BFP840FESD

Low Noise Amplifier for 5 to 6 GHz WLAN incl. 2.4GHz rejection with BFP840FESD

Application Note AN299

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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 Overview of Wi-Fi® Applications

Wireless Fidelity (Wi-Fi®) or well-known as wireless LAN (WLAN) plays a major role in today's communications by enabling constant connection in the 2.4 GHz and 5 GHz bands 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 5 – 6 GHz Wi-Fi® into their system to offer high-speed wireless connectivity.

When wider coverage areas are needed and especially when a higher order modulation scheme is used such as in emerging very high throughput wireless specifications like 256 Quadrature Amplitude Modulation (256QAM) in IEEE 802.11ac, the signal-to-noise-ratio (SNR) requirements for both the AP and the client are more stringent. For this kind of high-speed high data rate wireless communication standards it is essential to ensure the quality of the link path. Major performance criteria of these equipments have to be fulfilled: sensitivity, strong signal capability and interference immunity. Below a general application diagram of a WLAN system is shown.

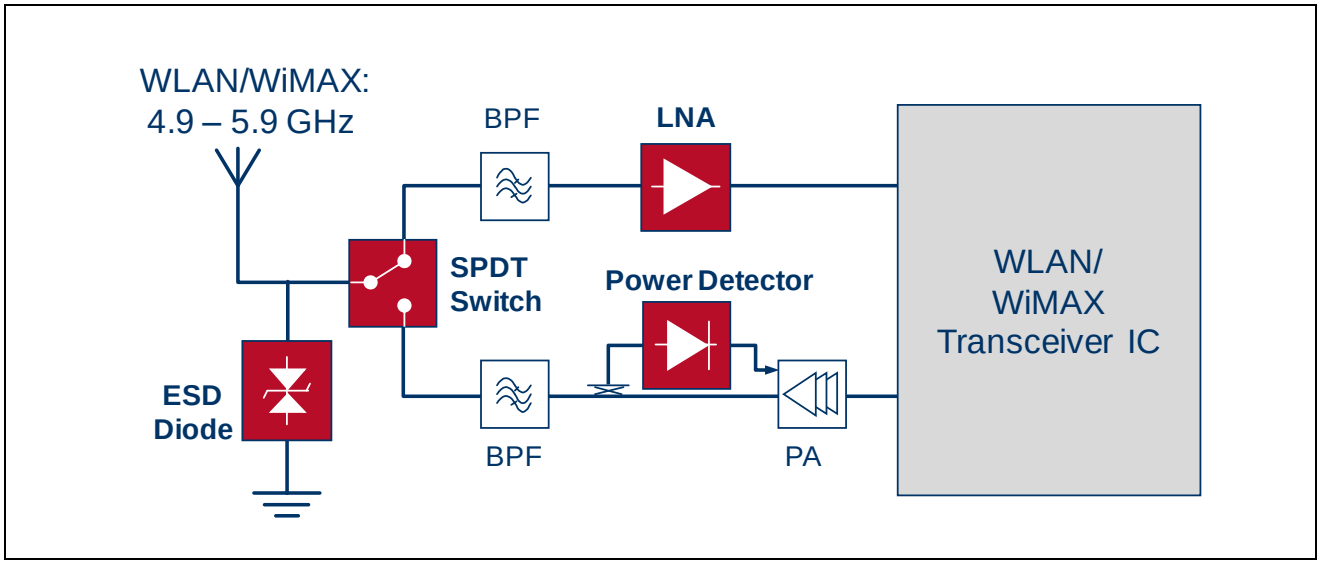

Figure 1 5-6 GHz Wi-Fi Wireless LAN (WLAN, IEEE802.11a/n/ac)

In order to increase the system sensitivity, an excellent low noise amplifier (LNA) in front of the receiver is mandatory, especially in an environment with very weak signal strength and because of the insertion loss of the 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 low noise amplifier.

In addition, strong signal environment can exist when the equipment is next to a transmitter. In that case, the LNA must be linear enough, i.e. have high 1dB compression point. 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 RF-switches, TVS-diodes for ESD protection and RF Schottky diodes for power detection.

1.2 Device Overview: BFP840FESD

The BFP840FESD is a discrete hetero-junction bipolar transistor (HBT) specifically designed for high performance 5 GHz band low noise amplifier (LNA) solutions for Wi-Fi connectivity applications. It combines the 80 GHz fT silicon-germanium:carbide (SiGe:C) B9HFM process with special device geometry engineering to reduce the parasitic capacitance between substrate and transistor that degrades high-frequency characteristics, resulting in an inherent input matching and a major improvement in power gain 5 GHz band together with a low noise figure performance that is industry's best.
The BFP840FESD has an integrated 1.5kV 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.
The BFP840FESD is housed in flat-leads TSFP-4-1 package. Further variants are available in industry standard visible-leads SOT343 package (BFP840ESD) and in the low-height 0.31mm TSLP-3-9 package (BFR840L3RHESD) specially fitting into modules.

2 5 to 6 GHz WLAN LNA with 2.4GHz Rejection using BFP840FESD

This application note presents the measurement results of the low noise amplifier using BFP840FESD for 5100 MHz to 5900 MHz WLAN applications. The circuit shown in Figure 2 doesn't require any external input matching elements. High rejection at 2.4 GHz band is achieved using a LC notch filter at the input of the LNA.

It requires ten passive 0402 size SMD components and brings gain from 17.9 dB to 18.8 dB over the frequency band. The noise figure varies from 1.05 dB to 1.15 dB (SMA and PCB losses are subtracted) over the complete frequency band. Moreover, 1dB compression point IP1dB at 2.4 GHz band is 4.4 dBm at input.

The circuit achieves an input and output return loss of better than 10 dB. Furthermore, the circuit is unconditionally stable from 10 MHz to 15 GHz.

At 5.5 GHz, using two tones spacing of 1 MHz, the output third order intercept point OIP3 reaches 17.2 dBm. Besides, we obtain input 1dB input compression point IP1dB of -10.5 dBm.

3 Application Circuit and Performance

3.1 Overview

Device: BFP840FESD
Application: Low Noise Amplifier for 5 to 6 GHz WLAN with 2.4GHz Rejection
PCB Marking: BFP840FESD TSFP-4 **M12080702**

3.2 Summary of Measurement Results

Table 1 Summary of Measurement Results

Parameter	Symbol	Value				Unit	Note/Test Condition
DC Voltage	Vcc	3.0				V	
DC Current	Icc	15				mA	
Frequency Range	Freq	2400	5100	5500	5900	MHz	
Gain	G	-7.3	18.8	18.4	17.9	dB	
Noise Figure	NF	--	1.05	1.10	1.15	dB	SMA and PCB losses (~0.15 dB) are subtracted
Input Return Loss	RLin	--	10.2	11.6	11.4	dB	
Output Return Loss	RLout	--	10.7	10.5	12.4	dB	
Reverse Isolation	IRev	--	26.4	25.9	25.5	dB	
Input P1dB	IP1dB	4.4	--	-10.5	--	dBm	
Output P1dB	OP1dB	**--**	--	6.9	--	dBm	
Input IP3	IIP3	-1.2				dBm	
Output IP3	OIP3	17.2				dBm	Power @ Input: -30 dBm f_1= 5500 MHz, f_2= 5501 MHz
Stability	k	> 1.0				--	Stability measured from 10MHz to 8GHz

