BFR840L3RHESD

Low Parts Count Low Noise Amplifier for 5 to 6 GHz WLAN with BFR840L3RHESD using 0201 SMDs

Application Note AN281

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Revision History: 2012-03-16

Previous Revision: No previous revision

Page	Subjects (major changes since last revision)

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1 Introduction

1.1 Wi-Fi®

The Wi-Fi® function is one of the most important connectivity functions in Access Point (AP) routers, notebooks, smart phones and tablet PCs. Wi-Fi® according to IEEE 802.11b/g at 2.4 GHz has been widely implemented over years. Due to the cloudy WLAN network at 2.4 GHz, the Wi-Fi® applications also at 5 – 6 GHz according to IEEE 802.11n and IEEE 802.11ac are gaining focus. Also, 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 connection.

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.

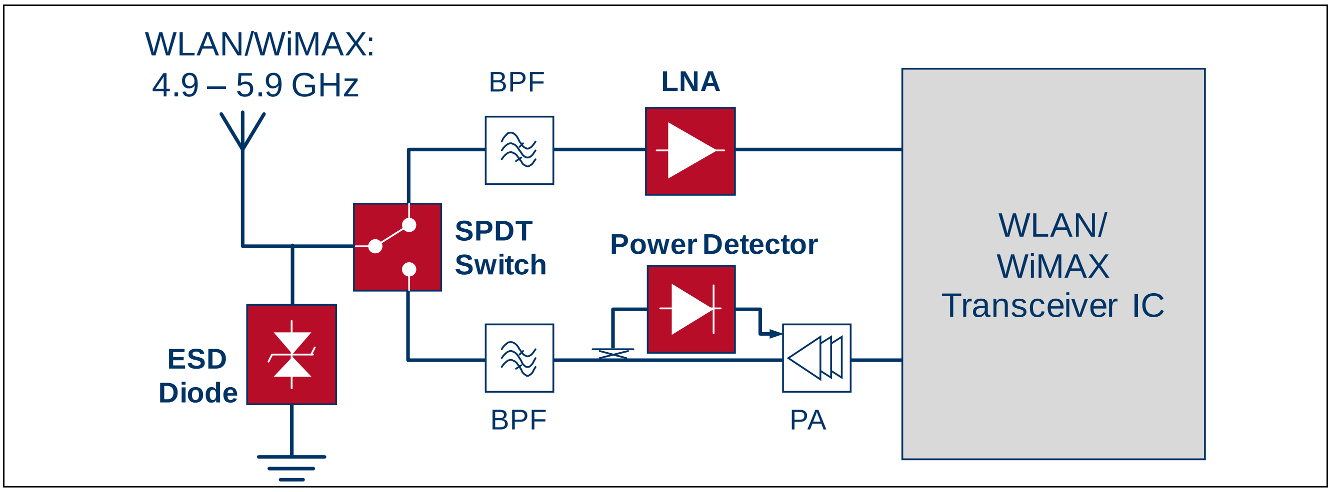

Figure 1 5 – 6 GHz Wi-Fi® Wireless LAN (WLAN, IEEE802.11a/n) and WiMAX (IEEE802.16e) Front-End

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 overall system Noise Figure (NF) of the receiver chain of approx. 2 dB can only be achieved by using a high-gain low noise amplifier. As an example, to increase the sensitivity by 5 dB means doubled link distance.

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.

The cloudy wireless environment nowadays makes the wireless system design more complicated. All kinds of interference might introduce signal distortion and reduce the real throughput data rate. To ensure that the low noise amplifier is not interfered by those signals good linearity characteristics like high IP3 are required.

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 high end ultra low noise SiGe:C Heterojunction Bipolar RF Transistor (HBT) BFR840L3RHESD has been developed using Infineon's latest B9HFM technology. This technology has been specifically designed for WiFi applications between 5 and 6 GHz. The BFR840L3RHESD is available in the extremely small and leadless TSLP-3-9 package (0.31mm height) and is especially suitable for portable battery-powered applications in which reduced power consumption and small size is a key requirement. 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 SiGe:C RF transistor BFR740L3RH. On top of that the BFR840L3RHESD has an integrated 1.5kV HBM ESD protection which makes the device robust against electrostatic discharge and extreme RF input power. Moreover the Gamma Opt point (location of optimum source impedance for minimum noise figure) at 5 to 6 GHz is located close to 50 Ohm which enables to achieve input matching without any external matching component.

