BFR840L3RHESD

Low Noise Amplifier with BFR840L3RHESD for 5 to 6 GHz WLAN Including 2.4GHz Rejection using 0201 SMDs

Application Note AN290

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Application Note AN290
Revision History: 2012-06-06

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 (256QAM) 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.

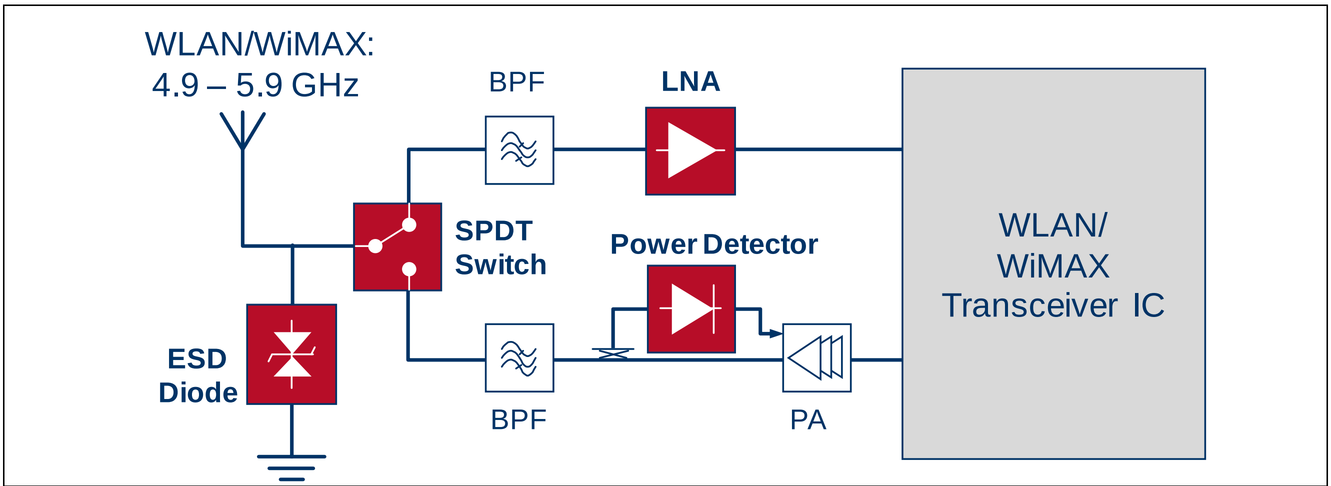

Figure 1 **5 – 6 GHz Wi-Fi® Wireless LAN (WLAN, IEEE802.11a/n/ac) and WiMAX (IEEE802.16e) Front-End**

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: BFR840L3RHESD

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

2 5 to 6 GHz WLAN LNA with 2.4 GHz Rejection using BFR840L3RHESD

This application note presents the measurement results of the Low Noise Amplifier using BFR840L3RHESD for 5100 MHz to 5900 MHz WLAN applications. The circuit schematic 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 10 passive 0201 size SMD components and brings gain from 14.9 dB to 14.4 dB over the frequency band. The noise figure varies from 1.08 dB to 1.03 dB (SMA and PCB losses are subtracted) over the complete frequency band. Moreover, 1dB compression point IP1dB at 2.4 - 2.5 GHz band is more than 0 dBm at input.

The circuit achieves an input and output return loss of 11 dB. Furthermore, the circuit is unconditionally stable from 10 MHz to 11 GHz.

At 5.5 GHz, using two tones spacing of 1 MHz, the output third intercept point OIP3 reaches 16.3 dBm. Besides, we obtain 1dB input compression point IP1dB of -8.3 dBm.

3 Overview

Device: BFR840L3RHESD
Application: Low Noise Amplifier for 5 to 6 GHz WLAN with 2.4 GHz Rejection
PCB Marking: BFR840L3RHESD TSLP-3-9 **M120510**

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	9.2				mA	
Frequency Range	Freq	2500	5100	5500	5900	MHz	
Gain	G	1.6	14.9	14.5	14.4	dB	
Noise Figure	NF		1.05	1.03	1.05	dB	SMA and PCB losses (~0.15 dB) are subtracted
Input Return Loss	RLin		11.9	11.7	11	dB	
Output Return Loss	RLout		15	18.3	21	dB	
Reverse Isolation	IRev		22.9	22.4	21.8	dB	
Input P1dB	IP1dB	**0**		-8.3		dBm	
Output P1dB	OP1dB	**0.6**		+5.2		dBm	
Input IP3	IIP3	+1.8				dBm	
Output IP3	OIP3	+16.3				dBm	Power @ Input: -25 dBm f_1= 5500 MHz, f_2= 5501 MHz
Stability	k	> 1.0				--	Stability measured from 10MHz to 11GHz

