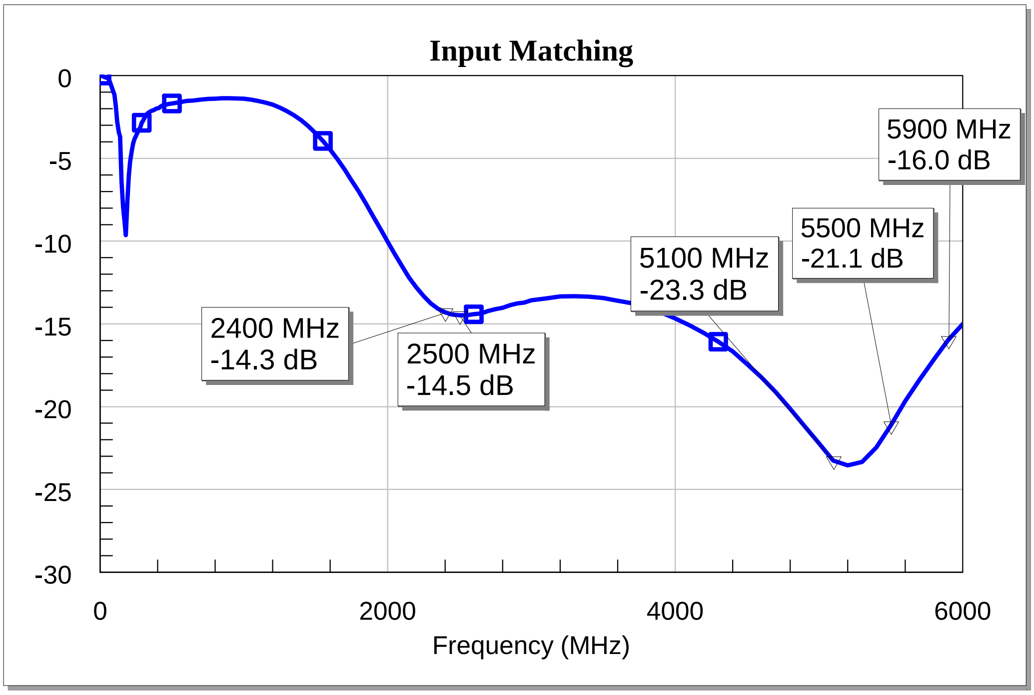

Figure 16 Input Matching of the WLAN LNA with BFP843F at 5 – 6 GHz

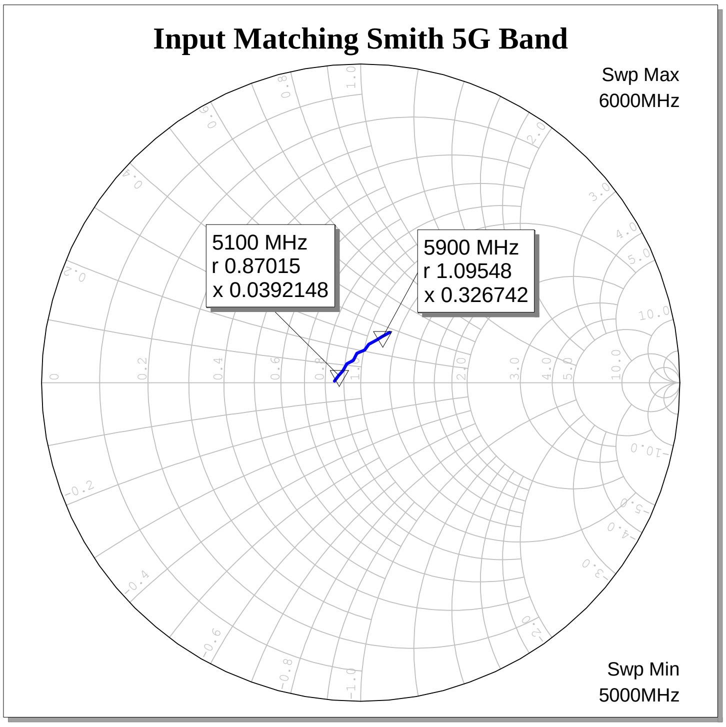

Figure 17 Input Matching at 5 – 6 GHz (Smith Chart, Port-Deembedded)