BFR840L3RHESD is also available in other packages, e.g. BFP840ESD (SOT343), BFP840FESD (TSFP-4-1).

Low Parts Count Low Noise Amplifier for 5 to 6 GHz WLAN with BFR840L3RHESD using 0201 SMDs

2 Low Parts Count Low Noise Amplifier for 5 to 6 GHz WLAN with BFR840L3RHESD using 0201 SMDs

This application note presents the measurement results of the Low Noise Amplifier using BFR840L3RHESD SiGe:C Heterojunction Bipolar RF transistor from Infineon Technologies for 5100 MHz to 5900 MHz WLAN applications. The circuit schematic shown in Figure 2 doesn't require any external input matching element. Nevertheless, proper RF grounding on PCB has to be ensured (please refer to Figure 18) in order to achieve the good performance.

It's a low parts count solution which requires only 8 passive 0201 SMD components. The LNA brings gain from 15.5 dB to 14.7 dB over the frequency band from 5100 MHz to 5900 MHz. The gain is approx. 1 dB higher compare to BFR740L3RH 5 – 6 GHZ WLAN LNA (AN170). Since there is no external passive required for matching at the input which is also better for noise figure, we have achieved noise figure as low as 0.92 dB (SMA and PCB losses are subtracted), which is 0.2 dB lower compare to BFR740L3RH 5 – 6 GHZ WLAN LNA (AN170).

Furthermore, this device provides an unconditional stability from 10 MHz to 11 GHz. The circuit is matched at input and output, and presents an input return loss more than 10 dB, and an output return loss more than 12 dB.

Moreover, the LNA consumes 3.5mA less current compare to BFR740L3RH 5 – 6 GHZ WLAN LNA (AN170). At the frequency of 5.5 GHz, using two tones spaced of 1 MHz, the output third intercept point reaches 17 dBm. Besides, we obtain 1dB compression point of -8 dBm at the input at 5.5 GHz.

3 Overview

Device: BFR840L3RHESD

Application: Low Parts Count Low Noise Amplifier for 5 to 6 GHz WLAN with BFR840L3RHESD using 0201 SMDs

PCB Marking: BFR840L3RHESD TSLP-3-9 **M120131**

(PCB designed for 0201 SMDs)

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	9.4			mA	
Frequency Range	Freq	5100	5500	5900	MHz	
Gain	G	15.5	15.1	14.7	dB	
Noise Figure	NF	0.98	0.96	0.92	dB	SMA and PCB losses (0.14 dB) are subtracted
Input Return Loss	RLin	10	11	13	dB	
Output Return Loss	RLout	12	13	14	dB	
Reverse Isolation	IRev	22	21	20	dB	
Input P1dB	IP1dB		-8		dBm	
Output P1dB	OP1dB		+6		dBm	
Input IP3	IIP3	+2			dBm	
Output IP3	OIP3	+17			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