5 Schematics

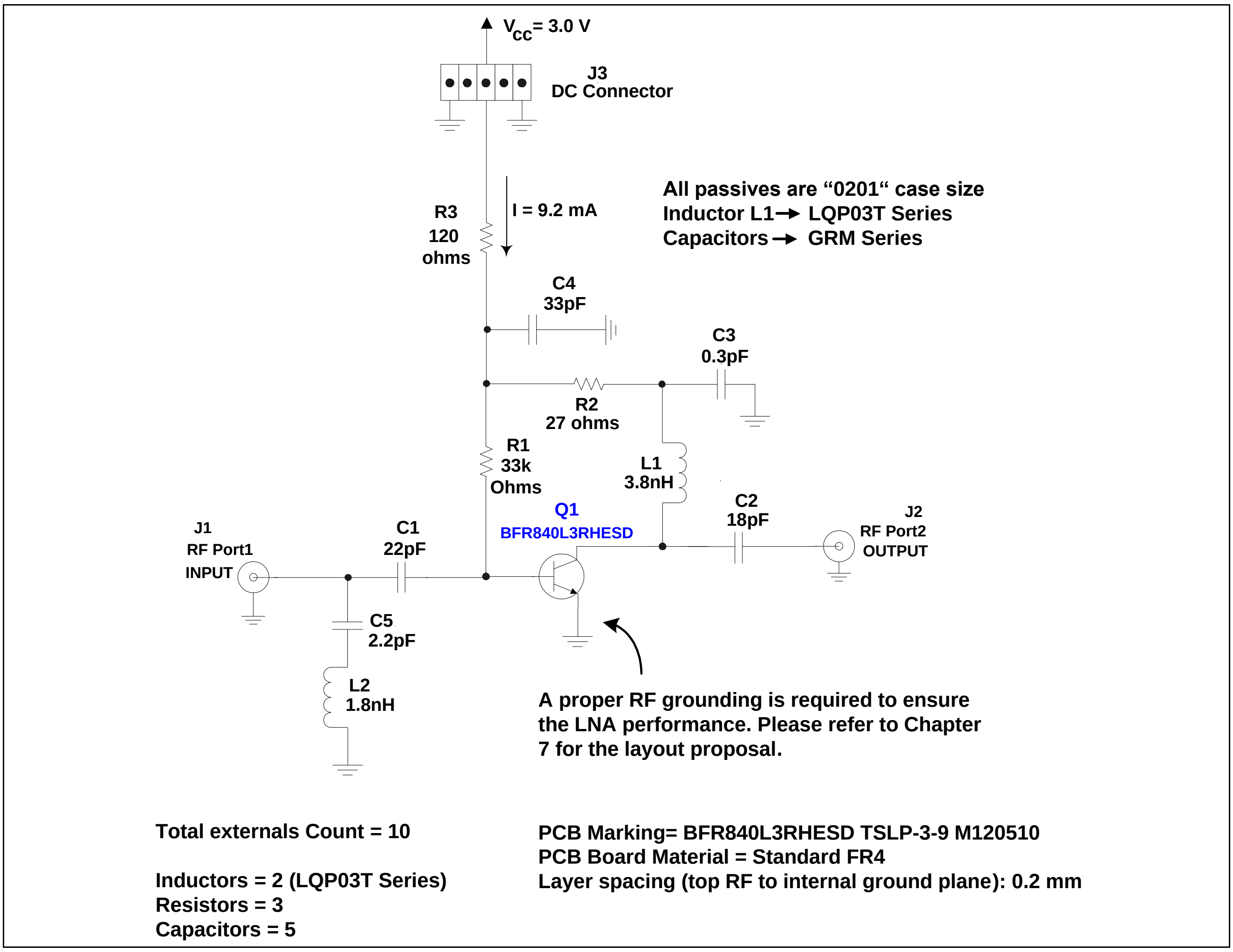

Figure 2 Schematic Diagram of the used Circuit

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	22	pF	0201	Various	Input DC block
C2	18	pF	0201	Various	Output DC block
C3	0.3	pF	0201	Various	Output matching. Influence the input matching as well.
C4	33	pF	0201	Various	RF decoupling / blocking cap
C5	2.2	pF	0201	Various	2.4 GHz rejection
L1	3.8	nH	0201	Murata LQP03T series	Output matching and biasing to the Collector
L2	1.8	nH	0201	Murata LQP03T series	2.4 GHz rejection
R1	33	kΩ	0201	Various	DC biasing
R2	27	Ω	0201	Various	Stability improvement
R3	120	Ω	0201	Various	DC biasing (provides DC negative feedback to stabilize DC operating point over temperature variation, transistor h_{FE} variation, etc.)
Q1			TSLP-3-9	Infineon Technologies	BFR840L3RHESD SiGe:C Heterojunction Bipolar RF Transistor

