BFP840ESD

Low Noise Amplifier for 5 to 6 GHz WLAN using BFP840ESD with Low Parts-Count

Application Note AN288

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Application Note AN288
Revision History: 2012-05-29

Previous Revision: No previous revision

Page	Subjects (major changes since last revision)

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1 Introduction

1.1 Wi-Fi®

Wireless Fidelity (Wi-Fi®) 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 (QAM) in IEEE 802.11ac, the 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.

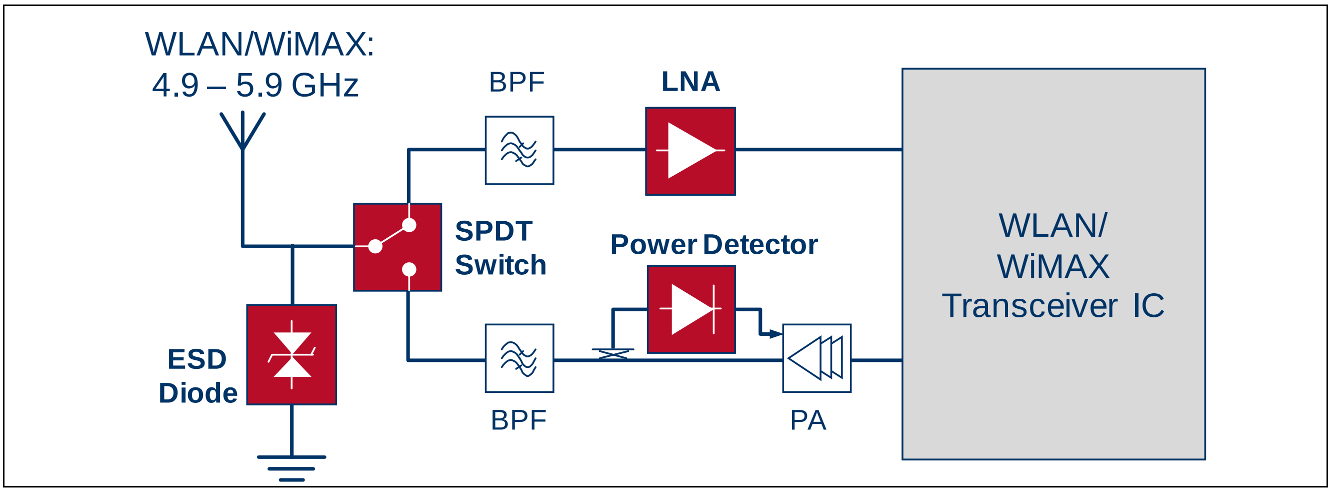

Figure 1 5 – 6 GHz Wi-Fi® Wireless LAN (WLAN, IEEE802.11a/n) and WiMAX (IEEE802.16e) Front-End

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 with RF-switches, TVS-diodes for ESD protection and RF Schottky diodes for power detection.

1.2 Device Overview: BFP840ESD

The BFP840ESD 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 f_T 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 BFP840ESD 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 BFP840ESD is housed in the industry standard SOT343 package with visible leads. Further variants are available in flat-lead TSFP-4-1 package (BFP840FESD) and in the low-height 0.31mm TSLP-3-9 package (BFR840L3RHESD) specially fitting into modules.

2 Low Parts Count Low Noise Amplifier for 5 to 6 GHz WLAN with BFP840ESD

This application note presents the measurement results of the Low Noise Amplifier using BFP840ESD for 5100 MHz to 5900 MHz WLAN applications. The circuit schematic shown in Figure 2 doesn't require any external input matching elements. Proper RF grounding on PCB has to be ensured in order to achieve stability k-factor ≥ 1 above 9 GHz (Figure 18).

It's a low parts count solution which requires only 8 passive 0402 SMD components and brings gain from 18.2 dB to 17.2 dB over the frequency band. The gain is approx. 3 dB higher compared to BFP740 (AN169). The noise figure varies from 1.02 dB to 0.95 dB (SMA and PCB losses are subtracted) over the frequency band, which is 0.15 dB lower compared to BFP740 (AN169).

The circuit achieves an input and output return loss more than 11 dB. Furthermore, the circuit is unconditionally stable from 10 MHz to 15 GHz. However, the frequency dependency of FR4 material can introduce measurement uncertainties above 8 GHz which need to be considered as well.

At 5.5 GHz, using two tones spacing of 1 MHz, the output third intercept point OIP3 reaches 15.6 dBm. Besides, we obtain 1dB input compression point IP1dB of -11.4 dBm.

Furthermore, through the proper design of the application circuit, this BFP840ESD LNA shows a signal rejection of more than 20 dB at 2.4 GHz. It helps to protect the following receiver stages to be interfered by the unwanted signals from 2.4 GHz band.

3 Overview

Device: BFP840ESD

Application: Low Noise Amplifier for 5 to 6 GHz WLAN with Low Parts-Count

PCB Marking: BFP840ESD SOT343 **M120418**

4 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	9.1			mA	
Frequency Range	Freq	5100	5500	5900	MHz	
Gain	G	18.2	17.7	17.2	dB	
Noise Figure	NF	1.02	1.0	0.99	dB	SMA and PCB losses (~0.15 dB) are subtracted
Input Return Loss	RLin	11.4	12.4	11.7	dB	
Output Return Loss	RLout	11.3	11	12.3	dB	
Reverse Isolation	IRev	26	25.5	25	dB	
Input P1dB	IP1dB		-11.4		dBm	
Output P1dB	OP1dB		+5.3		dBm	
Input IP3	IIP3	-2.1			dBm	
Output IP3	OIP3	+15.6			dBm	Power @ Input: -25 dBm f_1= 5500 MHz, f_2= 5501 MHz
Stability	k	≥ 1.0			--	Stability measured from 10MHz to 15GHz