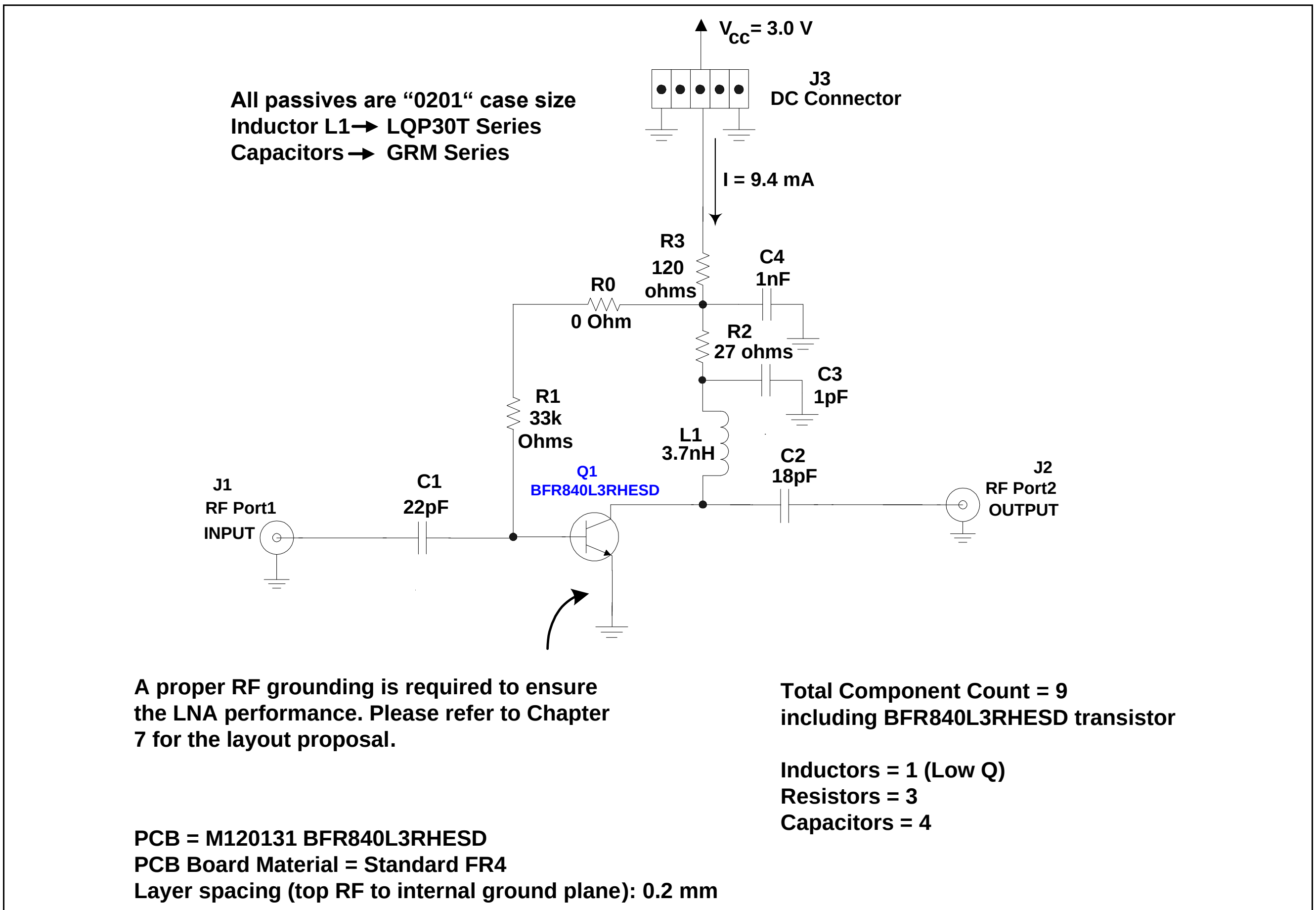

Figure 2 Schematic Diagram of the used Circuit

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	22	pF	0201	Murata GRM0335 series	Input DC block
C2	18	pF	0201	Murata GRM0335 series	Output DC block
C3	1	pF	0201	Murata GRM0335 series	Output matching
C4	1	nF	0201	Murata GRM0335 series	RF decoupling / blocking cap
L1	3.7	nH	0201	Murata LQP30T series	Output matching and biasing to the Collector
R0	0	Ω	0201	Various	Jumper
R1	33	kΩ	0201	Various	DC biasing
R2	27	Ω	0201	Various	Stability improvement
R3	120	Ω	0201	Various	DC biasing (provies 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