6 Measured Graphs

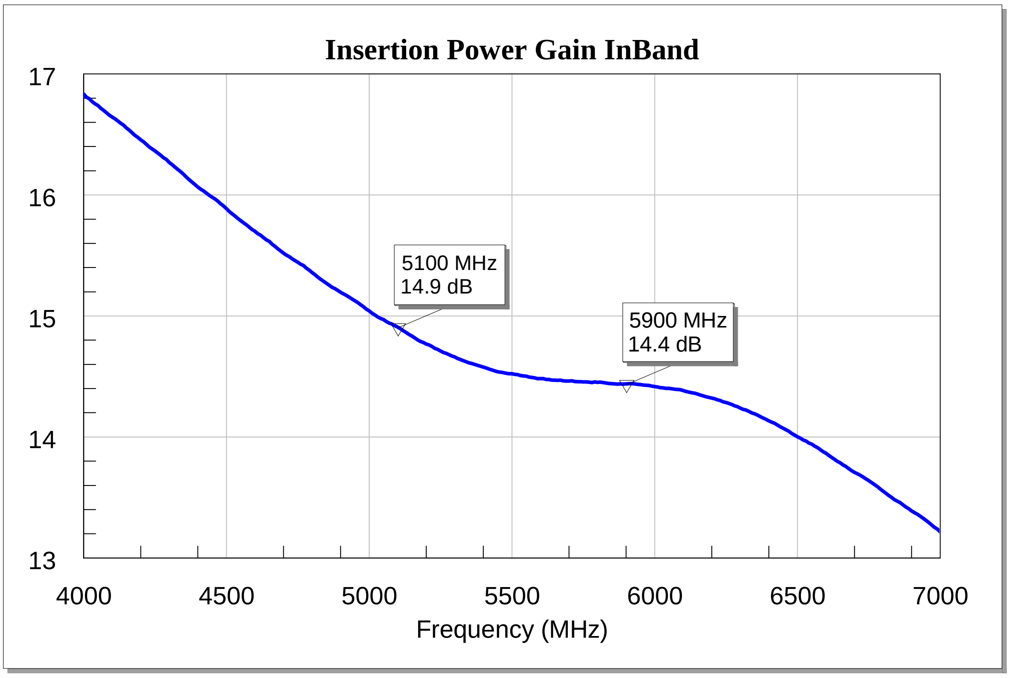

Figure 3 Insertion Power Gain of the 5-6 GHz WLAN LNA with BFR840L3RHESD

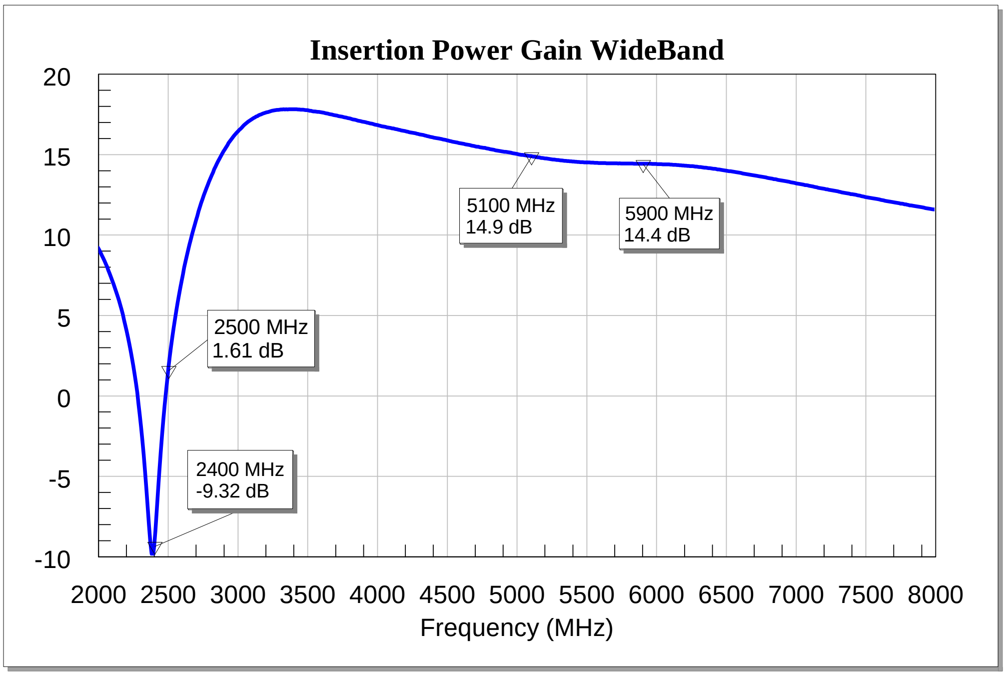

Figure 4 Wideband Insertion Power Gain of the 5-6 GHz WLAN LNA with BFR840L3RHESD