3.3 Schematics

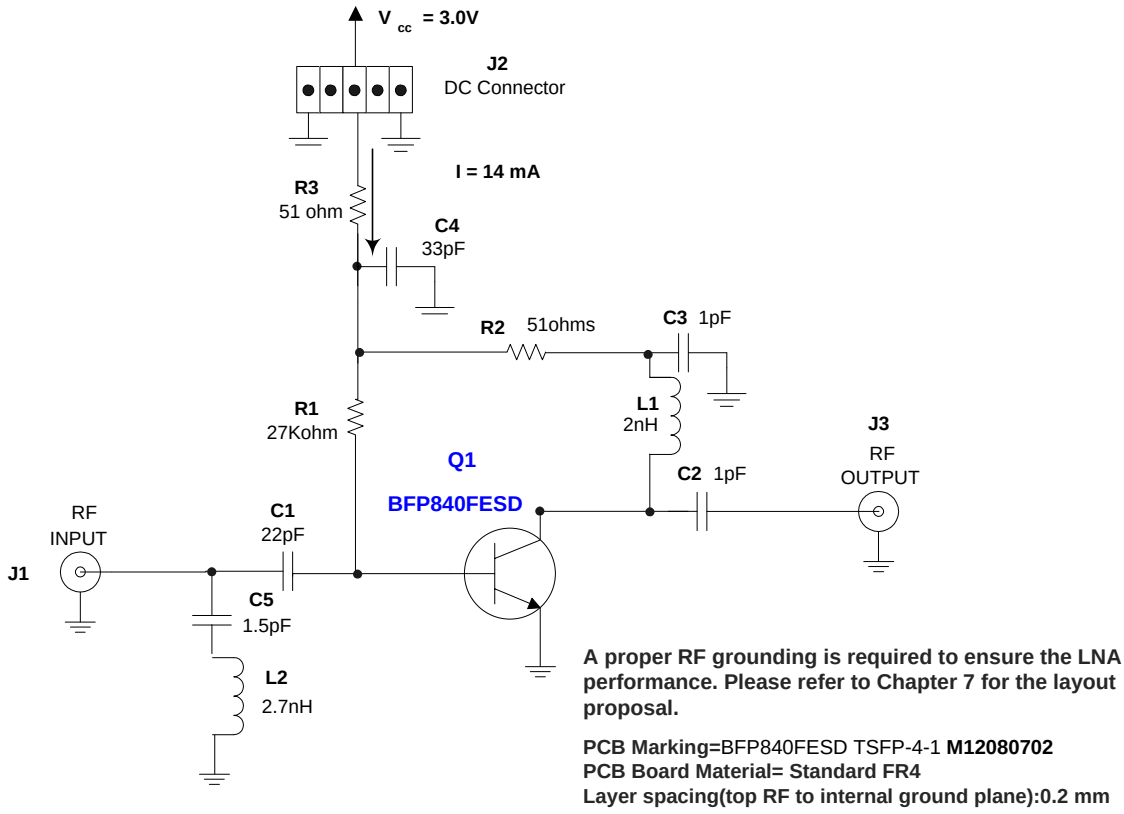

Figure 2 Schematic Diagram of the Application Circuit

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	22	pF	0402	Various	Input DC block
C2	1.0	pF	0402	Various	Output DC block & output matching
C3	1.0	pF	0402	Various	Output matching. Influence the input matching as well.
C4	33	pF	0402	Various	RF decoupling / blocking cap
C5	1.5	pF	0402	Various	2.4 GHz rejection
L1	2.0	nH	0402	Murata LQP15series	Output matching and biasing to the Collector
L2	2.7	nH	0402	Murata LQP15 series	2.4 GHz rejection
R1	27	kΩ	0402	Various	DC biasing
R2	51	Ω	0402	Various	Stability improvement
R3	51	Ω	0402	Various	DC biasing (provides DC negative feedback to stabilize DC operating point over temperature variation, transistor h_{FE} variation, etc.)
Q1			TSFP-4-1	Infineon Technologies	BFP840FESD SiGe:C Heterojunction Bipolar RF Transistor