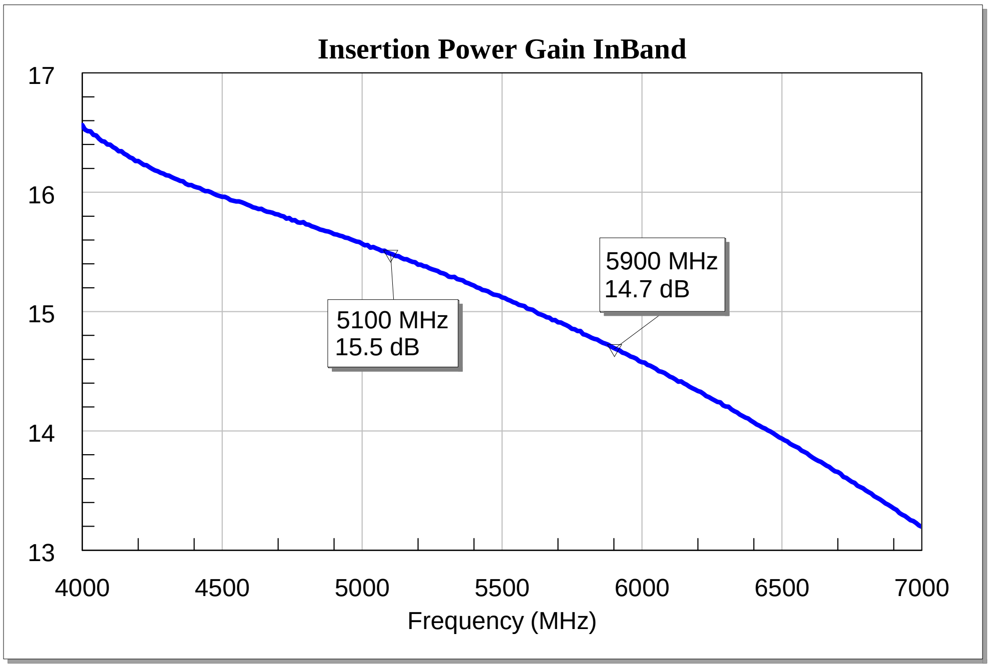

Figure 3 Insertion Power Gain of the 5-6GHz WLAN LNA with BFR840L3RHESD

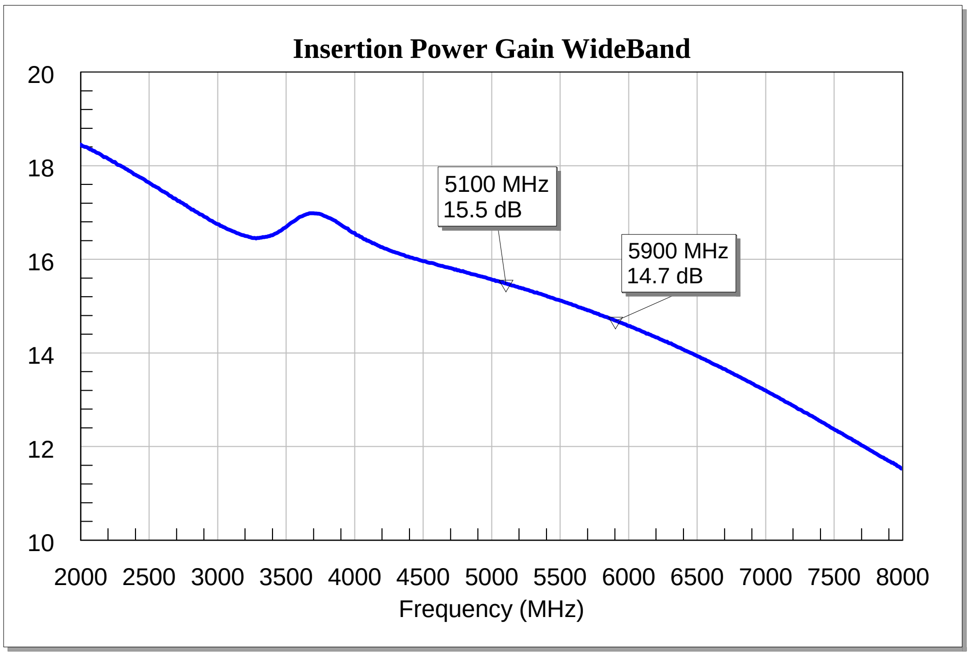

Figure 4 Wideband Insertion Power Gain of the 5-6GHz WLAN LNA with BFR840L3RHESD