5 Schematics

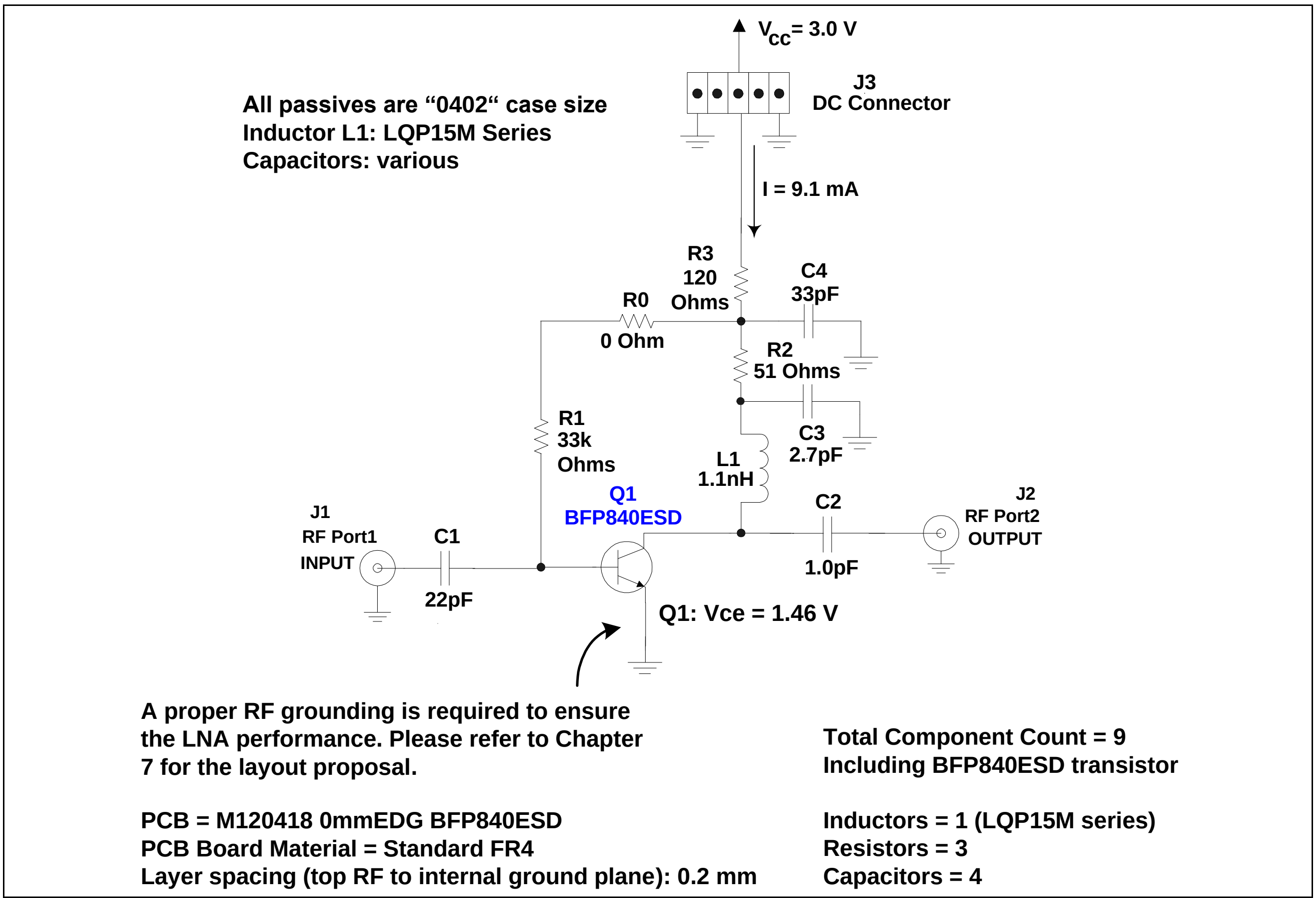

Figure 2 Schematic Diagram of the used Circuit

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	2.7	pF	0402	Various	Output matching
C4	33	pF	0402	Various	RF decoupling / blocking cap
L1	1.1	nH	0402	Murata LQP15M series	Output matching and biasing to the Collector
R0	0	Ω	0402	Various	Jumper
R1	33	kΩ	0402	Various	DC biasing
R2	51	Ω	0402	Various	Stability improvement
R3	120	Ω	0402	Various	DC biasing (provides DC negative feedback to stabilize DC operating point over temperature variation, transistor h_{FE} variation, etc.)
Q1			SOT343	Infineon Technologies	BFP840ESD SiGe:C Heterojunction Bipolar RF Transistor