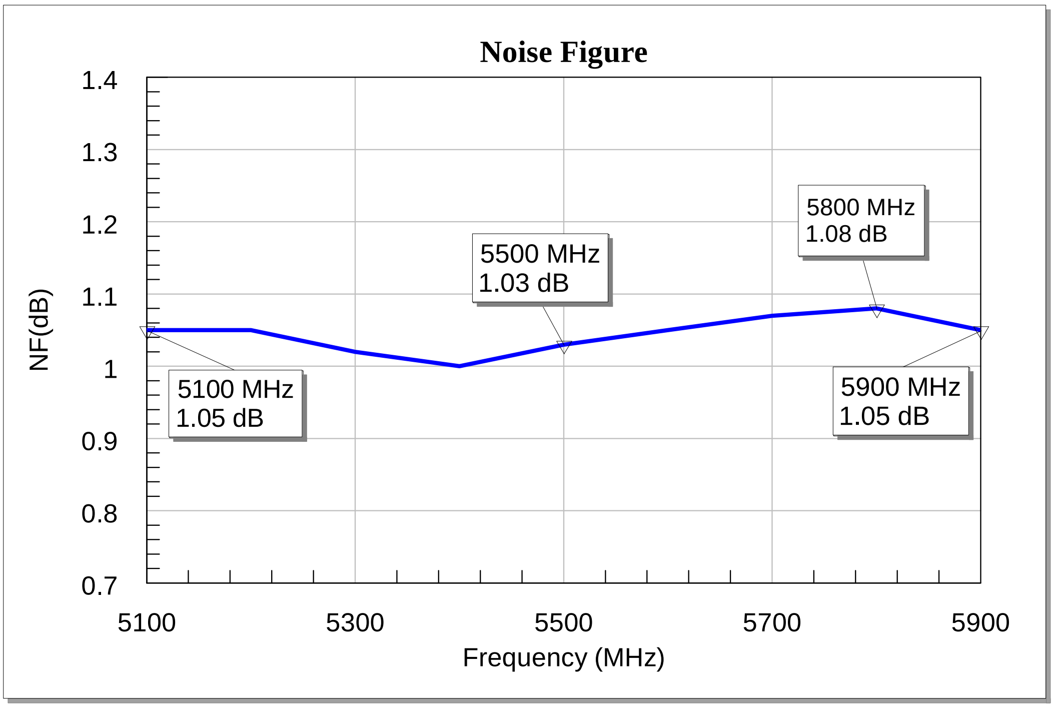

Figure 5 Noise Figure of BFR840L3RHESD LNA for 5100 - 5900 MHz

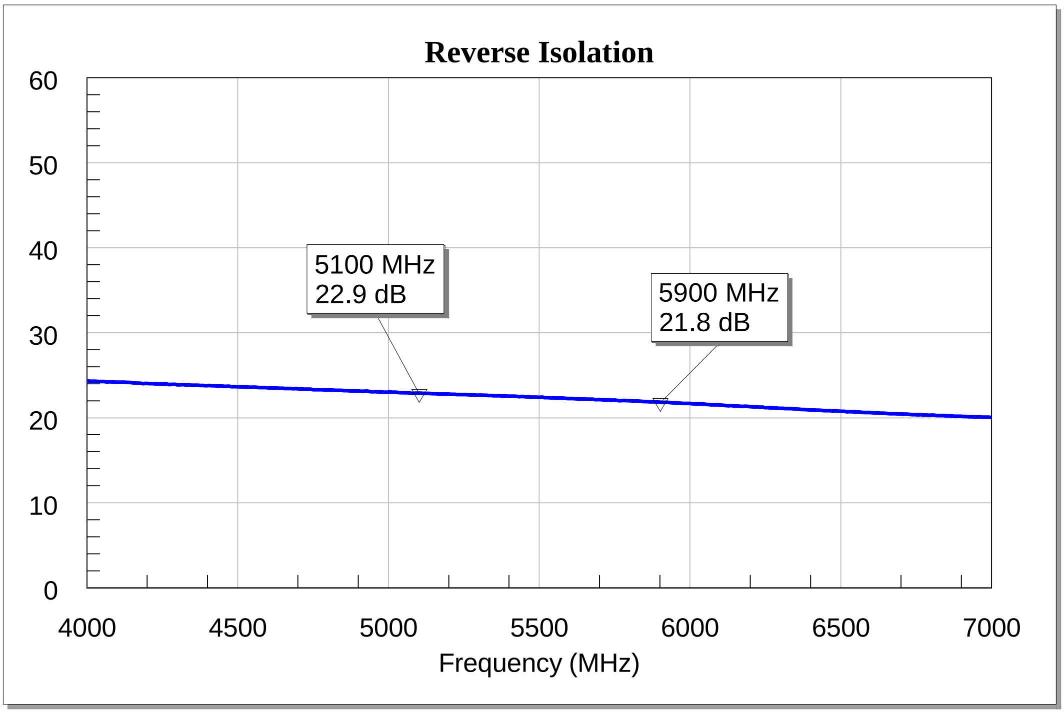

Figure 6 Reverse Isolation of the 5-6 GHz WLAN LNA with BFR840L3RHESD

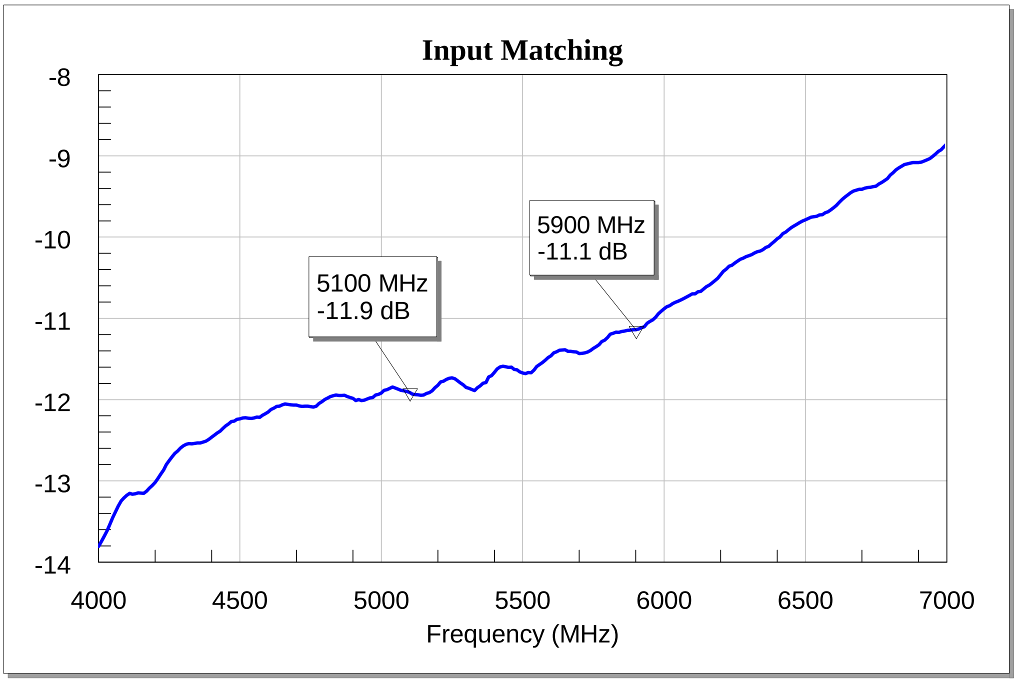

Figure 7 **Input Matching of the 5-6 GHz WLAN LNA with BFR840L3RHESD**

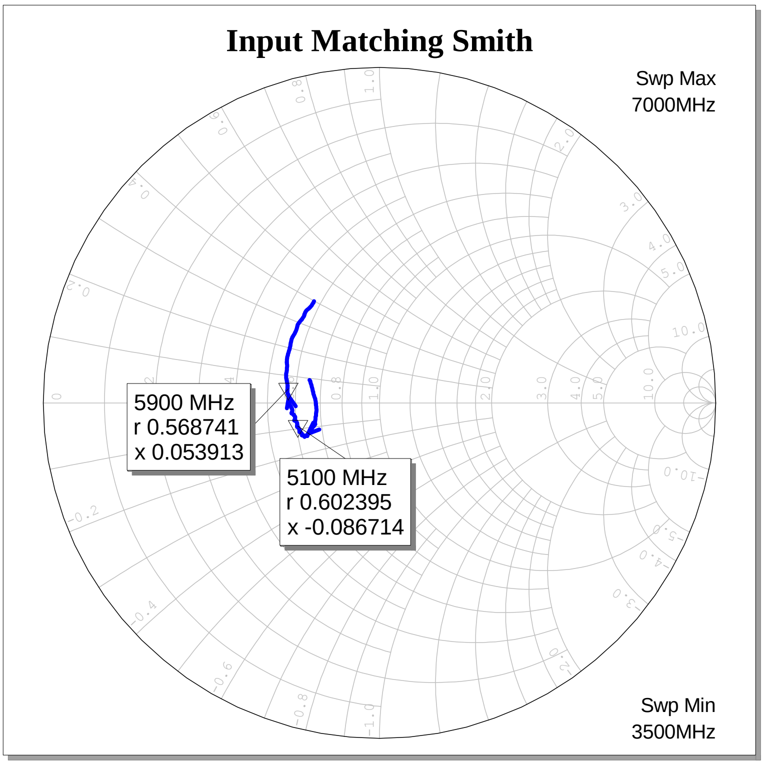

Figure 8 **Input Matching of the 5-6 GHz WLAN LNA with BFR840L3RHESD (Smith Chart)**