4 Measured Graphs

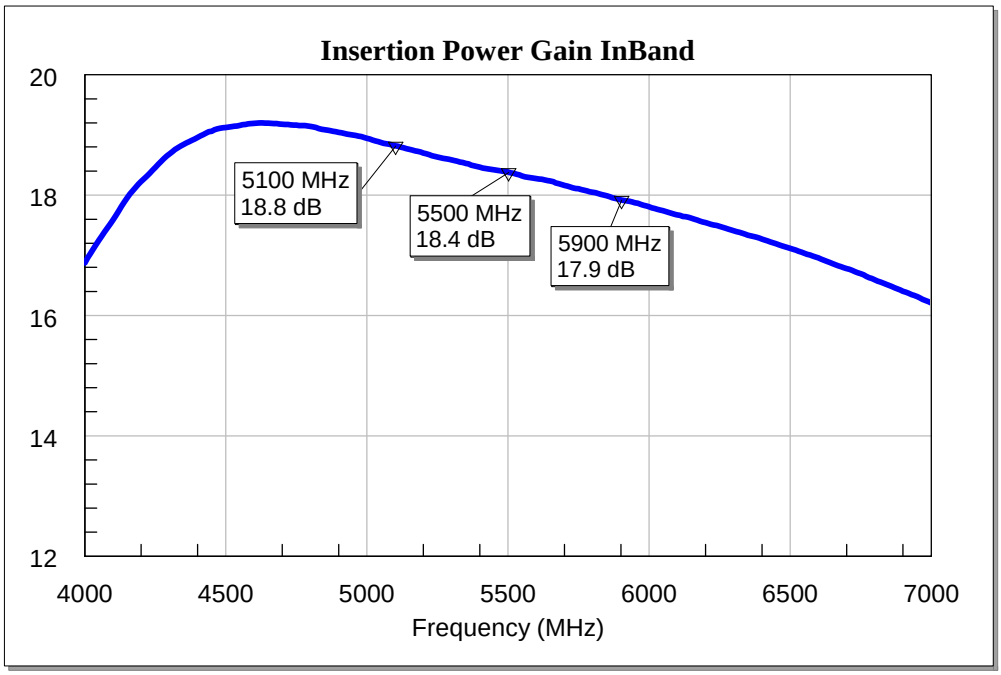

Figure 3 In-Band Insersion Power Gain of the 5-6GHz WLAN LNA with BFP840FESD

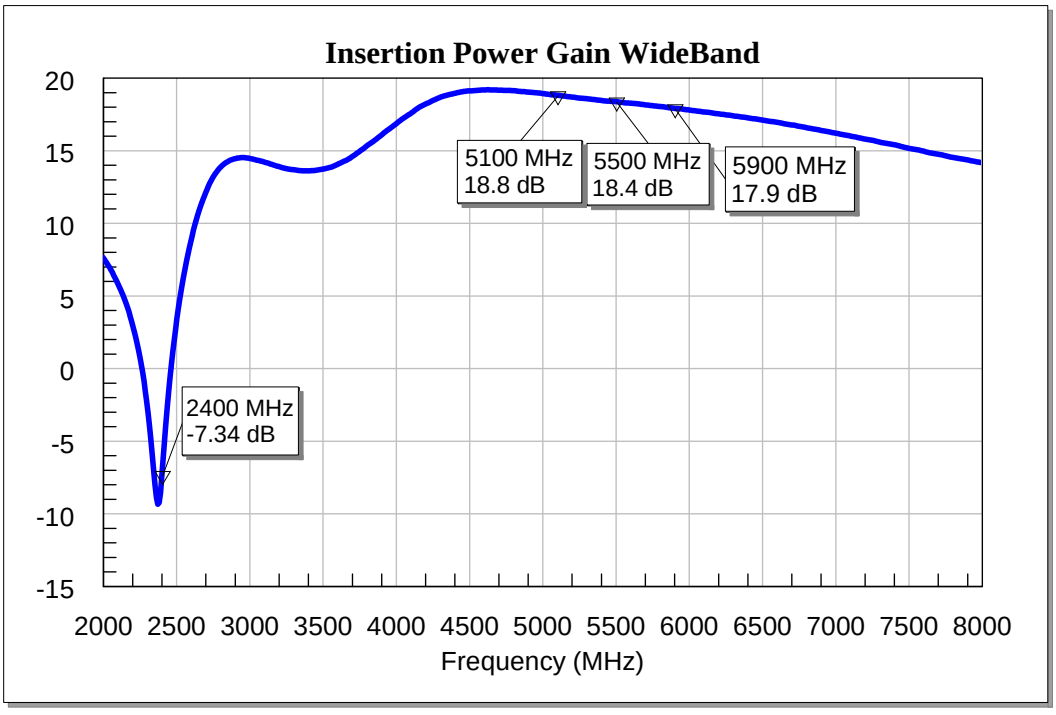

Figure 4 Wideband Insersion Power Gain of the 5-6GHz WLAN LNA with BFP840FESD

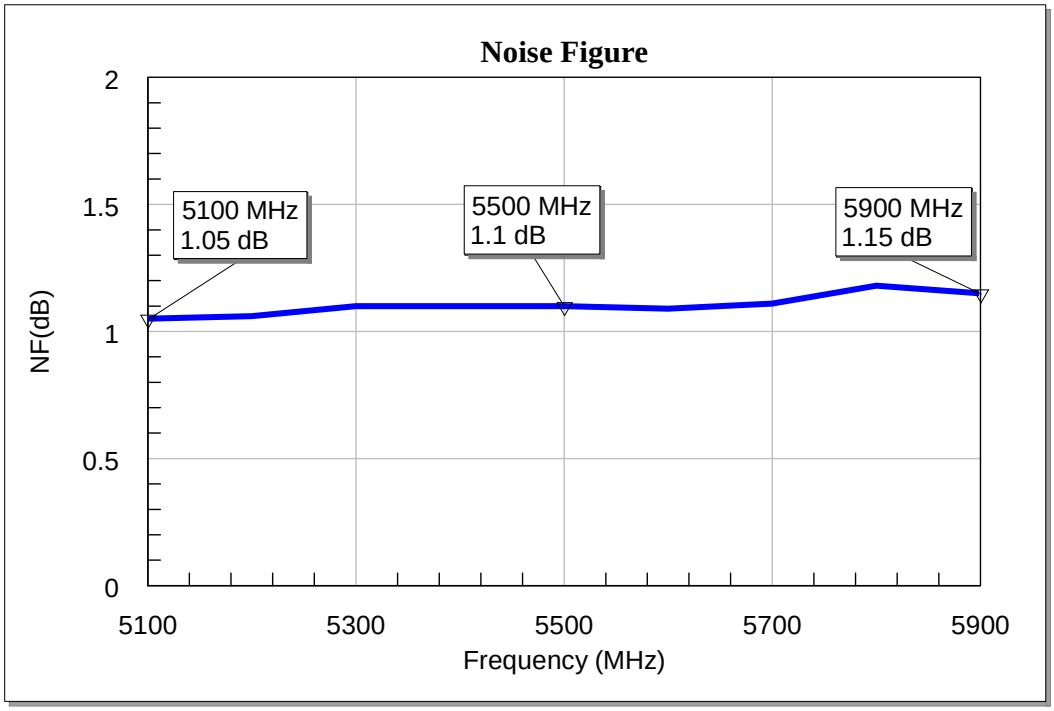

Figure 5 Noise Figure of BFP840FESD LNA for 5100-5900 MHz