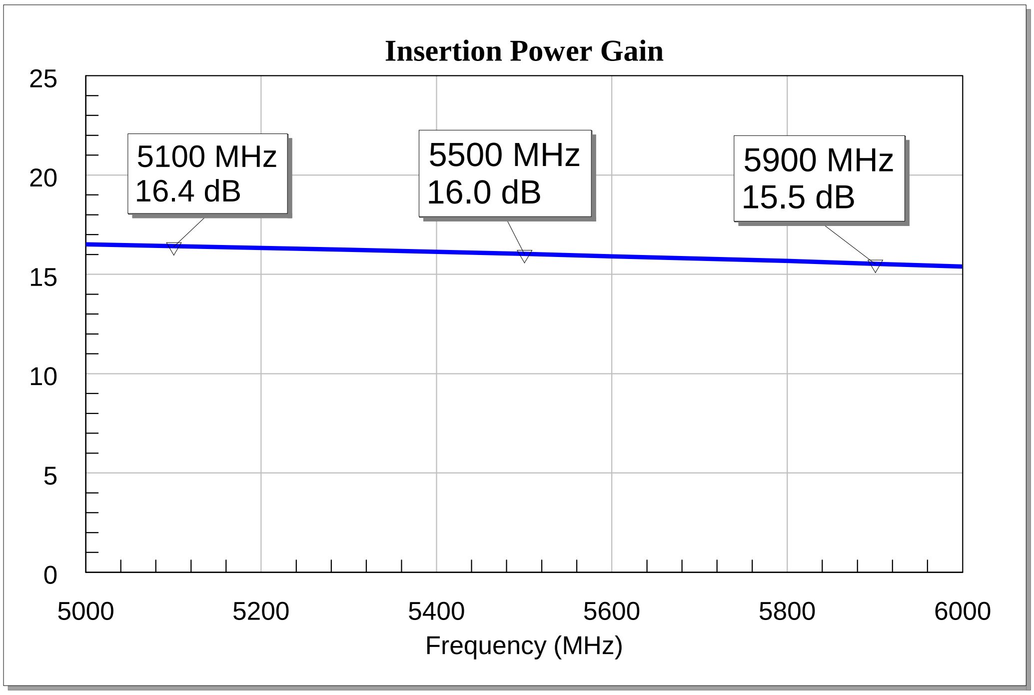

Figure 18 Insertion Power Gain of the WLAN LNA with BFP843F at 5 – 6 GHz

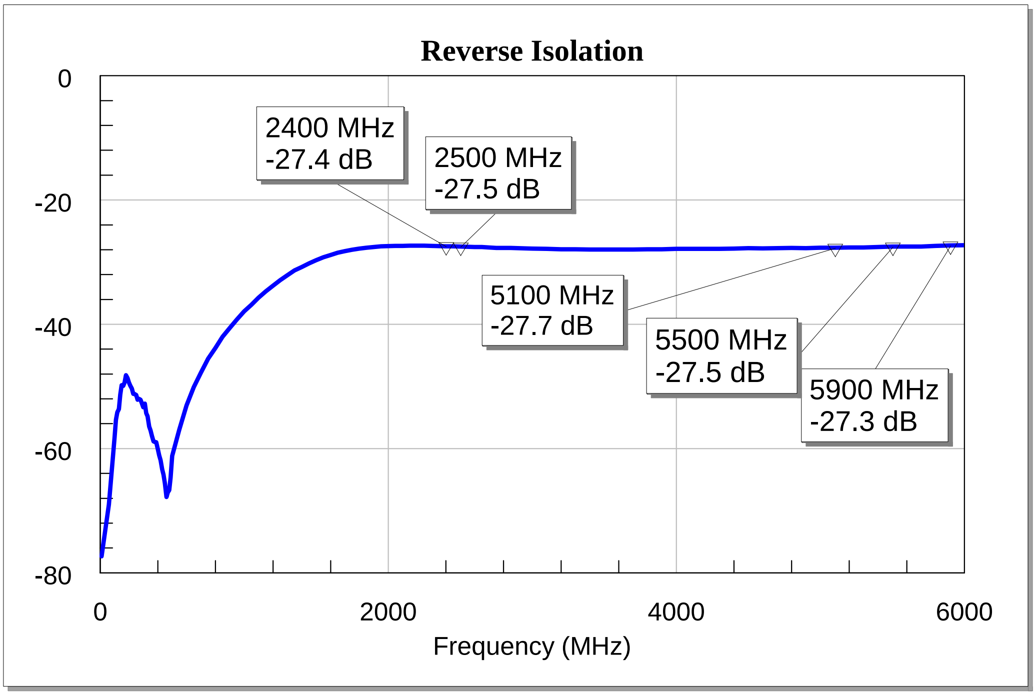

Figure 19 Reverse Isolation of the WLAN LNA with BFP843F at 5 – 6 GHz