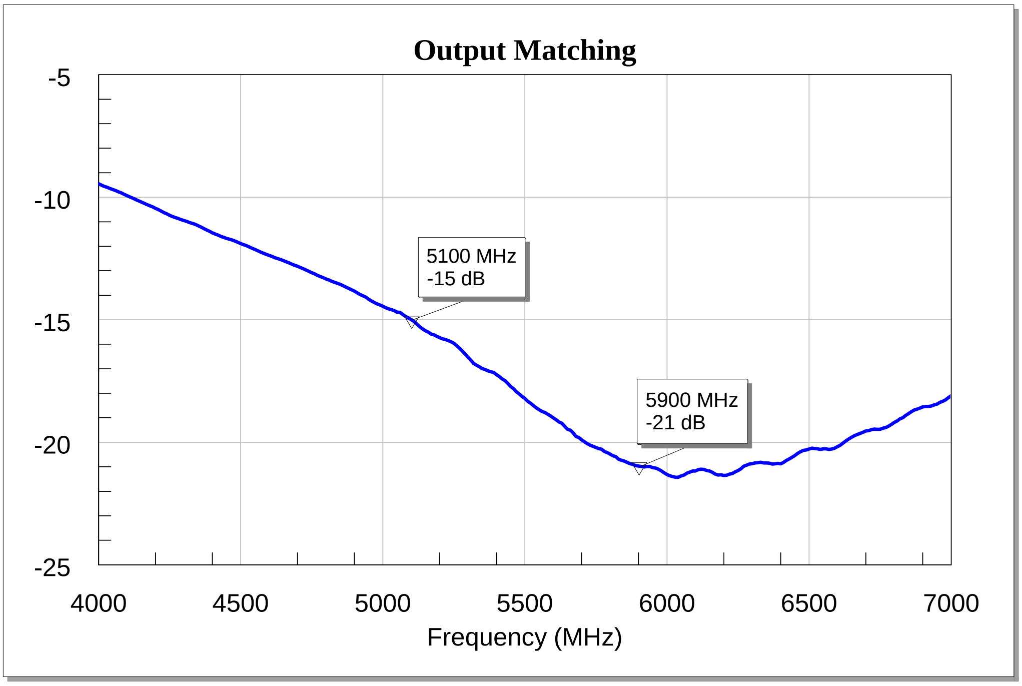

Figure 9 Output Matching of the 5-6 GHz WLAN LNA with BFR840L3RHESD

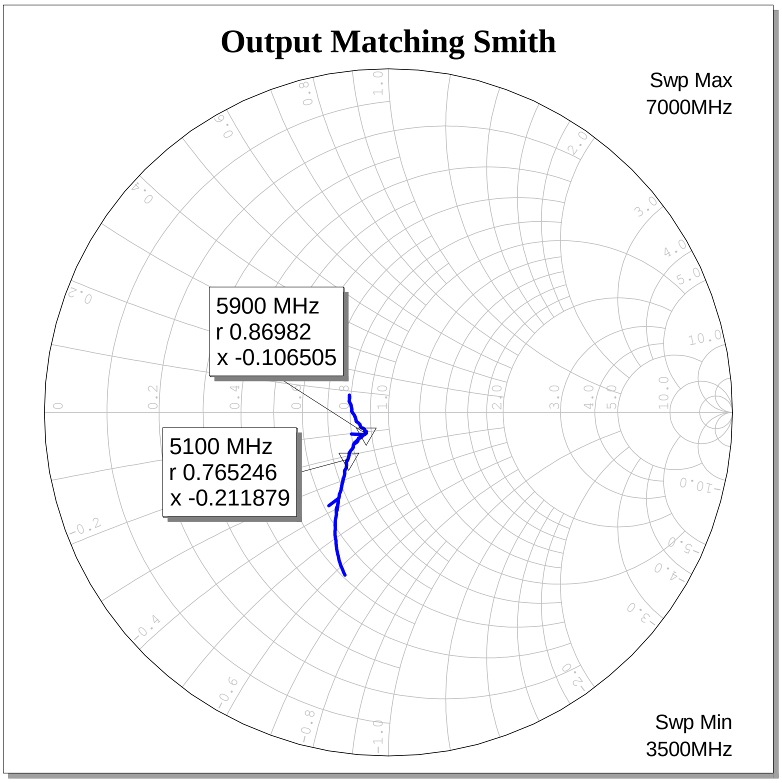

Figure 10 Output Matching of the 5-6 GHz WLAN LNA with BFR840L3RHESD (Smith Chart)