6 Measured Graphs

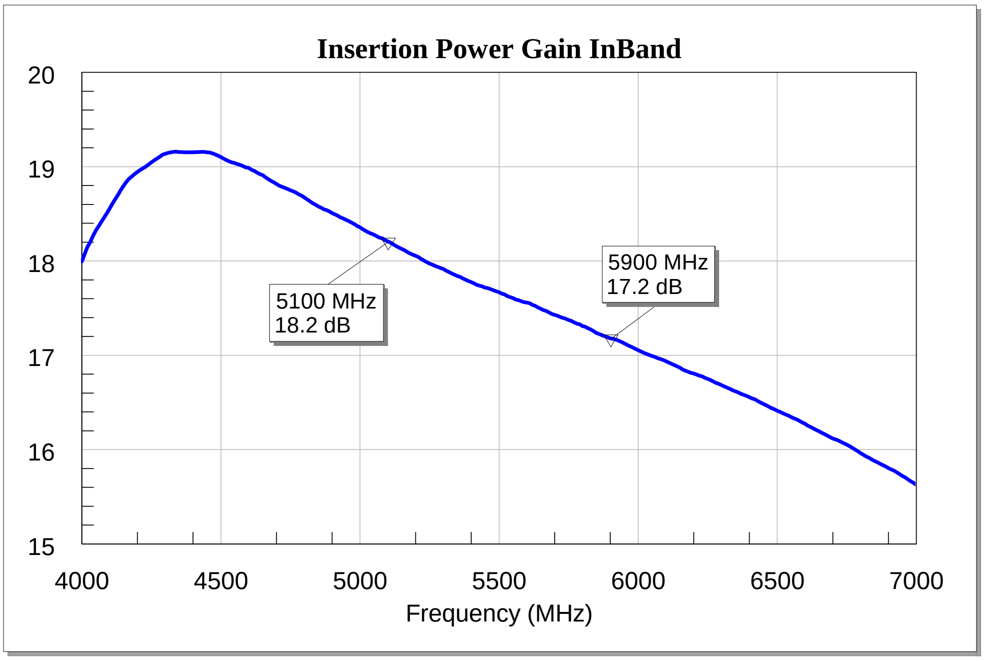

Figure 3 Insertion Power Gain of the 5-6 GHz WLAN LNA with BFP840ESD

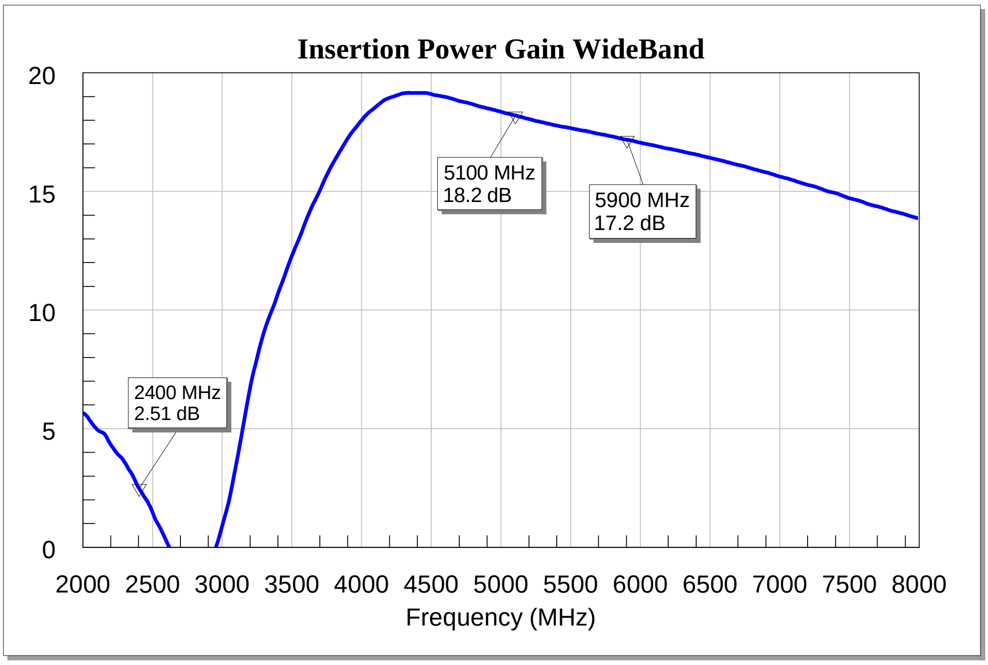

Figure 4 Wideband Insertion Power Gain of the 5-6 GHz WLAN LNA with BFP840ESD

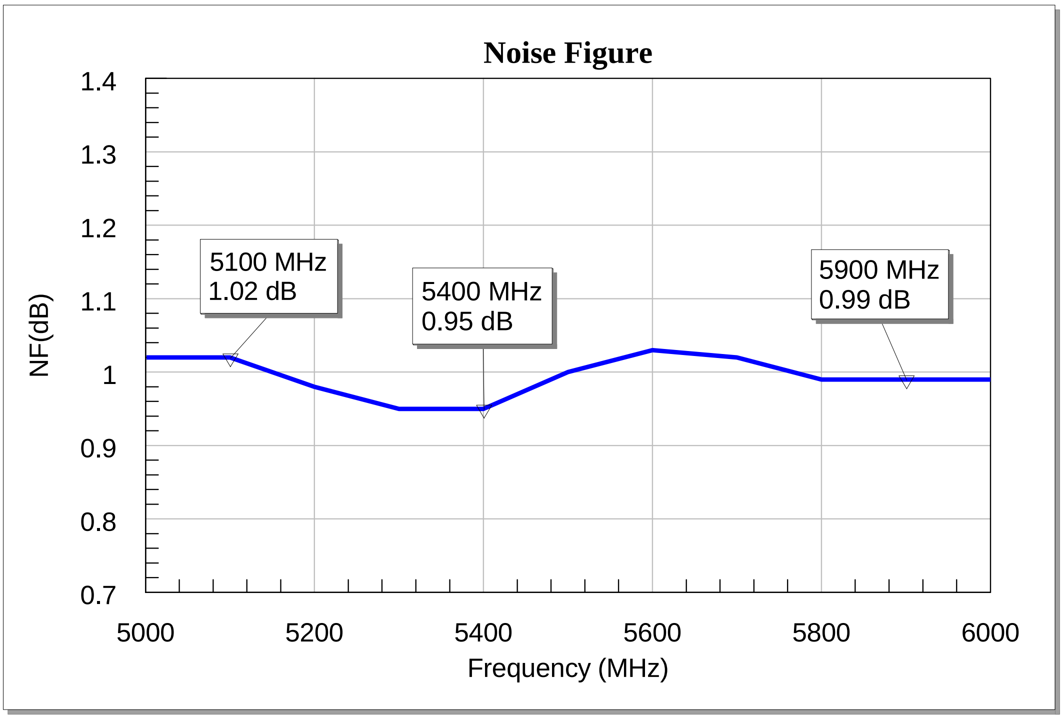

Figure 5 Noise Figure of BFP840ESD LNA for 5100 - 5900 MHz