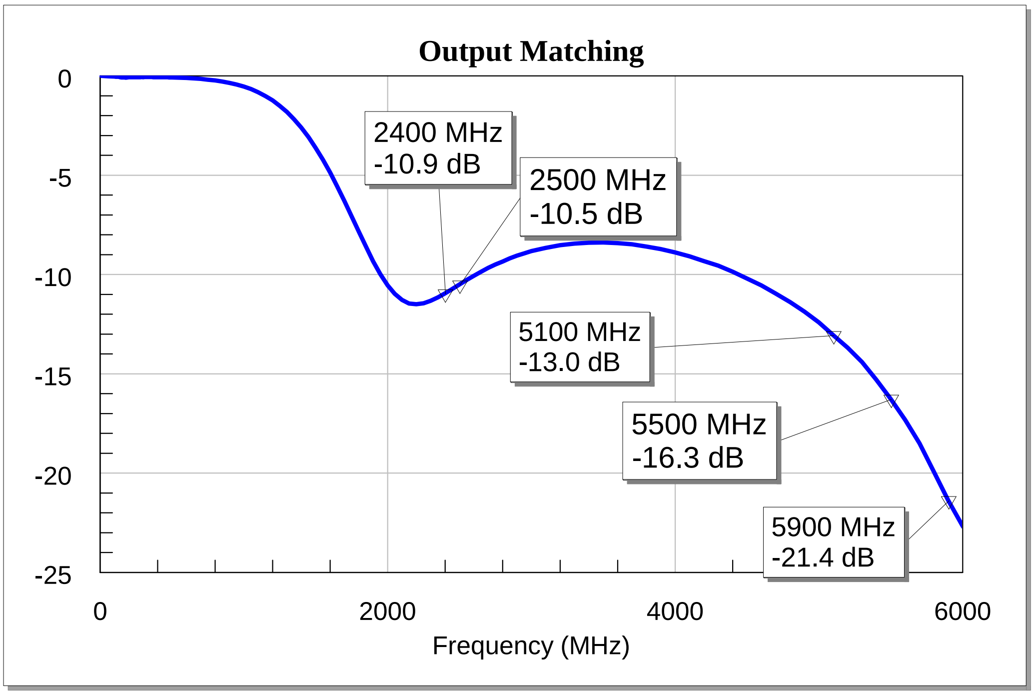

Figure 20 Output Matching of the WLAN LNA with BFP843F at 5 – 6 GHz

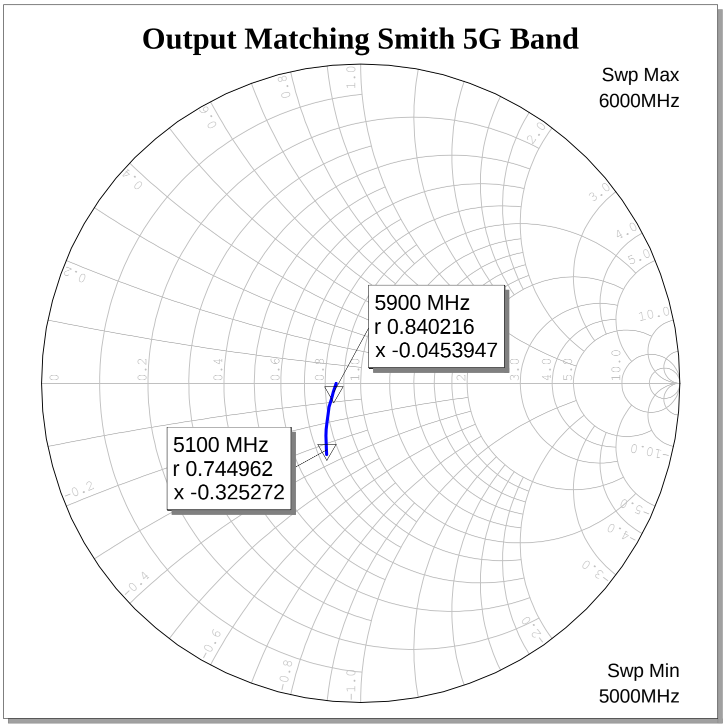

Figure 21 Output Matching at 5 – 6 GHz (Smith Chart, Port-Deembedded)