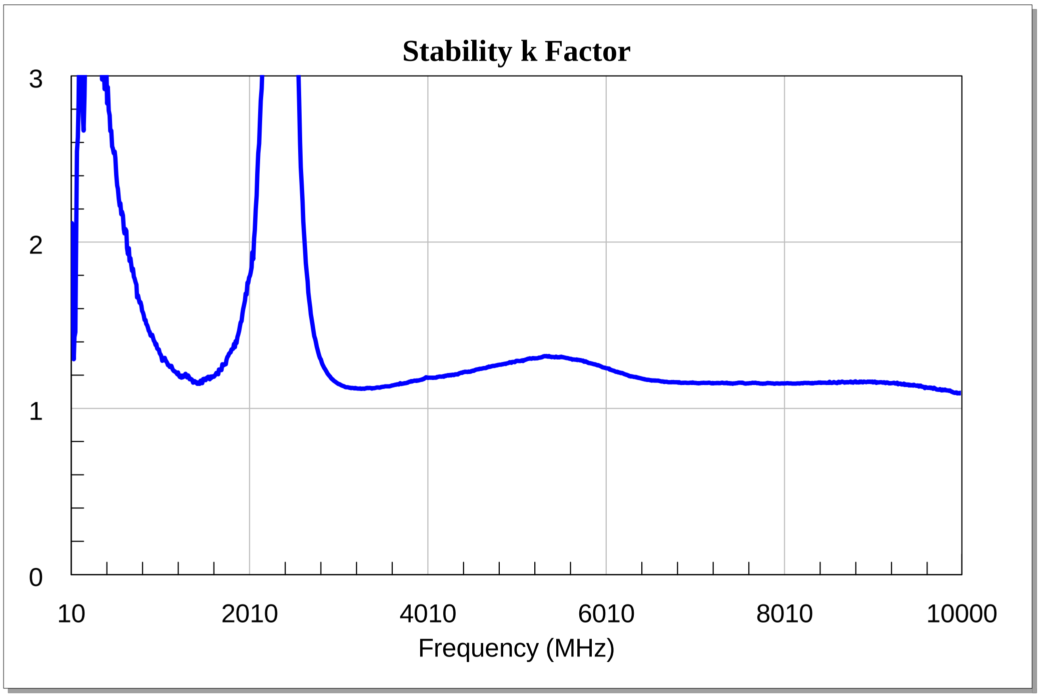

Figure 11 Wideband Stability k Factor of the 5-6 GHz WLAN LNA with BFR840L3RHESD

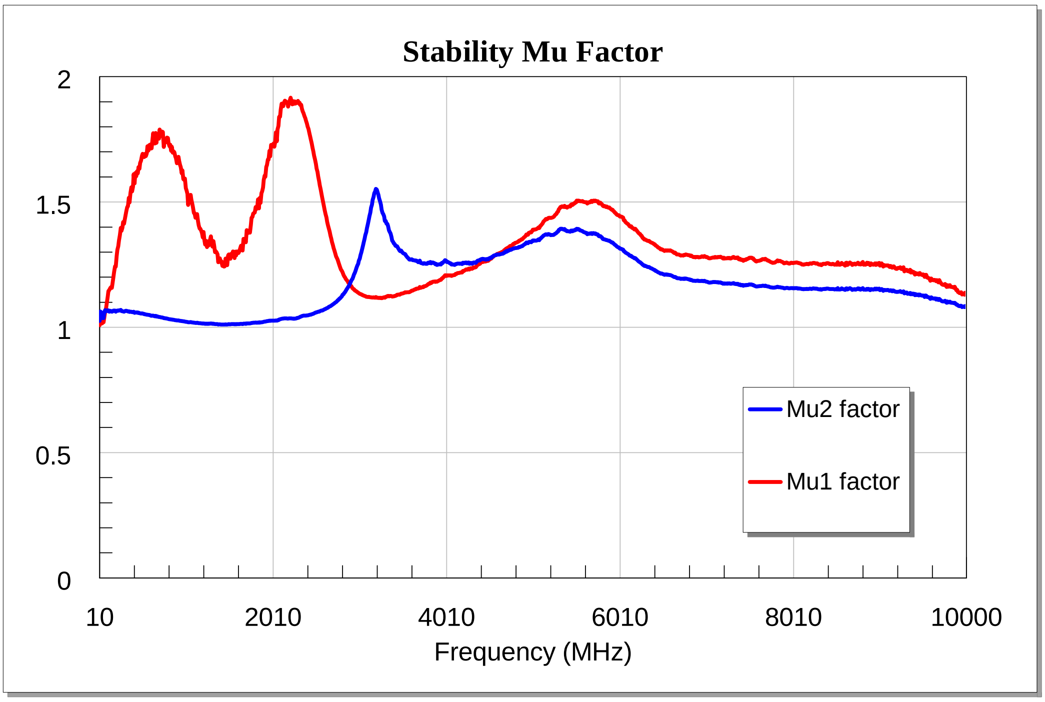

Figure 12 Wideband Stability Mu Factor of the 5-6 GHz WLAN LNA with BFR840L3RHESD