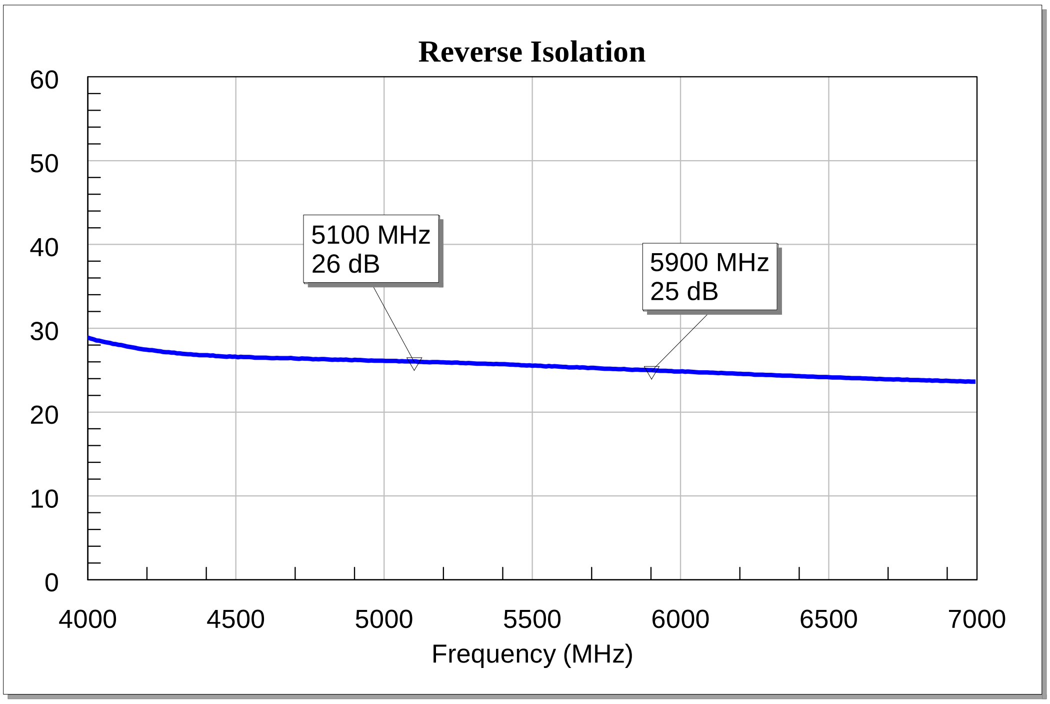

Figure 6 Reverse Isolation of the 5-6 GHz WLAN LNA with BFP840ESD

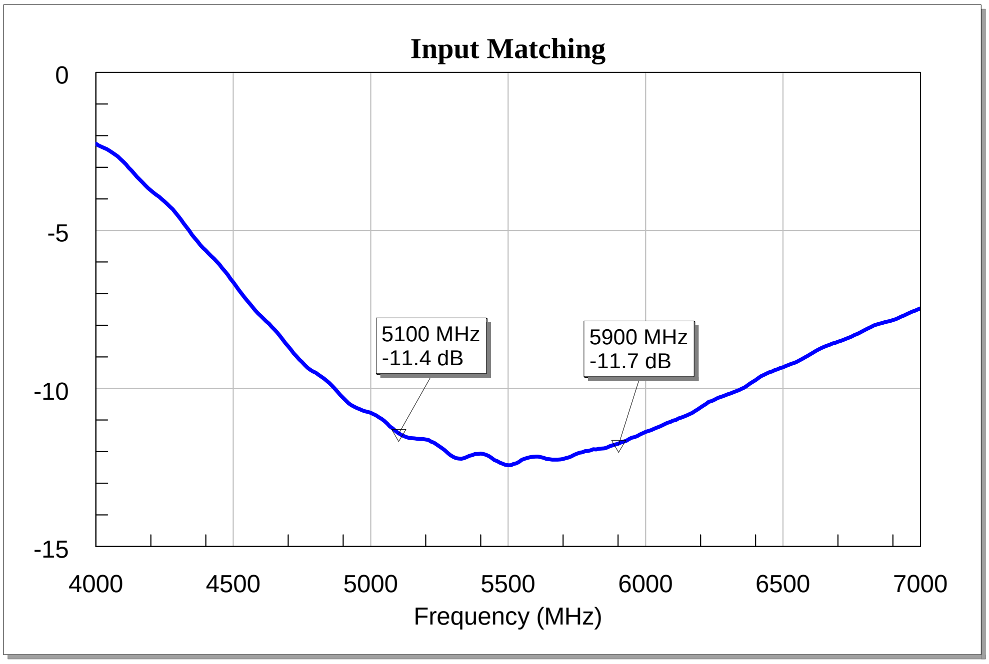

Figure 7 Input Matching of the 5-6 GHz WLAN LNA with BFP840ESD

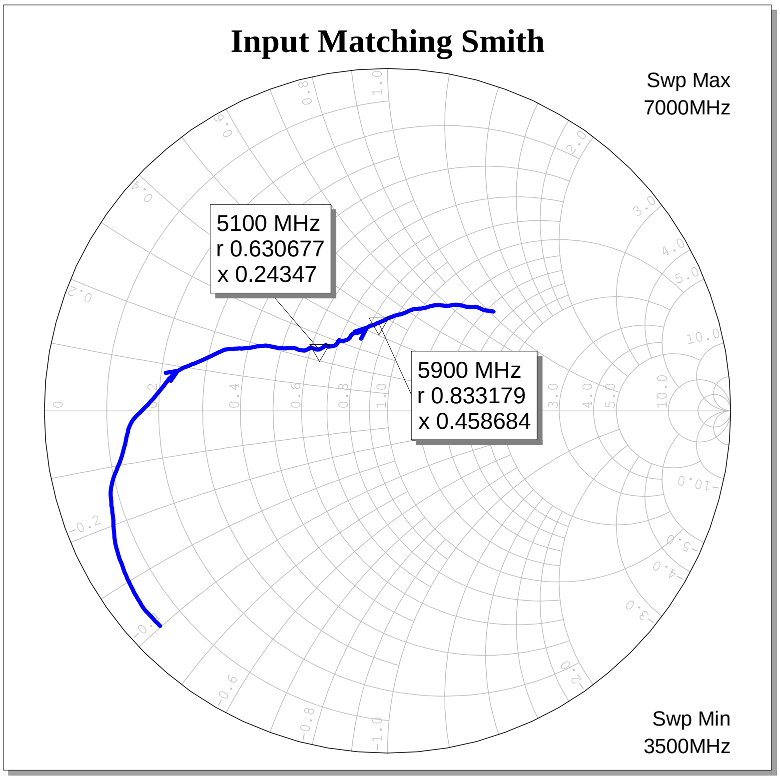

Figure 8 Input Matching of the 5-6 GHz WLAN LNA with BFP840ESD (Smith Chart)