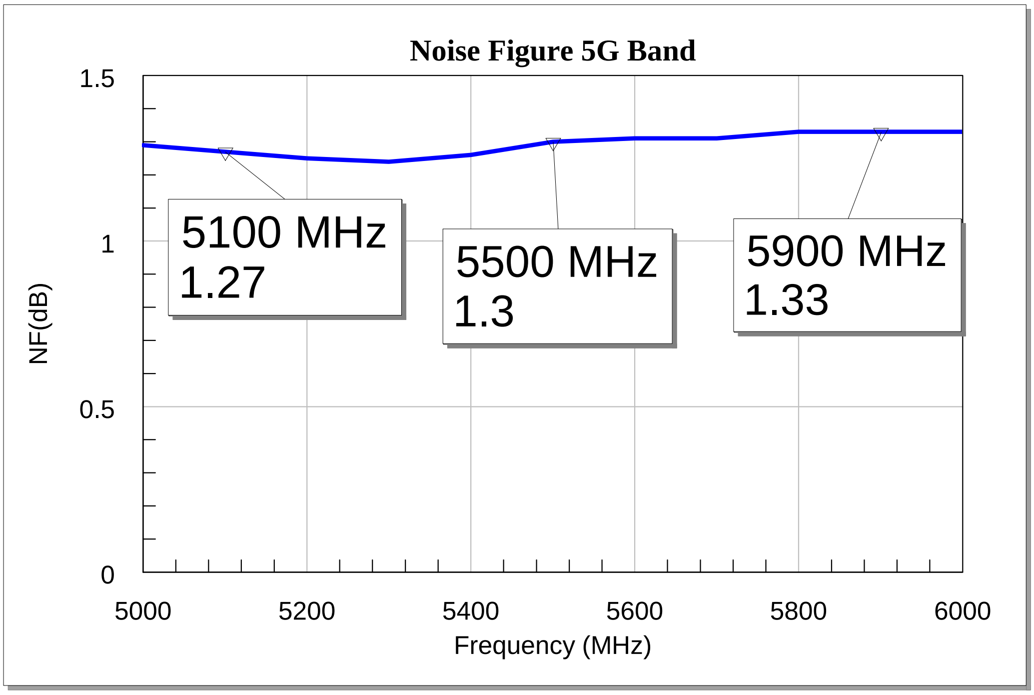

Figure 22 Noise Figure of the WLAN LNA with BFP843F at 5 – 6 GHz

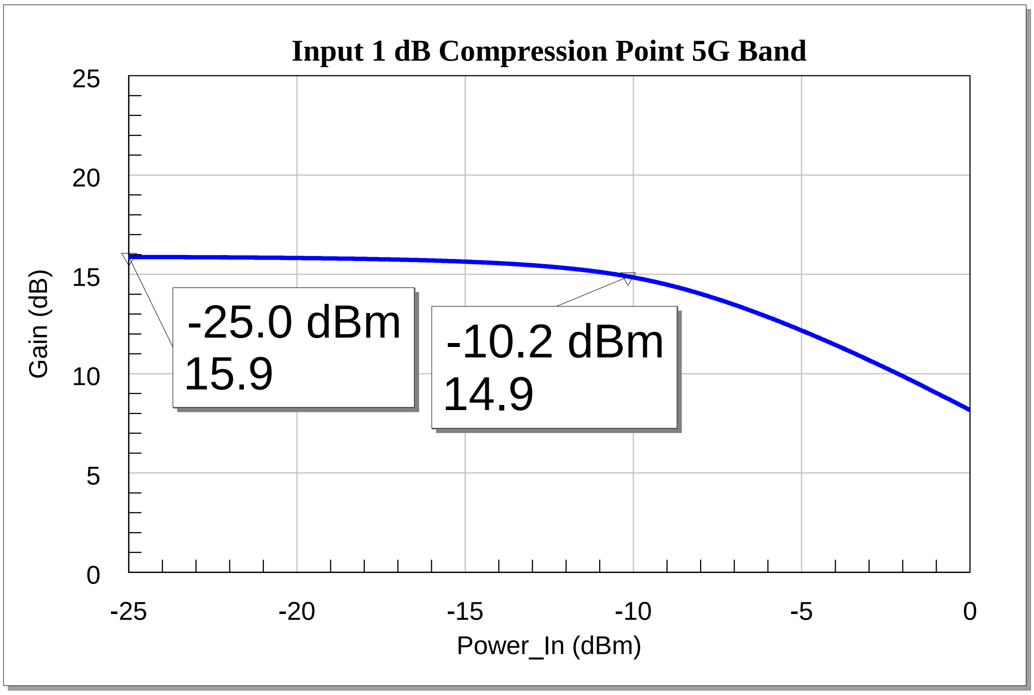

Figure 23 Input 1dB Compression Point (IP1dB) of the WLAN LNA with BFP843F at 5500 MHz