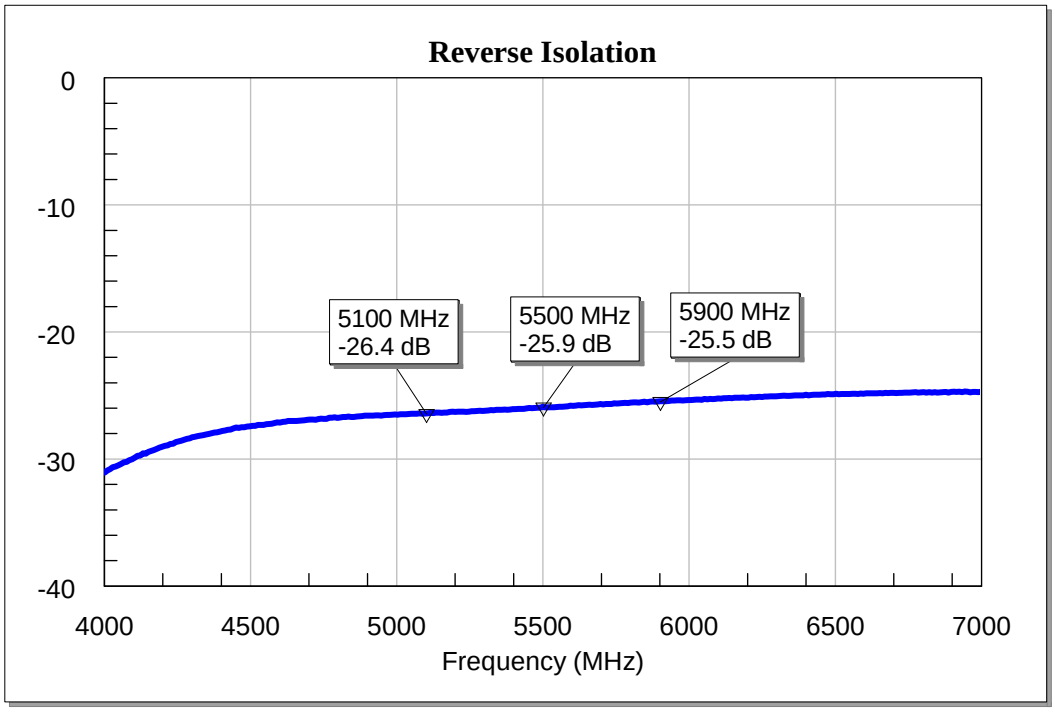

Figure 6 Reverse Isolation of the 5-6 GHz WLNA LNA with BFP840FESD

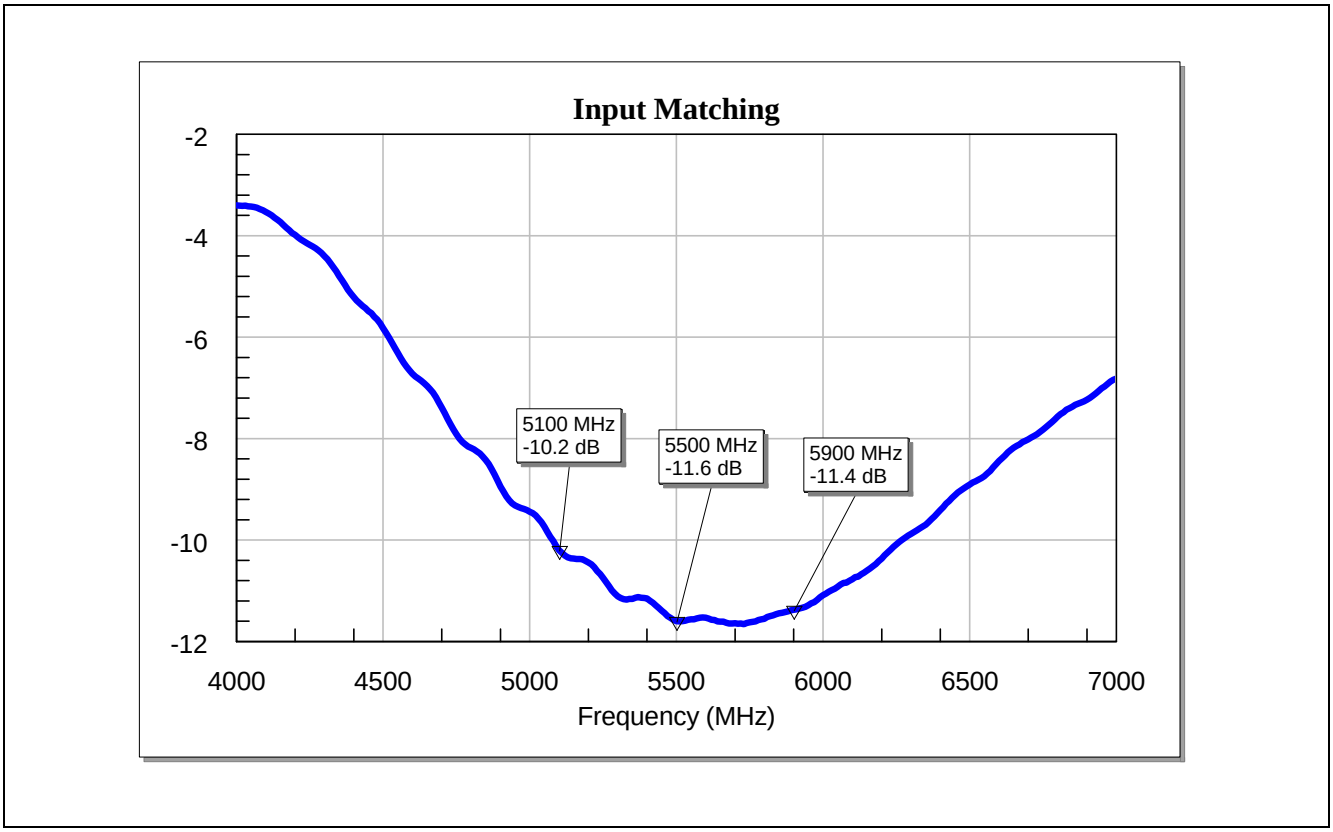

Figure 7 Input Matching of the 5-6GHz WLAN LNA with BFP840FESD

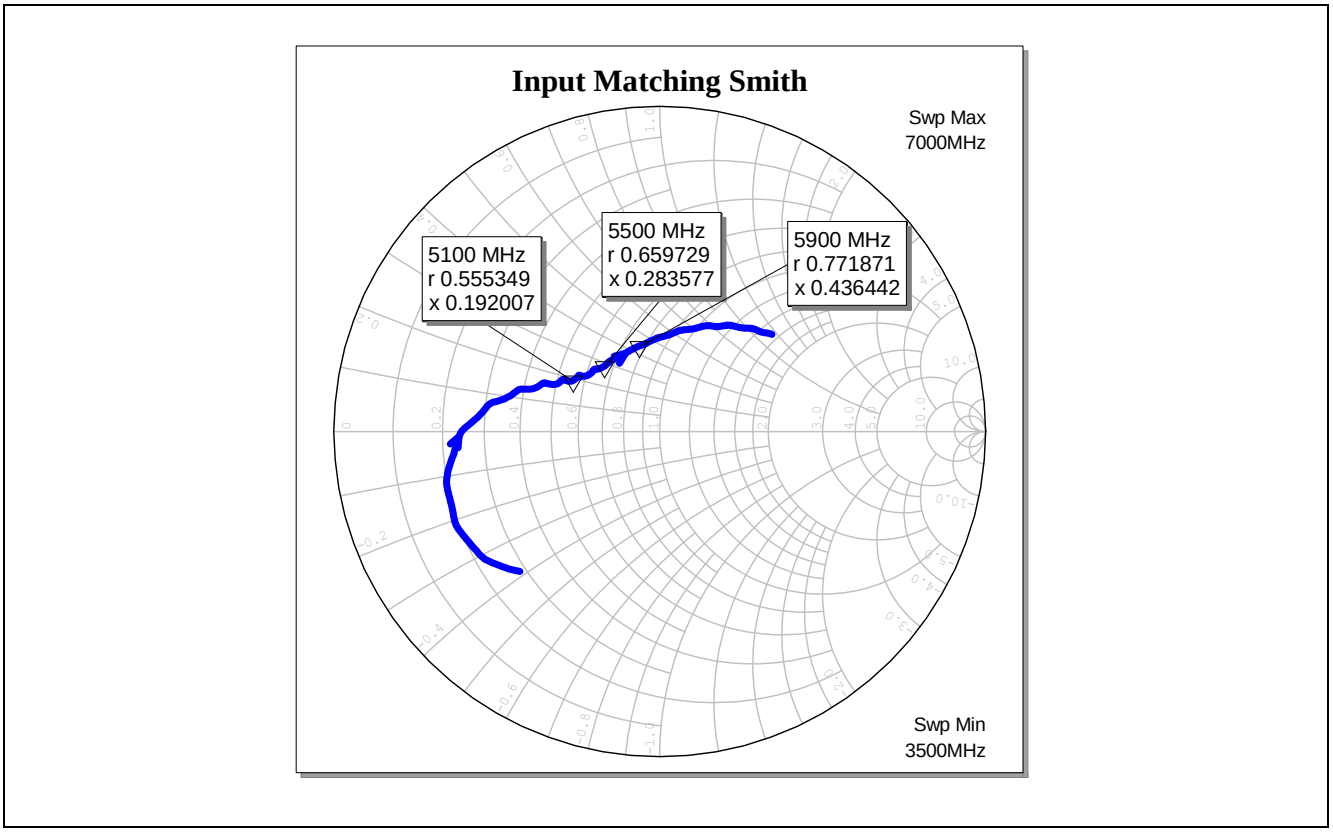

Figure 8 Input Matching of the 5-6GHz WLAN LNA with BFP840FESD (Smith Chart)