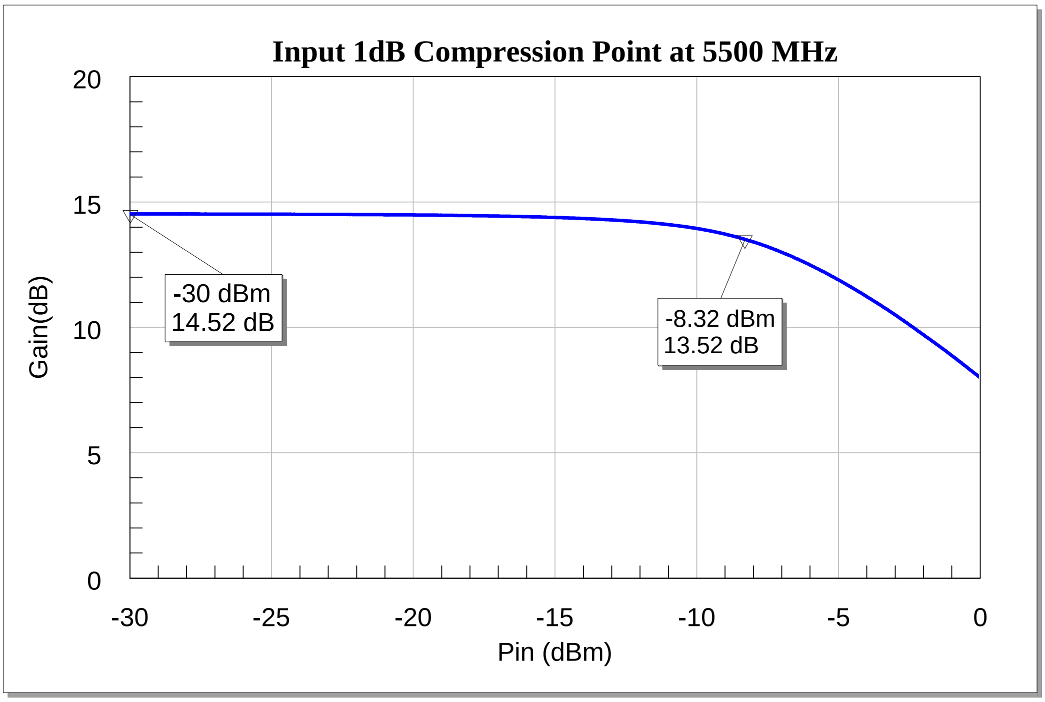

Figure 13 Input 1dB Compression Point of the BFR840L3RHESD Circuit at 5500 MHz

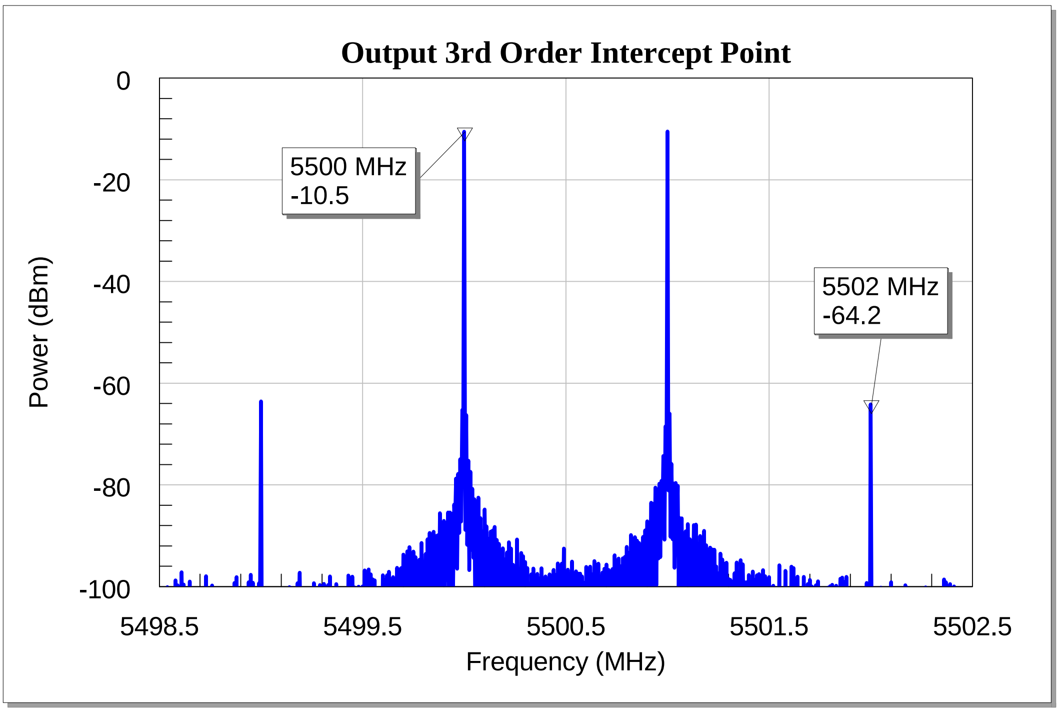

Figure 14 Output 3rd Order Intercept Point of BFR840L3RHESD at 5500 MHz

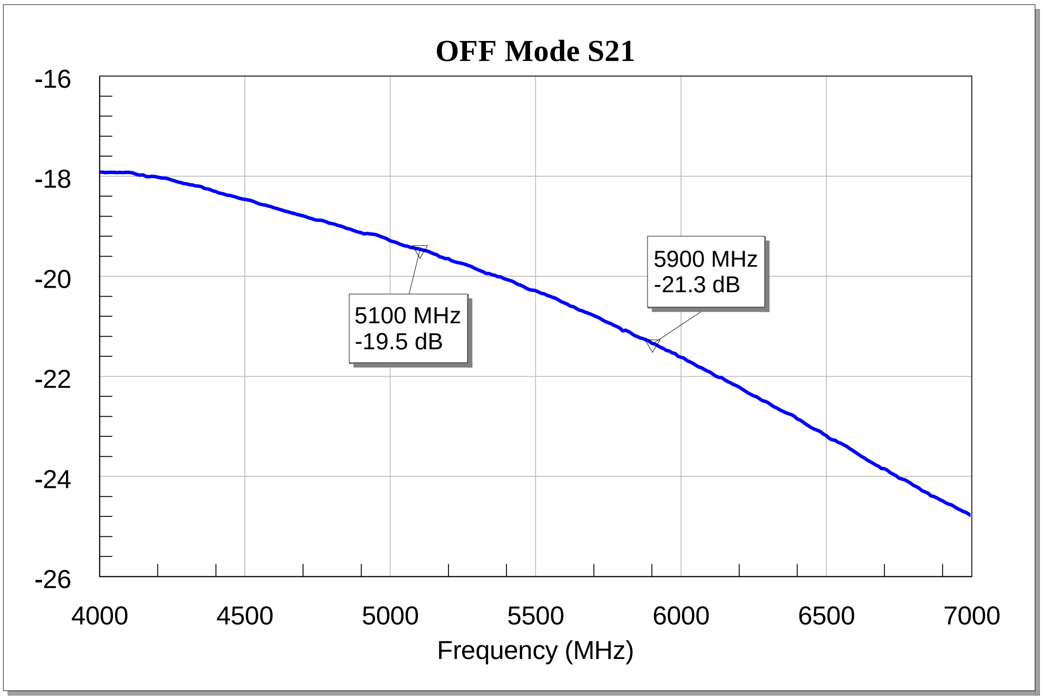

Figure 15 **OFF-Mode (Vcc = 0V, Icc = 0mA) S21 of the 5-6 GHz WLAN LNA with BFR840L3RHESD**

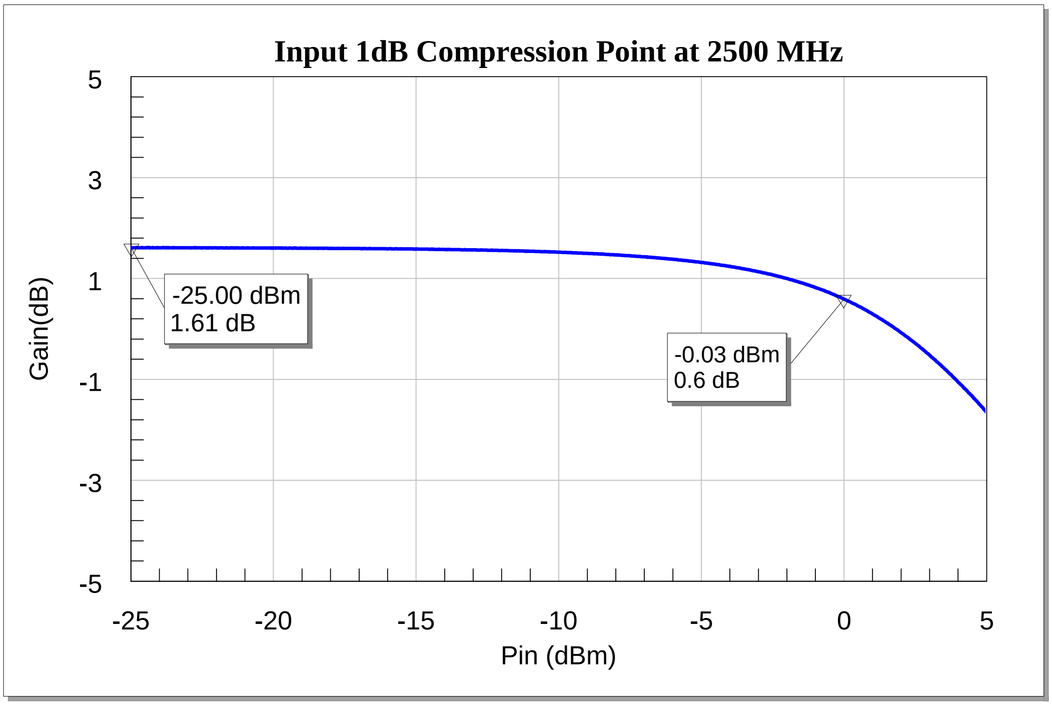

Figure 16 **Input 1dB Compression Point of the BFR840L3RHESD Circuit at 2500 MH**