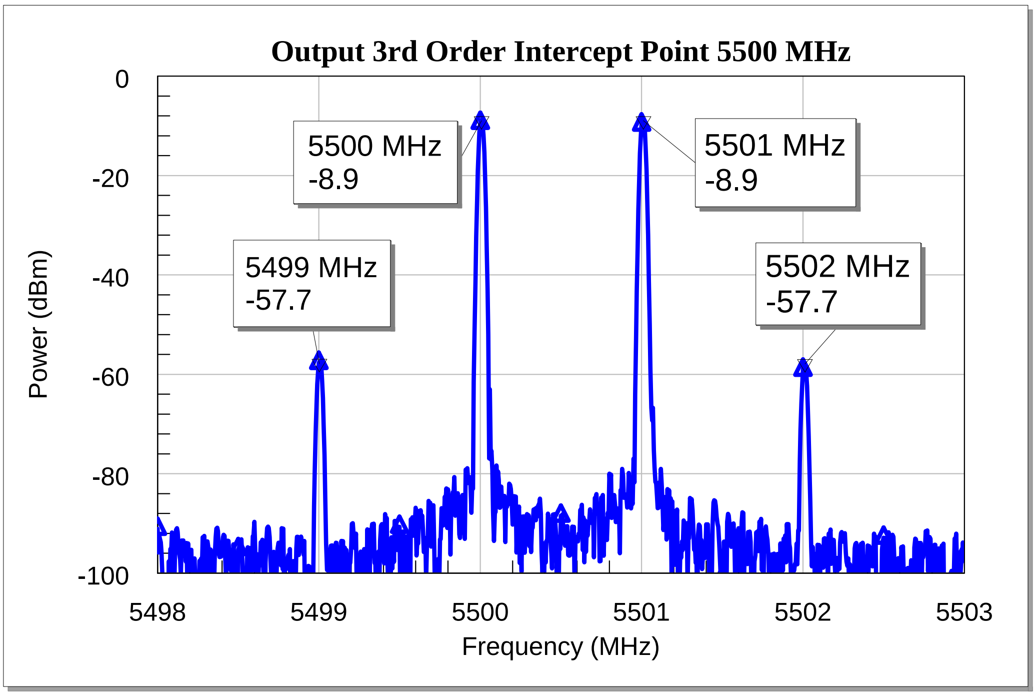

Figure 24 Output Third Order Intercept Point (OIP3) of the WLAN LNA with BFP843F at 5500 MHz