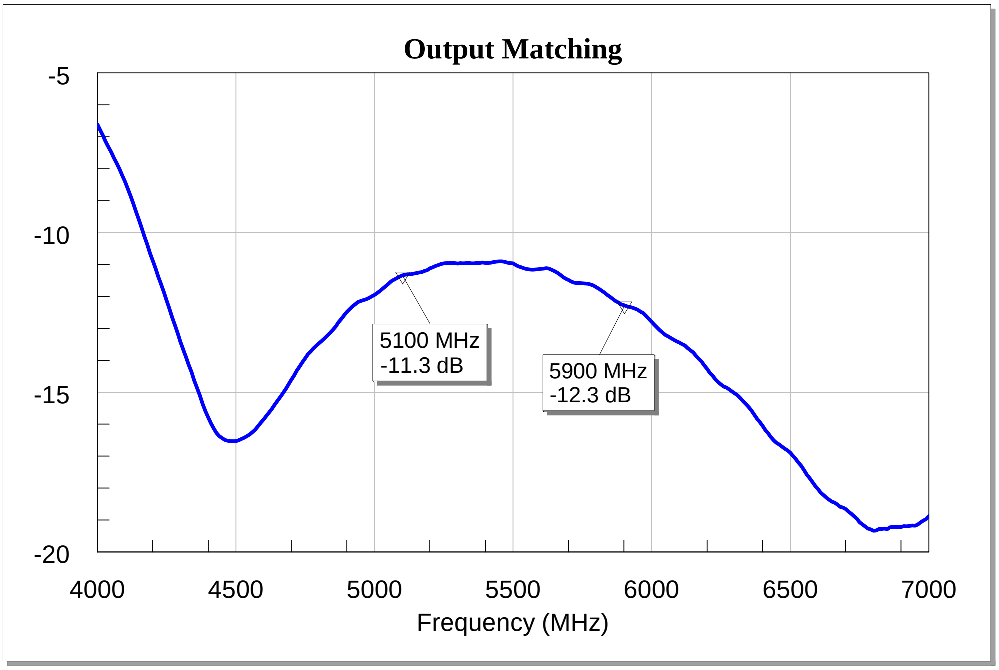

Figure 9 Output Matching of the 5-6 GHz WLAN LNA with BFP840ESD

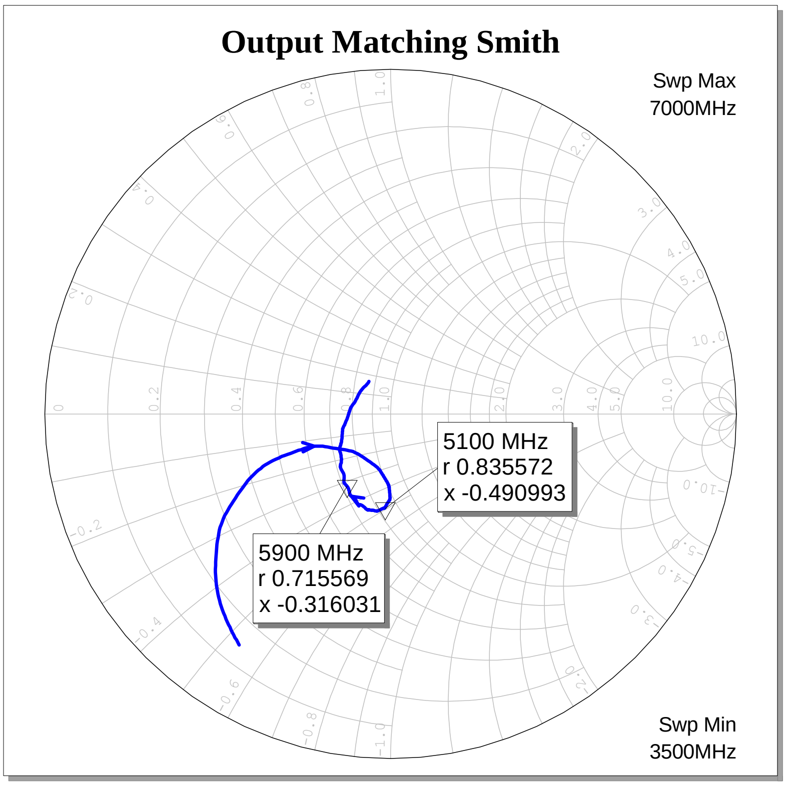

Figure 10 Output Matching of the 5-6 GHz WLAN LNA with BFP840ESD (Smith Chart)