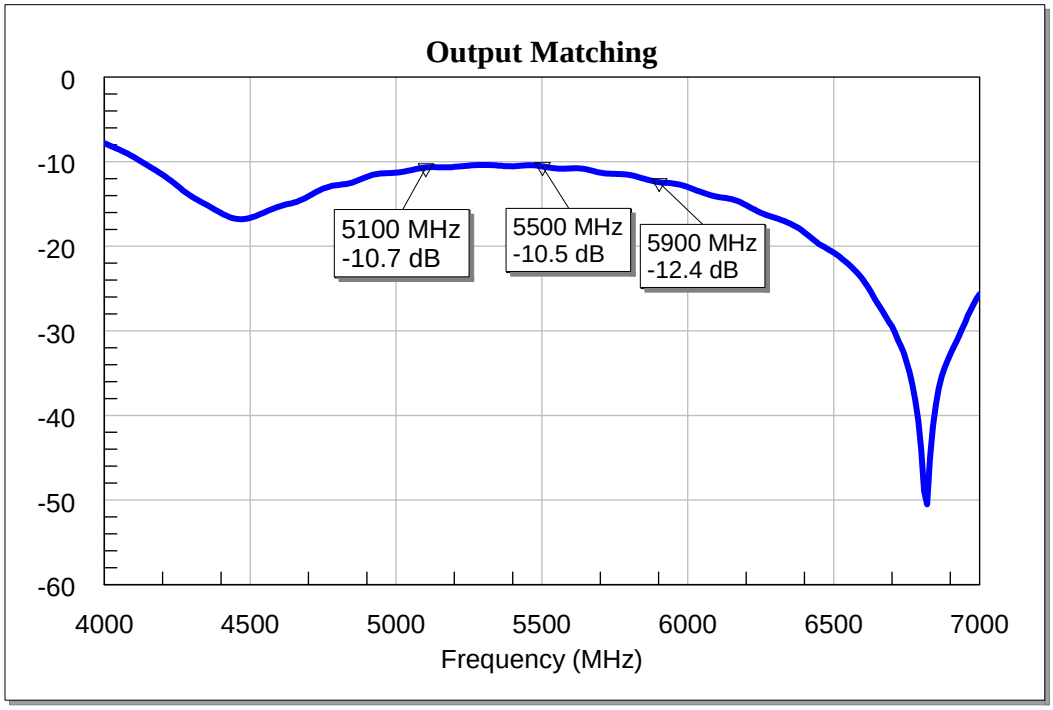

Figure 9 Output Matching of the 5-6GHz WLAN LNA with BFP840FESD

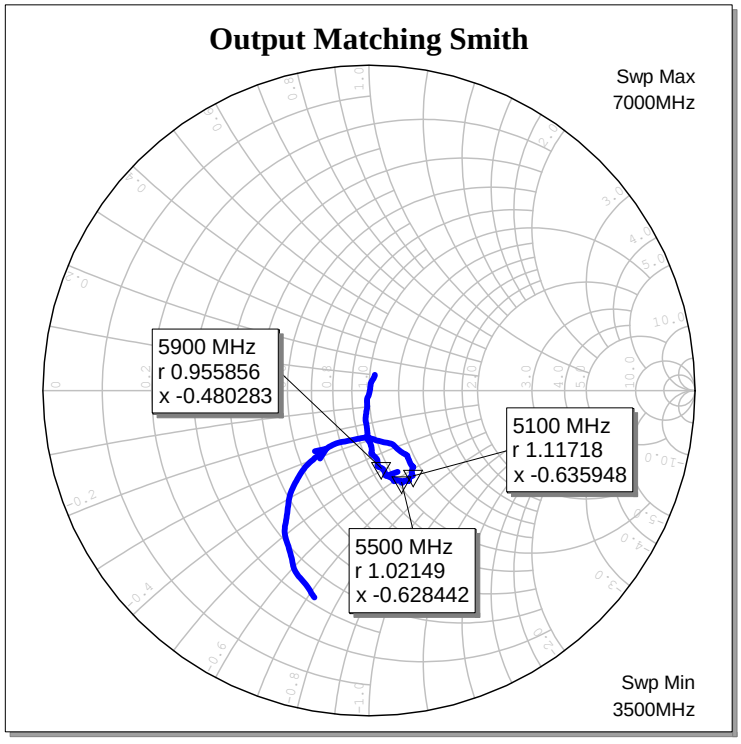

Figure 10 Output Matching of the 5-6GHz WLAN LNA with BFP840FESD (Smith Chart)