7 Evaluation Board and Layout Information

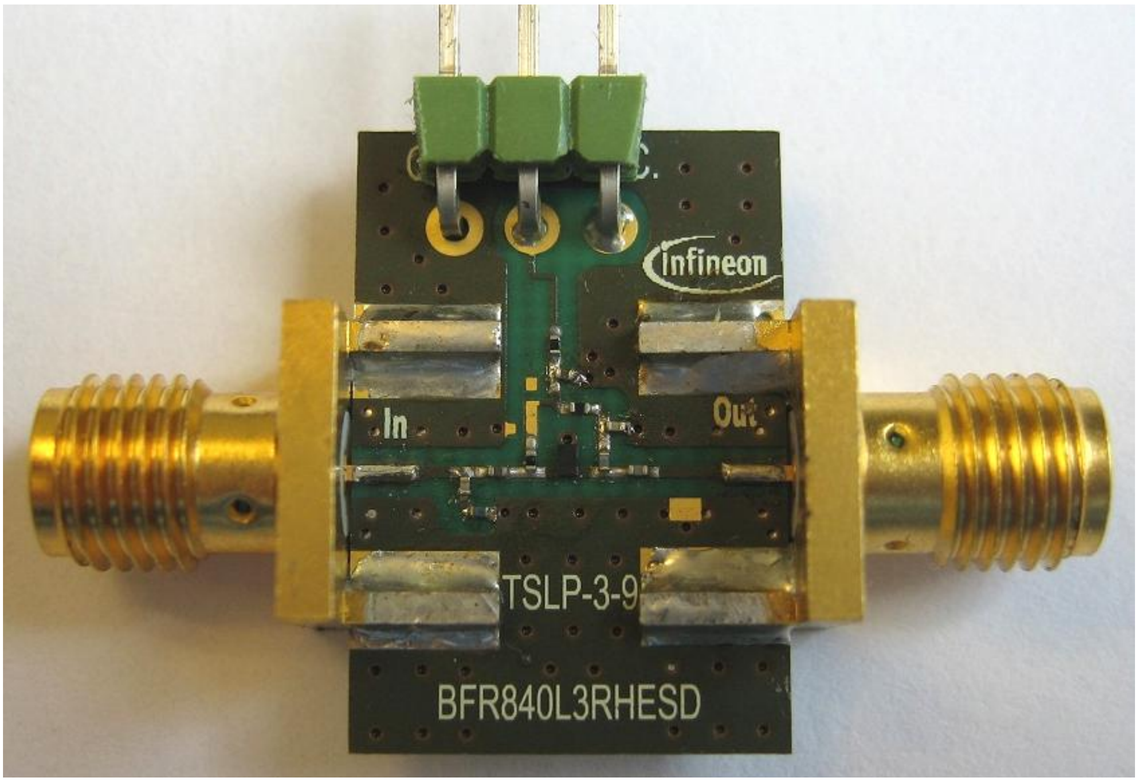

Figure 17 Photo of the BFR840L3RHESD 5-6 GHz WLAN LNA Evaluation Board

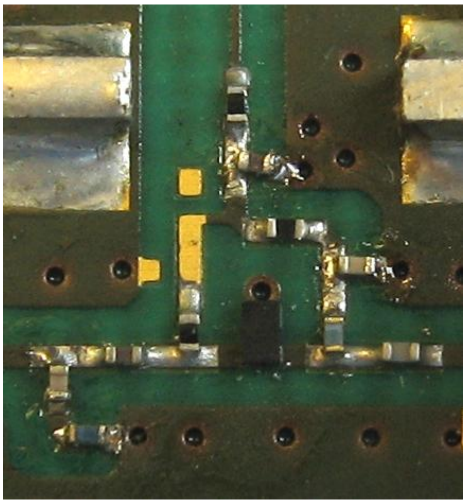

Figure 18 Zoom-In on the BFR840L3RHESD 5-6 GHz WLAN LNA Evaluation Board

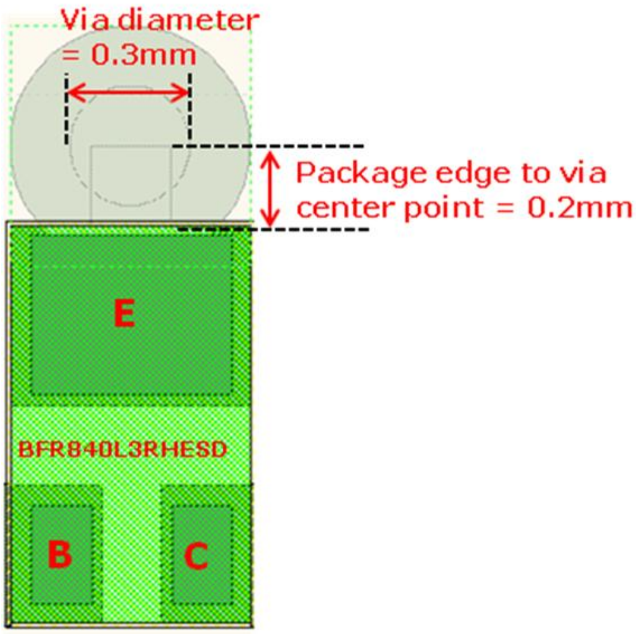

Figure 19 Layout Proposal for RF Grounding of the 5-6 GHz WLAN LNA with BFR840L3RHESD

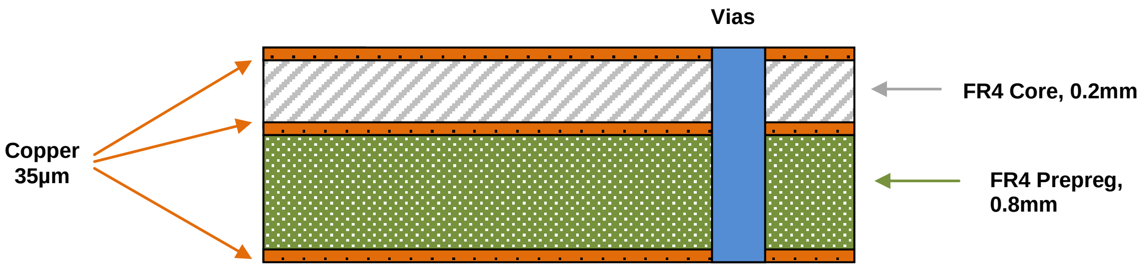

Figure 20 PCB Layer Information

8 Authors

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9 Remark

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

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