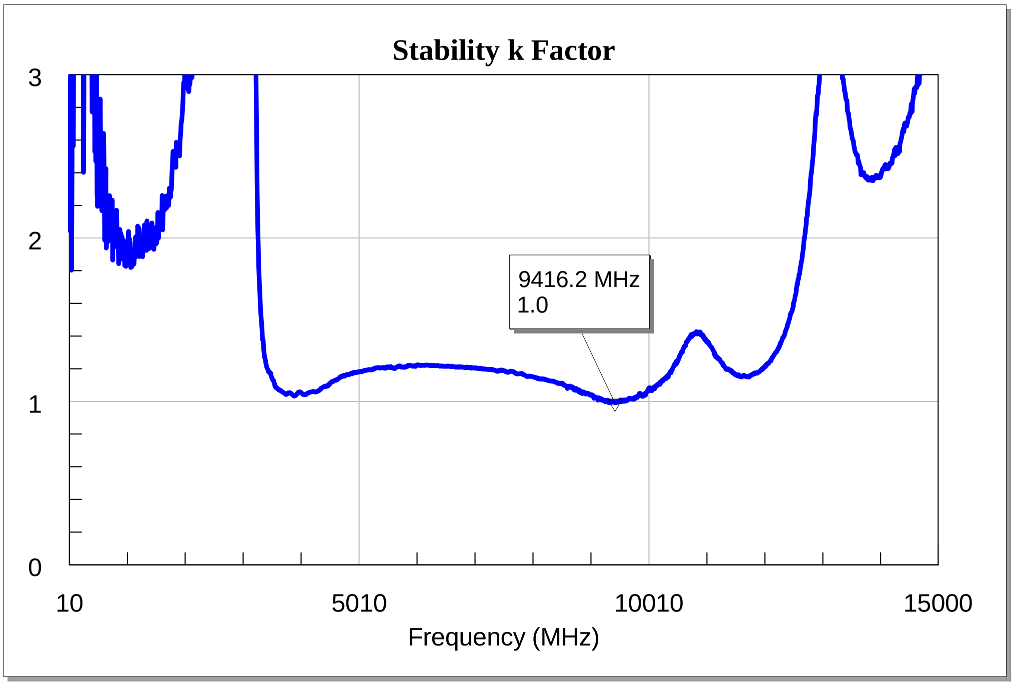

Figure 11 Wideband Stability k Factor of the 5-6 GHz WLAN LNA with BFP840ESD

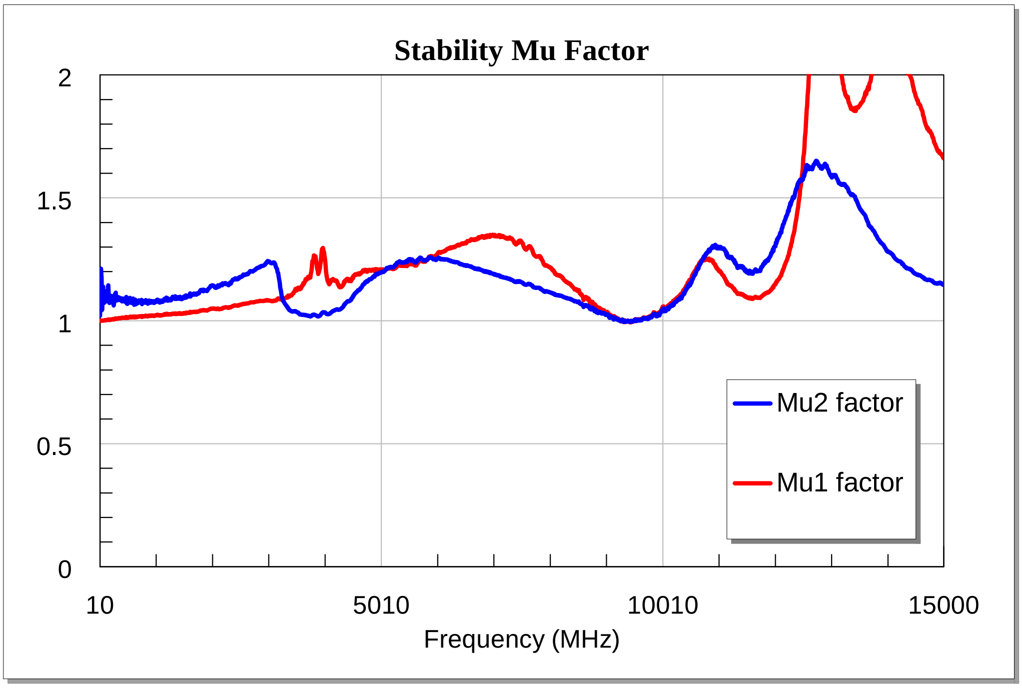

Figure 12 Wideband Stability Mu Factor of the 5-6 GHz WLAN LNA with BFP840ESD

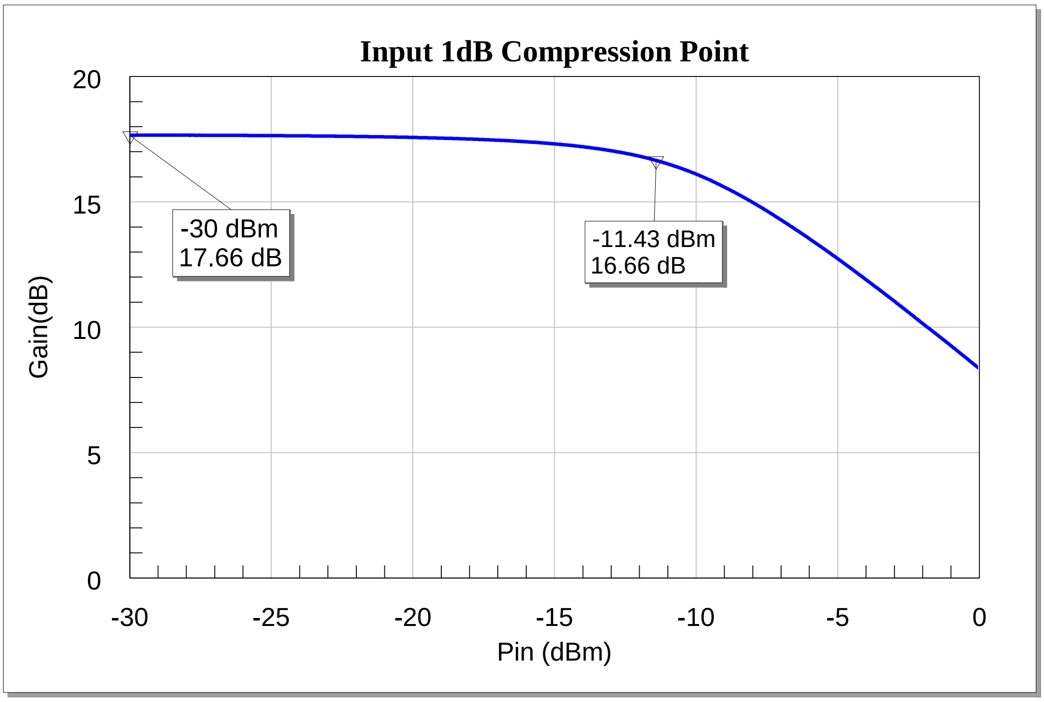