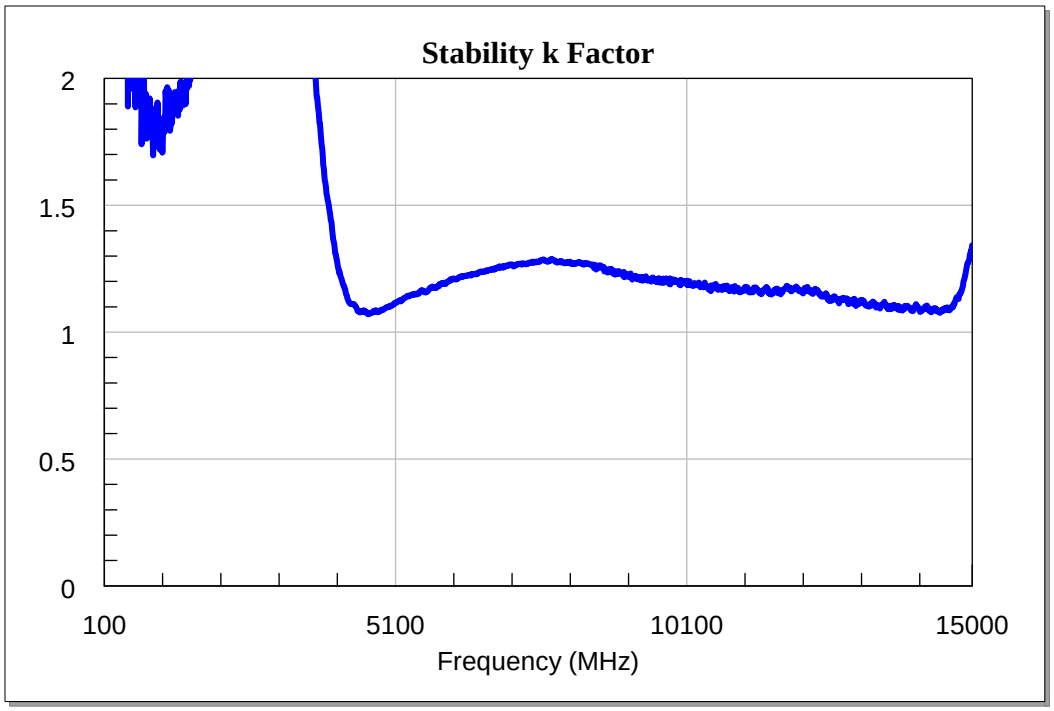

Figure 11 Wideband Stability K Factor of the 5-6GHz WLAN LNA with BFP840FESD

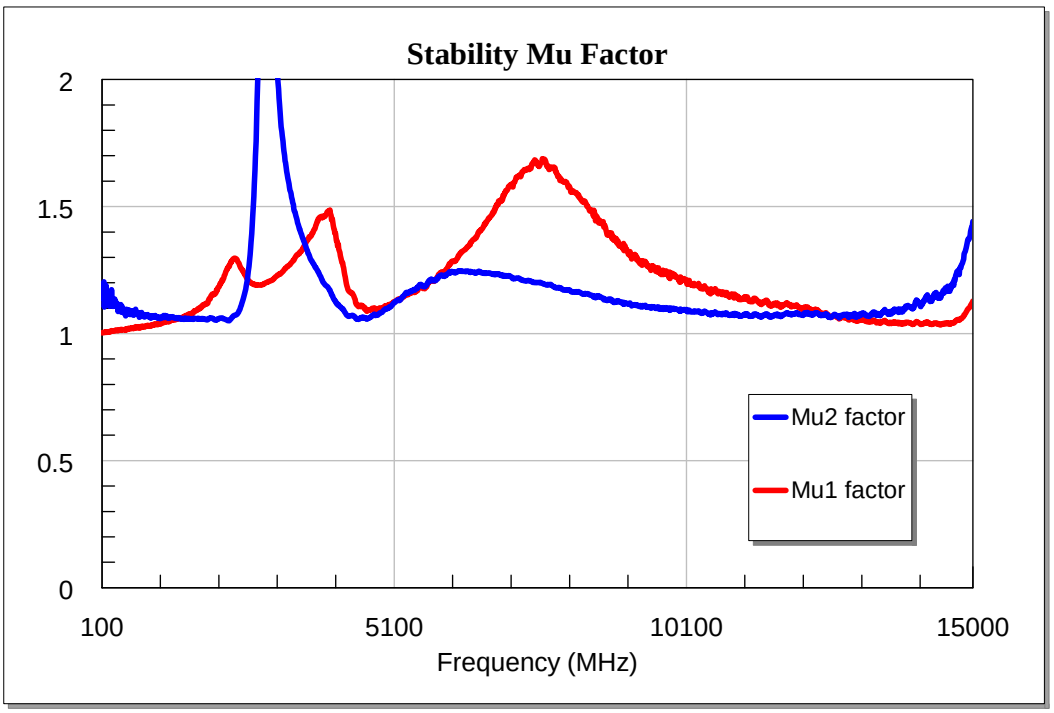

Figure 12 Wideband Stability Mu Factor of the 5-6GHz WLAN LNA with BFP840FESD

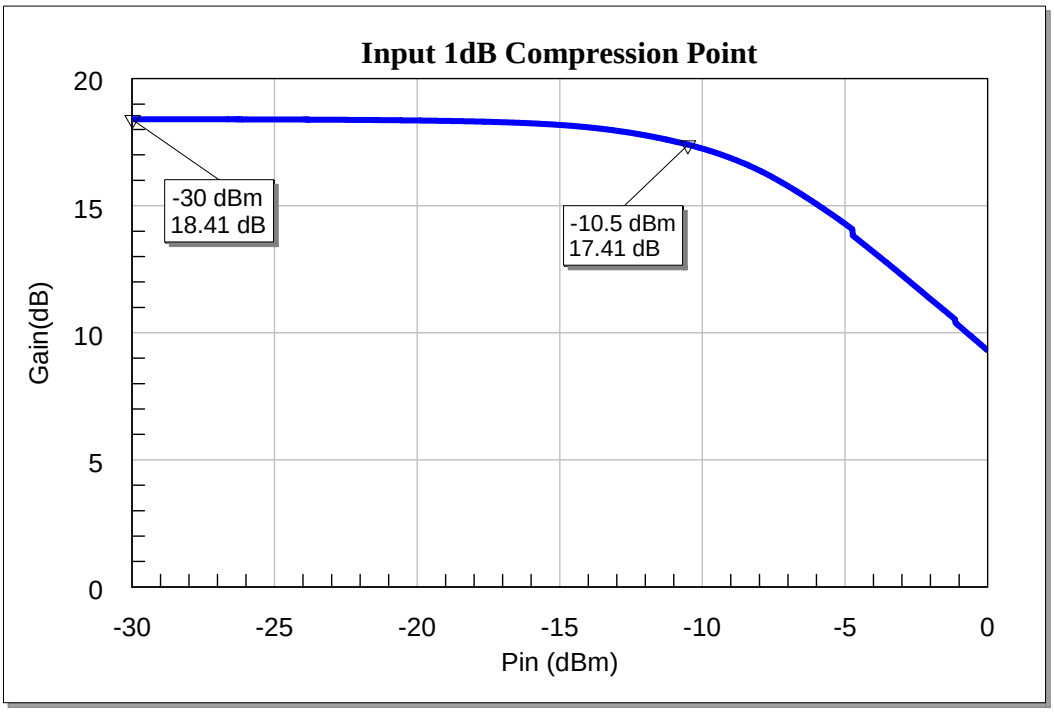

Figure 13 Input 1dB Compression Point of the BFP840FESD Circuit at 5500MHz

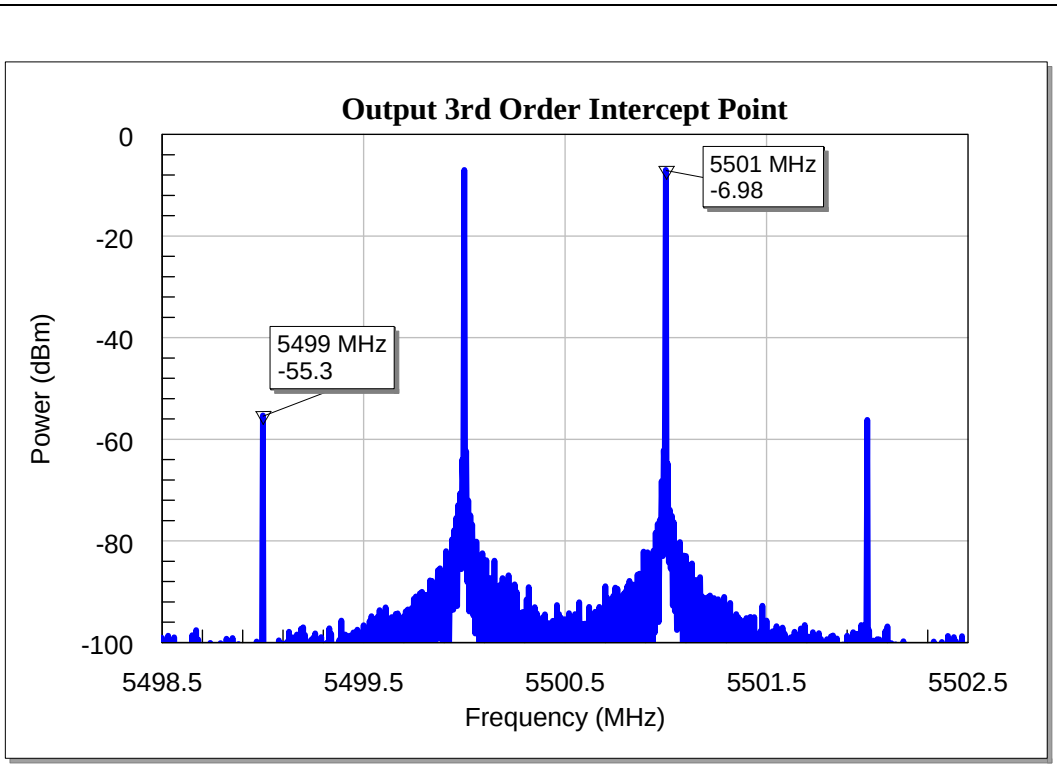

Figure 14 Input 3rd Order Intercept Point of the BFP840FESD Circuit at 5500MHz