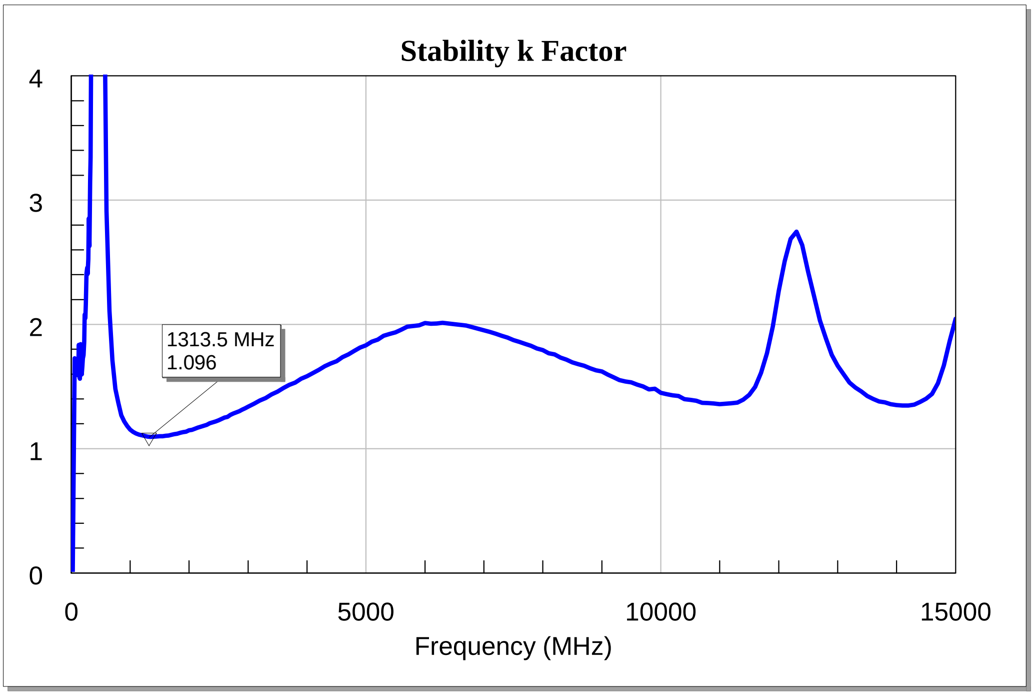

Figure 25 Stability K Factor of the 2.4 - 2.5 GHz & 5- 6 GHz WLAN LNA with BFP843F

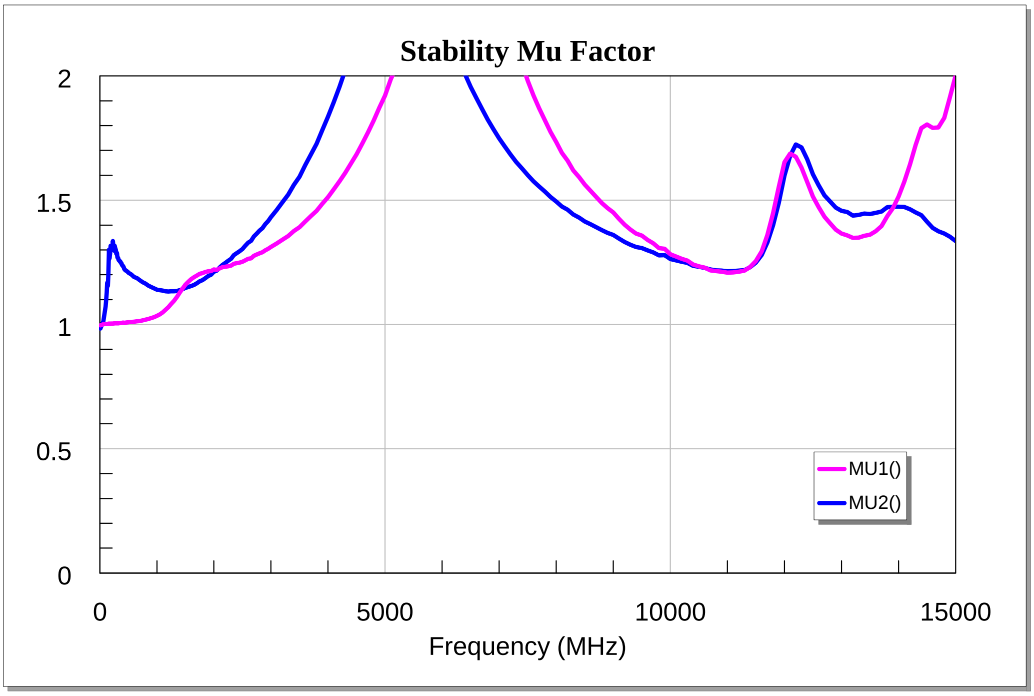

Figure 26 Stability Mu Factor of the 2.4 - 2.5 GHz & 5- 6 GHz WLAN LNA with BFP843F

6 Evaluation Board

In this application note, the following PCB is used:

PCB Marking: **M12051302** BFP840FESD

PCB material: <FR4>

ε_r of PCB material: <4.3>

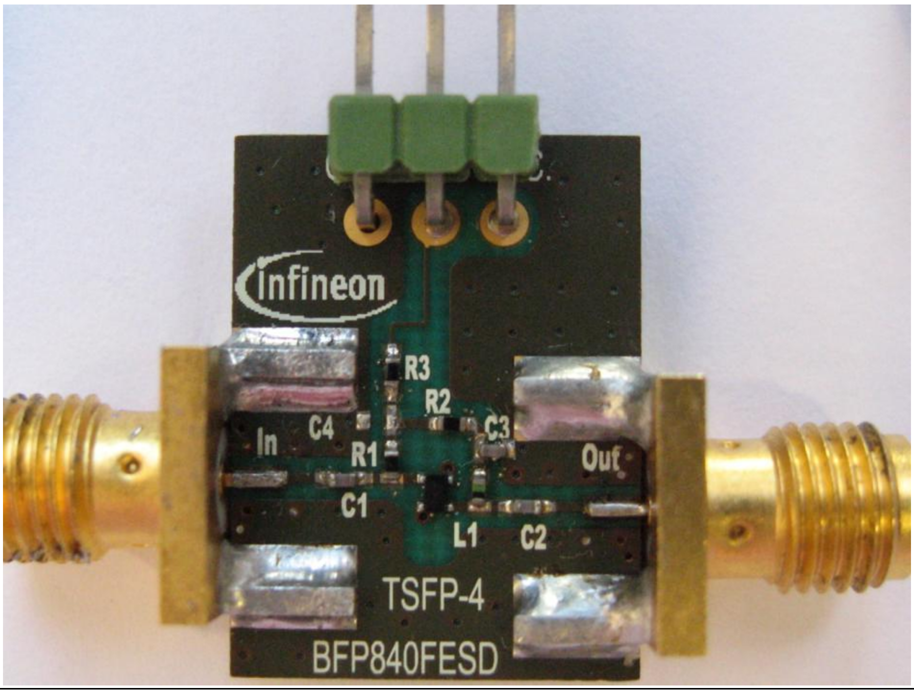

Figure 27 Photo Picture of Evaluation Board (overview) <M12051302>

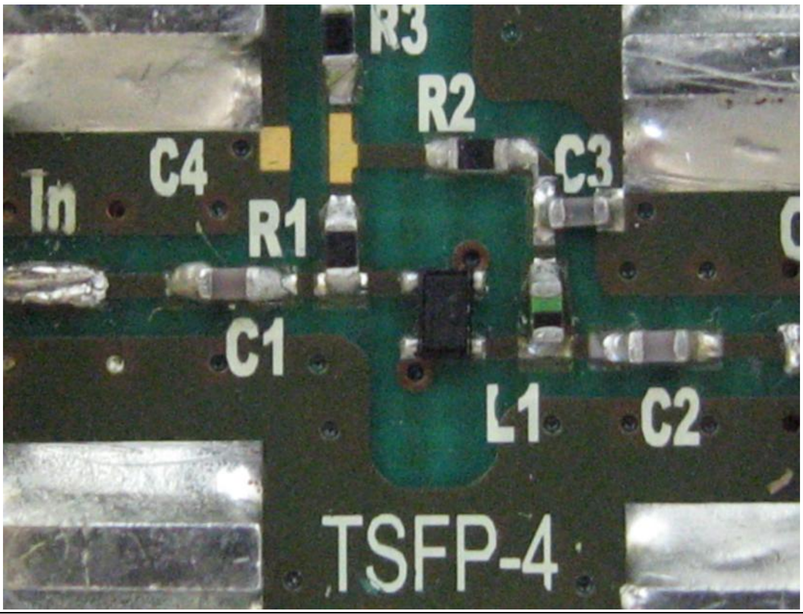

Figure 28 Photo Picture of Evaluation Board (detailed view)