Figure 13 Input 1dB Compression Point of the BFP840ESD Circuit at 5500 MHz

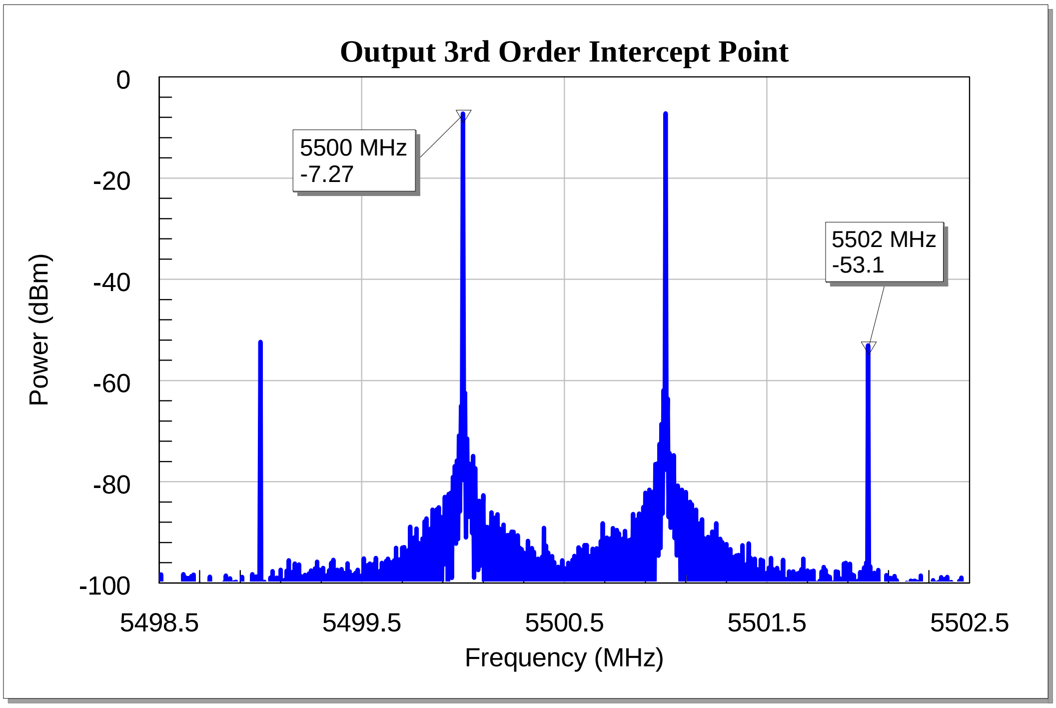

Figure 14 Output 3rd Order Intercept Point of BFP840ESD at 5500 MHz

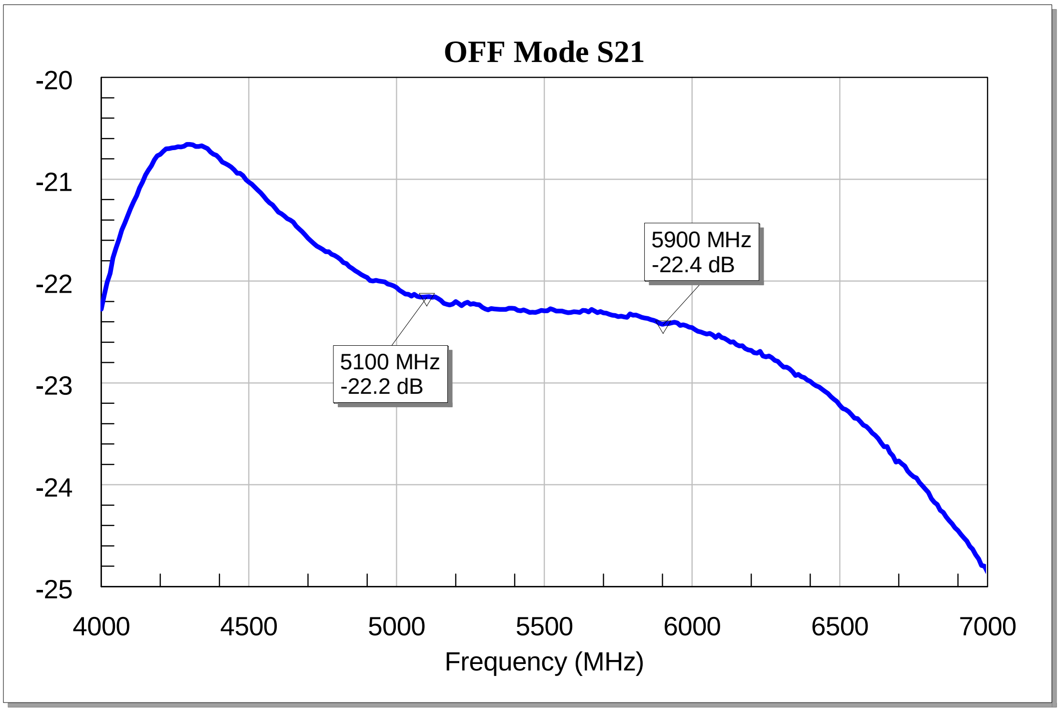

Figure 15 OFF-Mode (Vcc = 0V, Icc = 0mA) S21 of the 5-6 GHz WLAN LNA with BFP840ESD