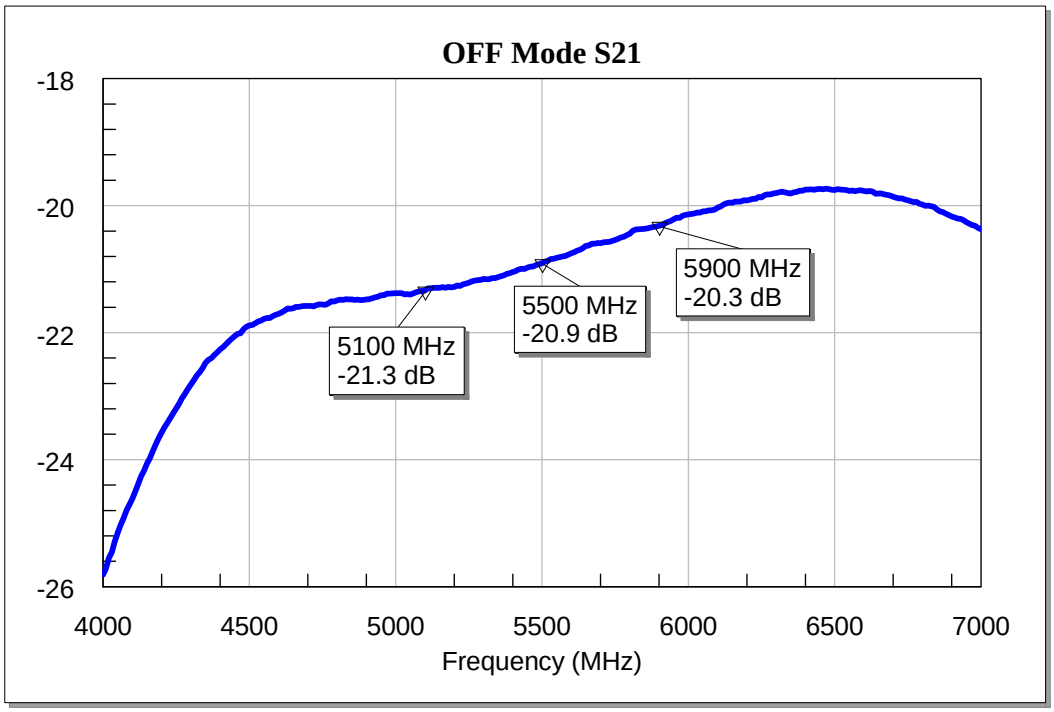

Figure 15 OFF-Mode(Vcc=0V, Icc=0mA) S21 of the 5-6GHz WLAN LNA with BFP840FESD

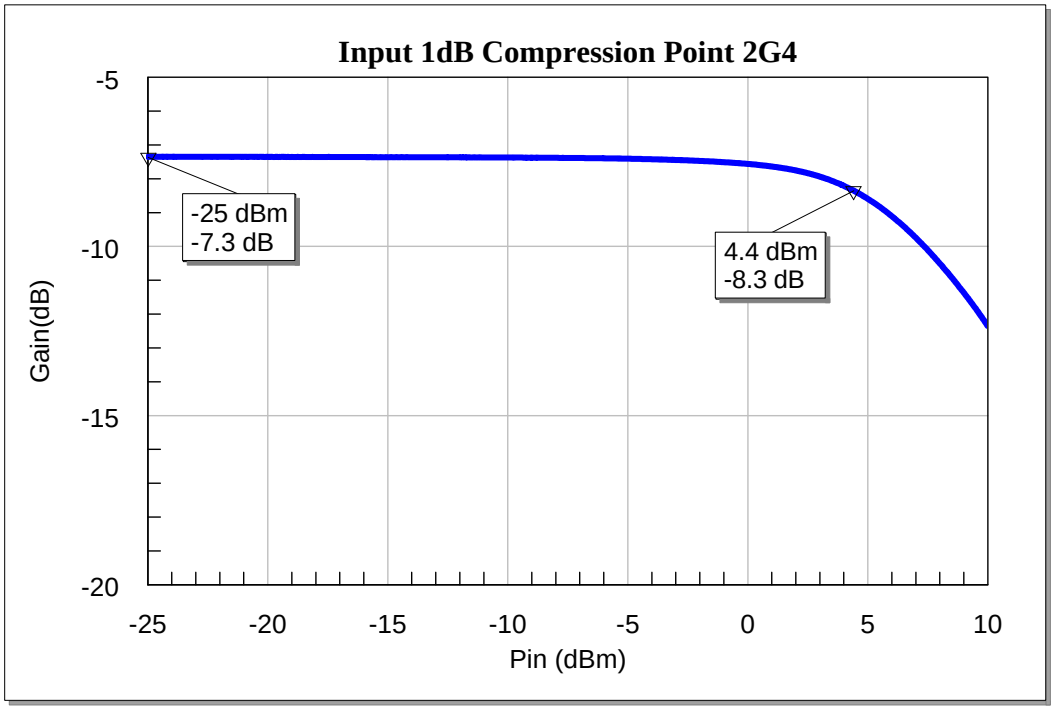

Figure 16 Input 1dB Compression Point of the BFP840FESD Circuit at 2400MHz

5 Evaluaton Board and Layout Information

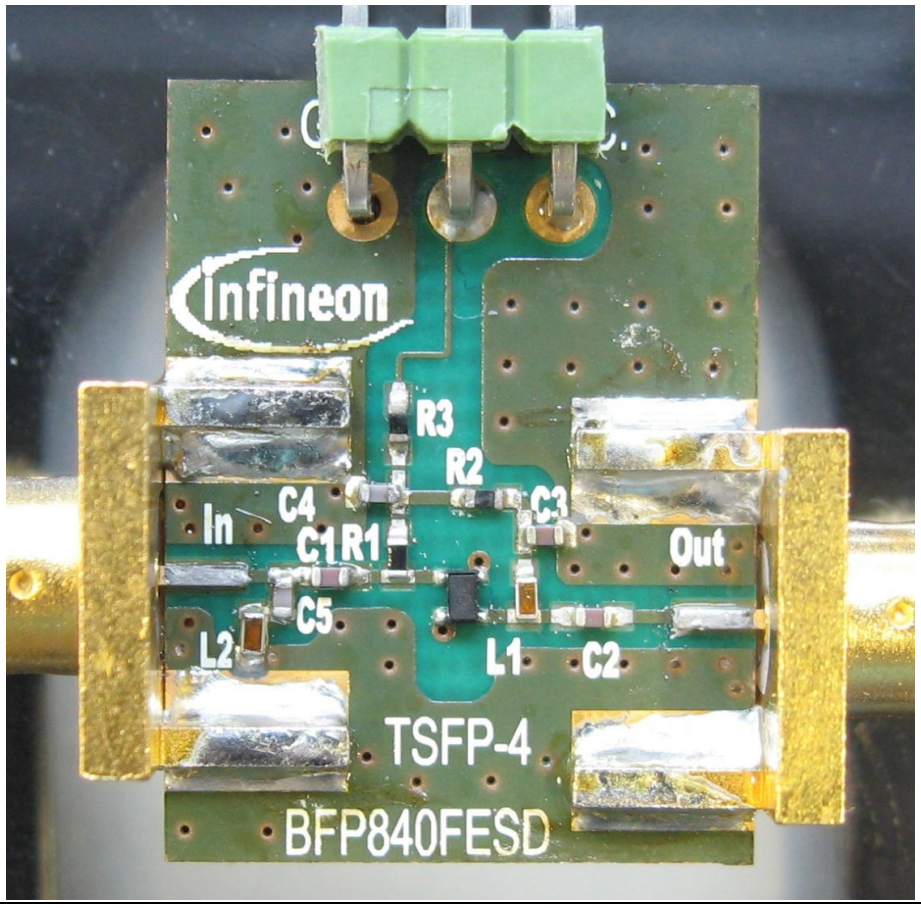

Figure 17 Photo of the BFP840FESD 5-6GHz WLAN LNA Evaluation Board

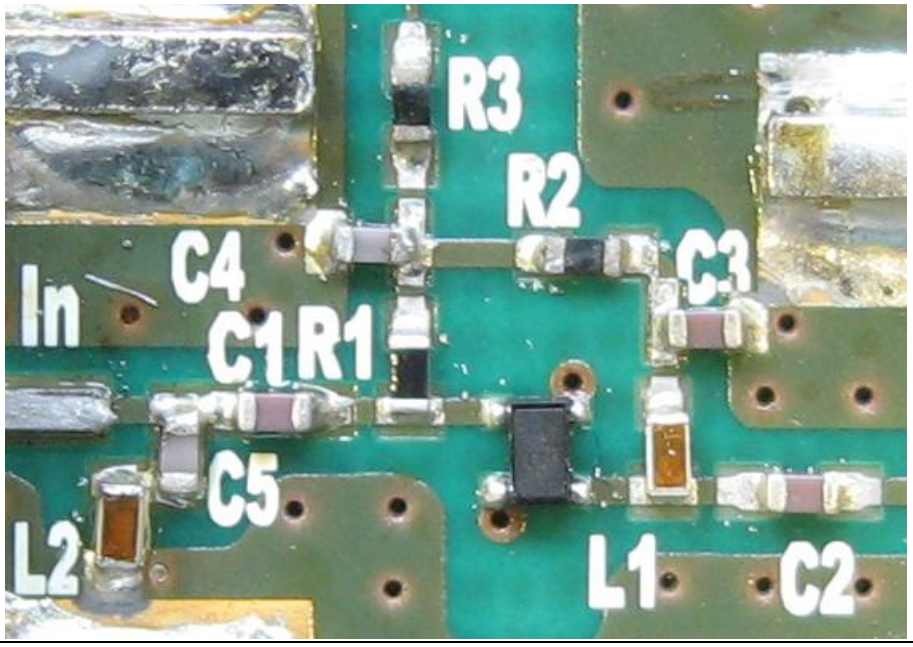