7 Layout Information

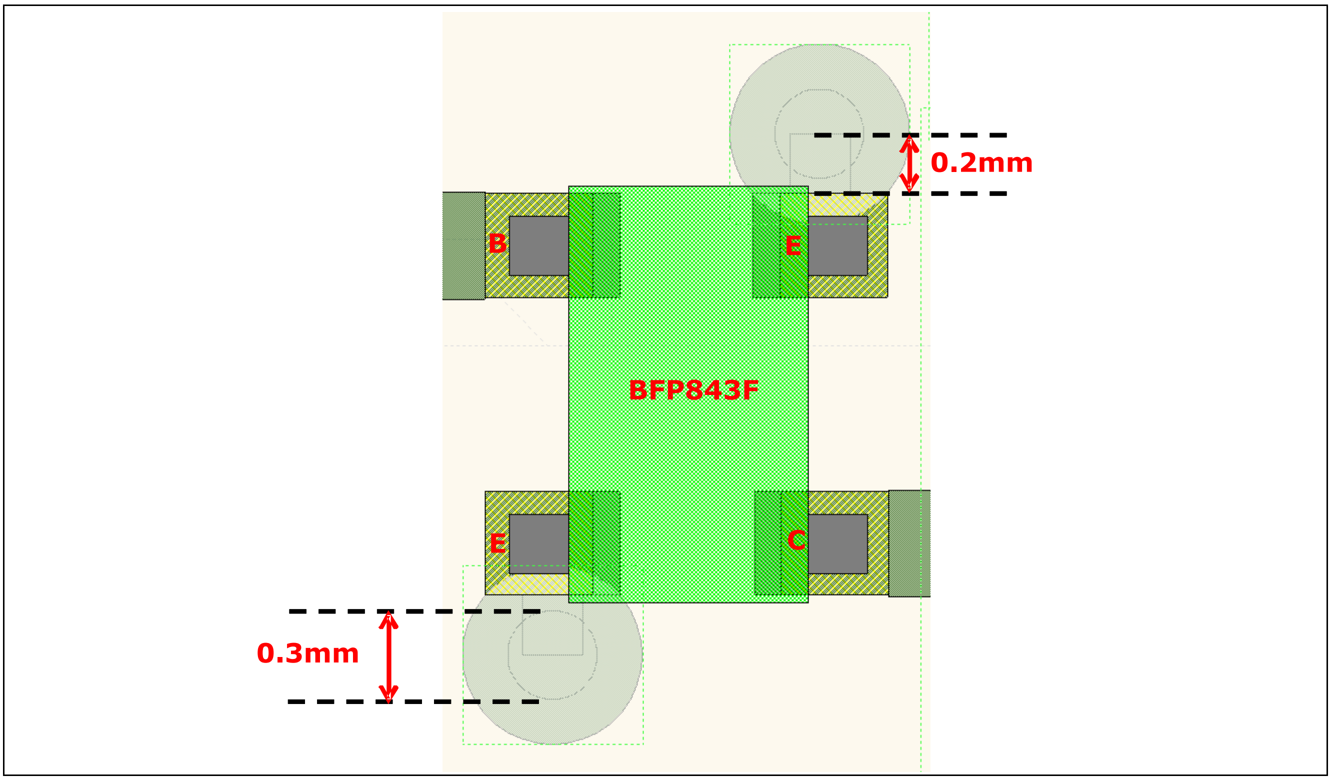

Figure 29 Layout Proposal for RF Grounding of the 2.4 - 2.5 GHz & 5 - 6 GHz WLAN LNA with BFP843F

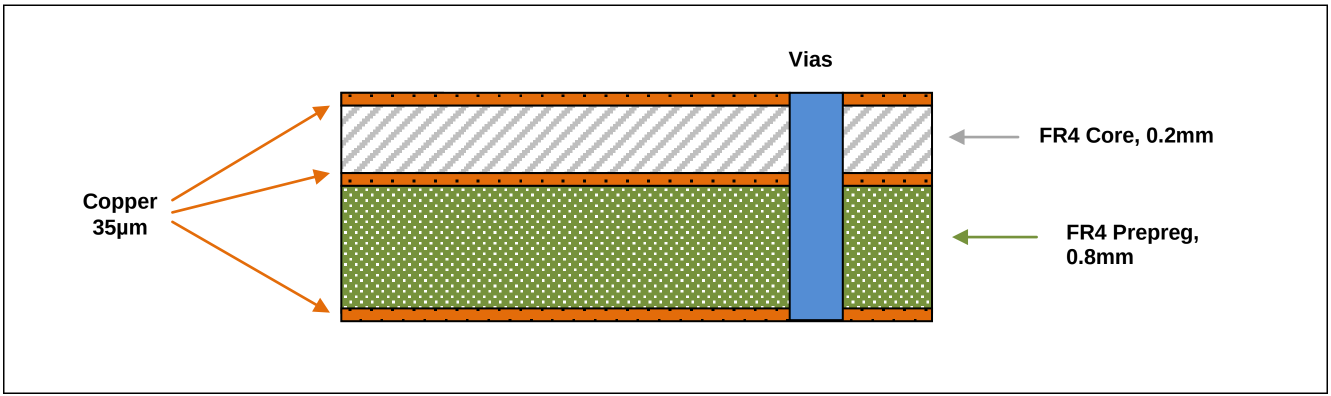

Figure 30 PCB Layer Information

8 Authors

Xiang Li, Application Engineer of Business Unit “RF and Protection Devices”

Ahmed Shamsuddin, Application Engineer of Business Unit “RF and Protection Devices”

9 Remark

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

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AN315