7 Evaluation Board and Layout Information

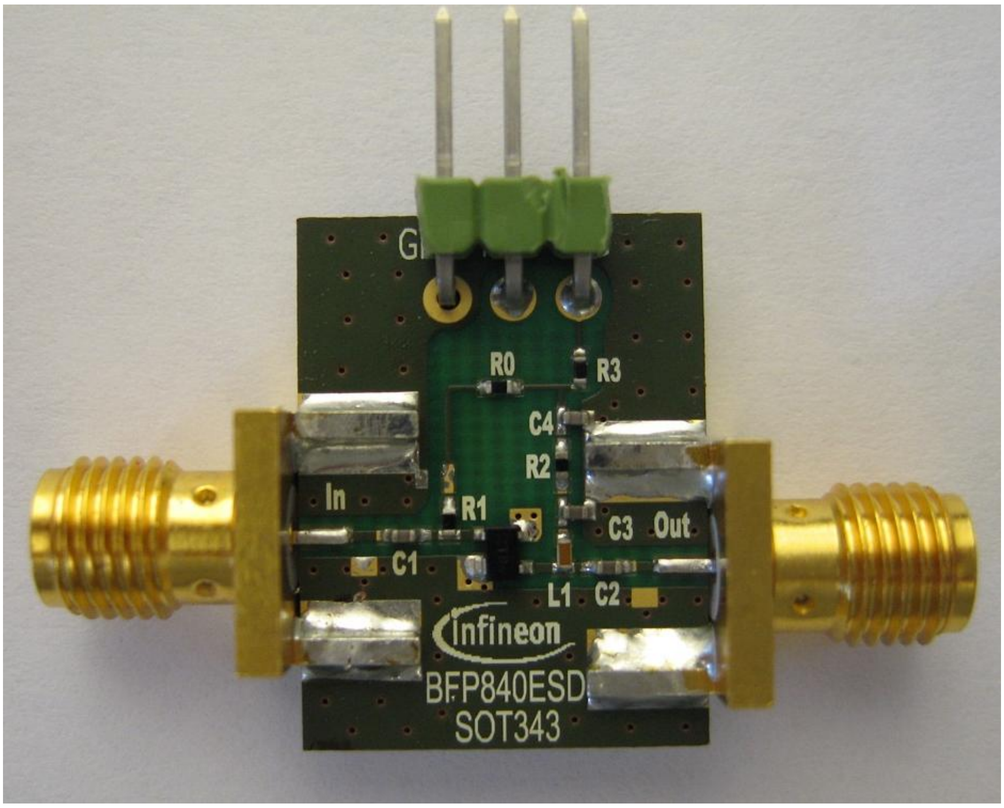

Figure 16 Photo of the BFP840ESD 5-6 GHz WLAN LNA Evaluation Board

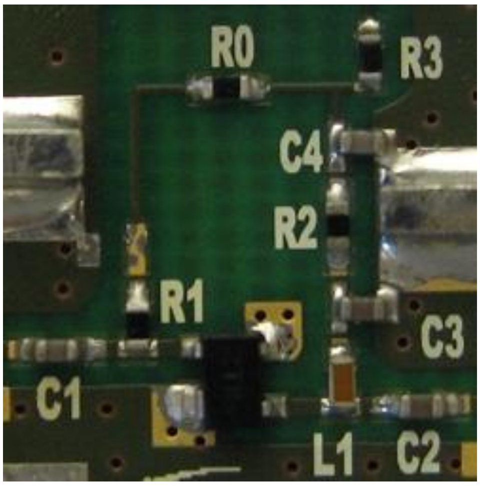

Figure 17 Zoom-In Picture of the BFP840ESD 5-6 GHz WLAN LNA Evaluation Board

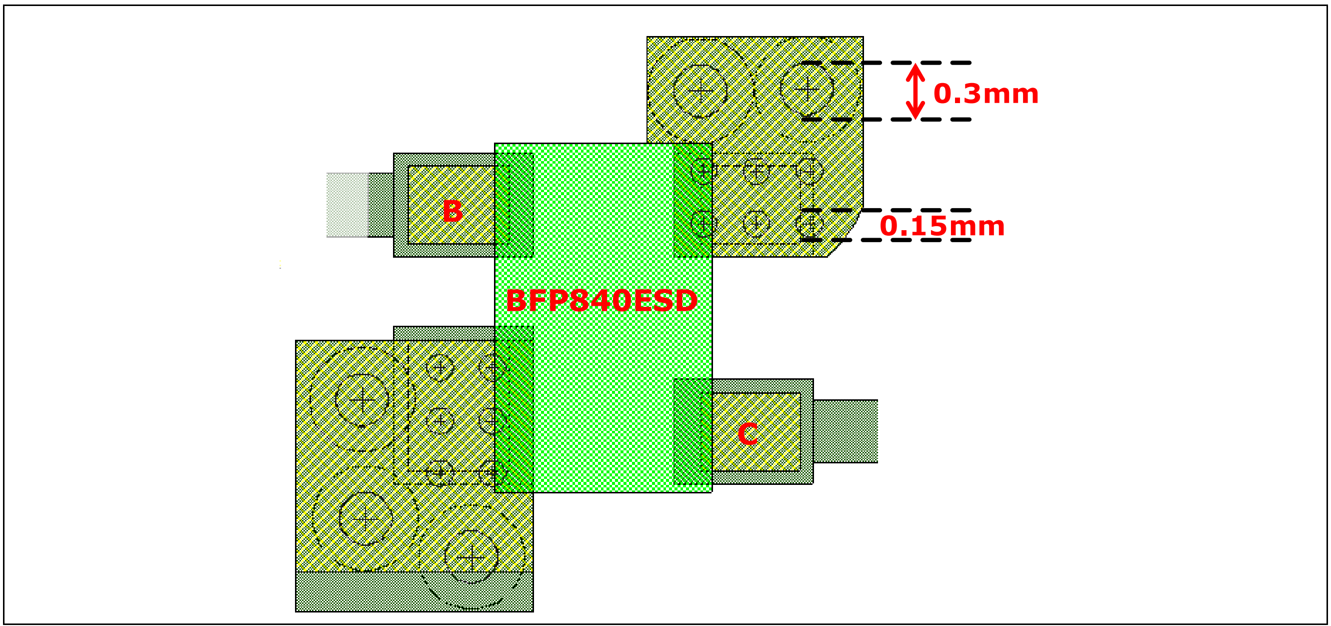

Figure 18 Layout Proposal for RF Grounding of the 5-6 GHz WLAN LNA with BFP840ESD

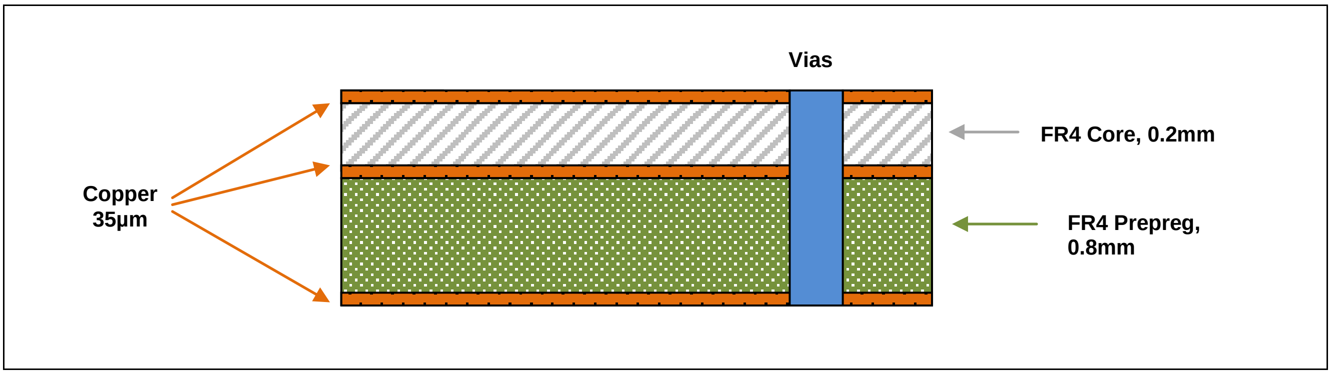

Figure 19 PCB Layer Information

8 Authors

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9 Remark

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

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