Figure 18 ZOOM-In Photo of the BFP840FESD 5-6GHz WLAN LNA Evaluation Board

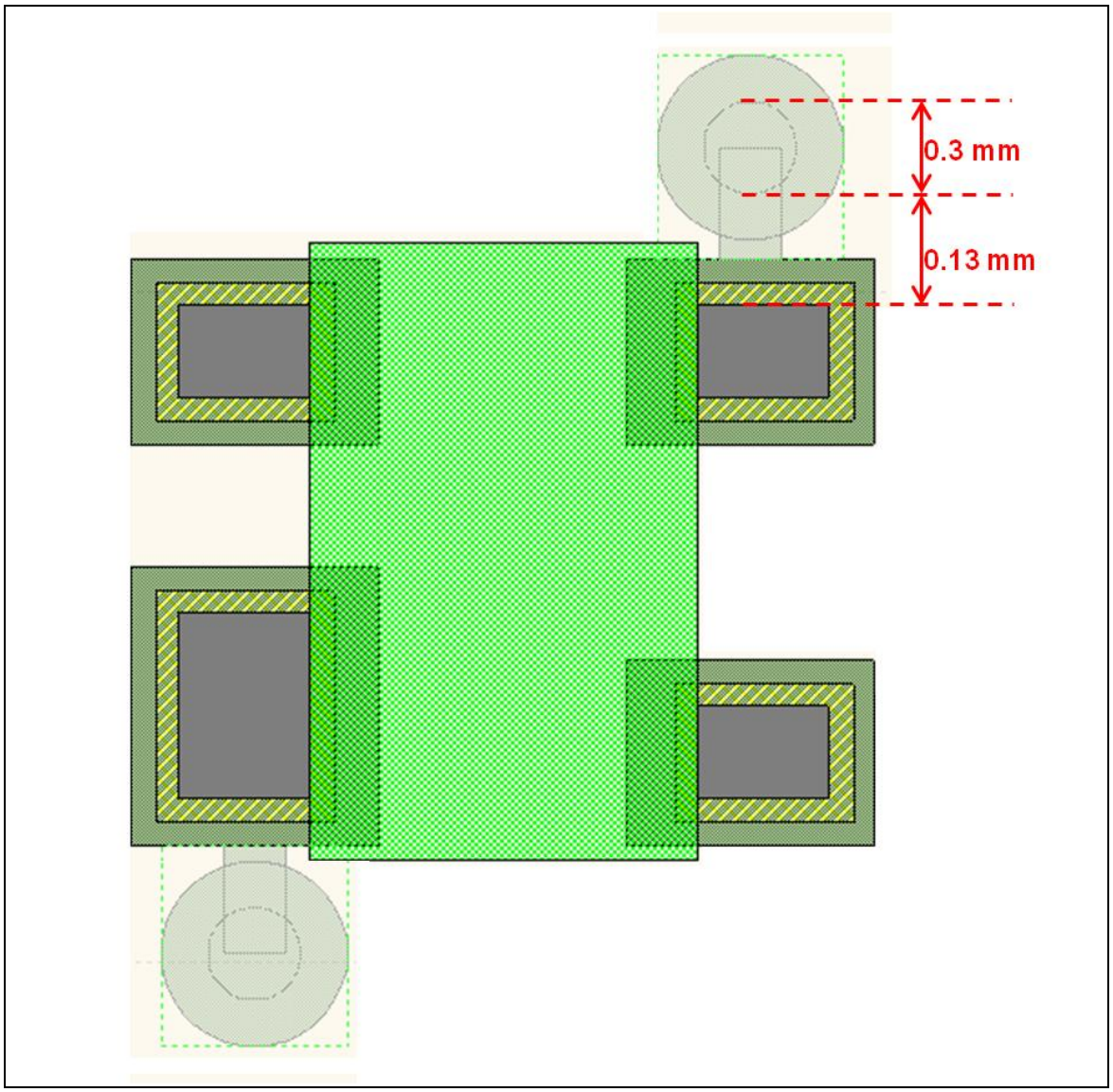

Figure 19 Layout Proposal for the RF Grounding of the 5-6GHz WLAN LNA with BFP840FESD

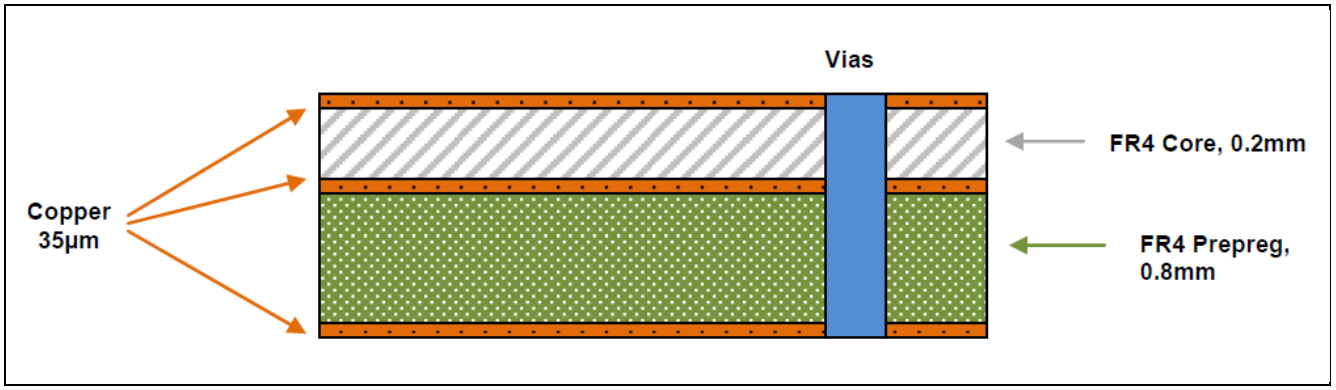

Figure 20 PCB Layer Information

6 Authors

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7 Remark

The graphs are generated with the simulation program “Agilent - Advanced Design System”

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