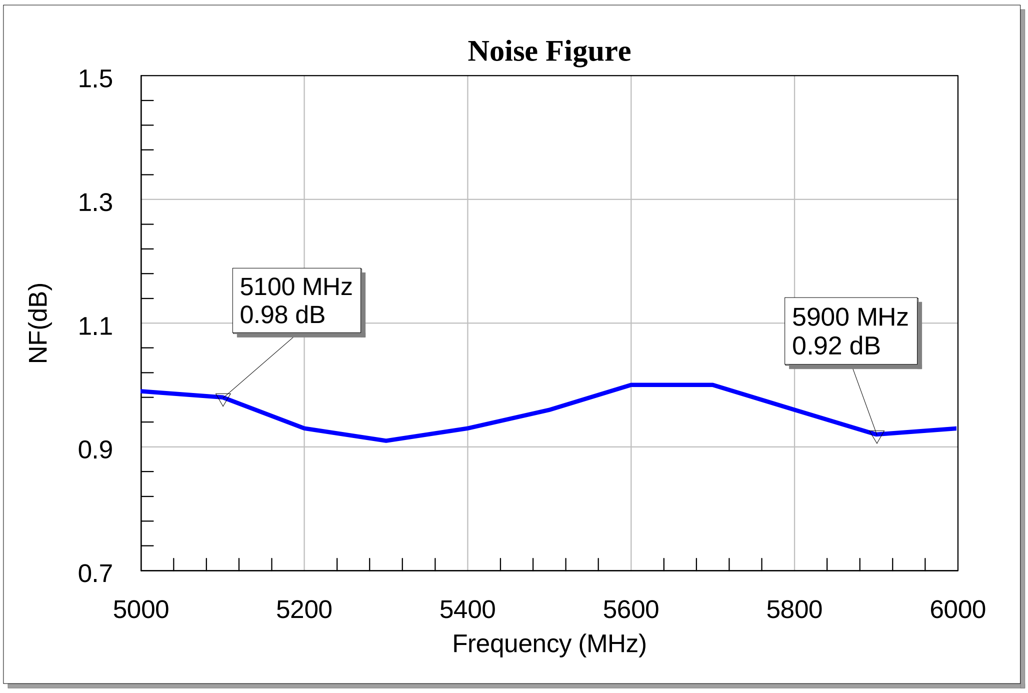

Figure 5 Noise figure of BFR840L3RHESD for 5100-5900 MHz

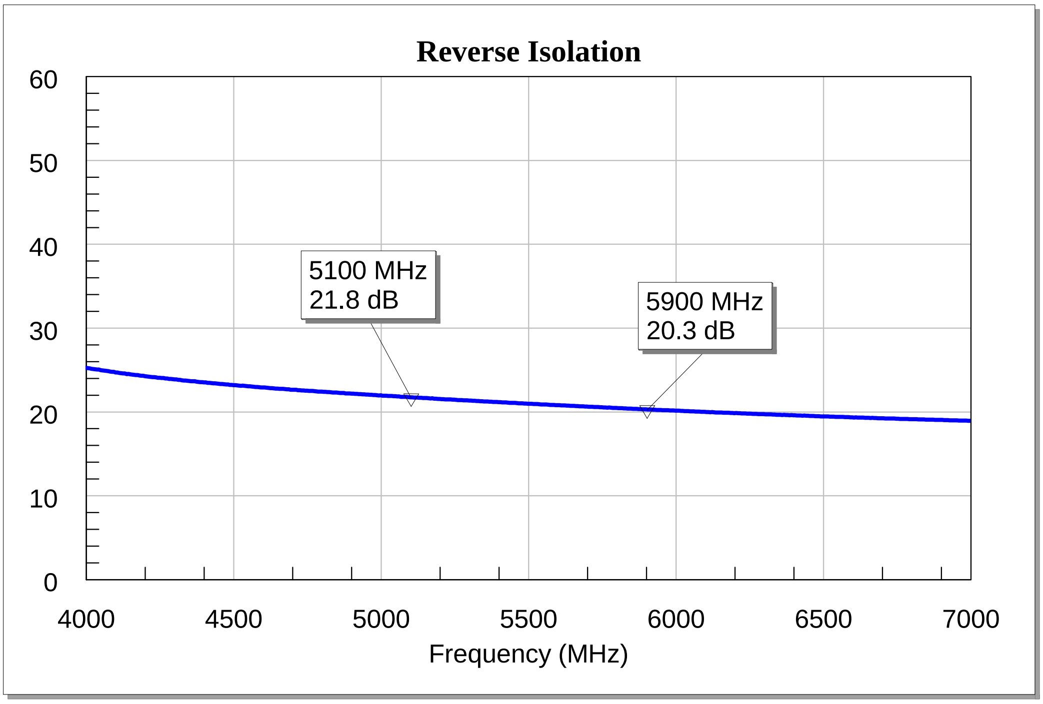

Figure 6 Reverse Isolation of the 5-6GHz WLAN LNA with BFR840L3RHESD

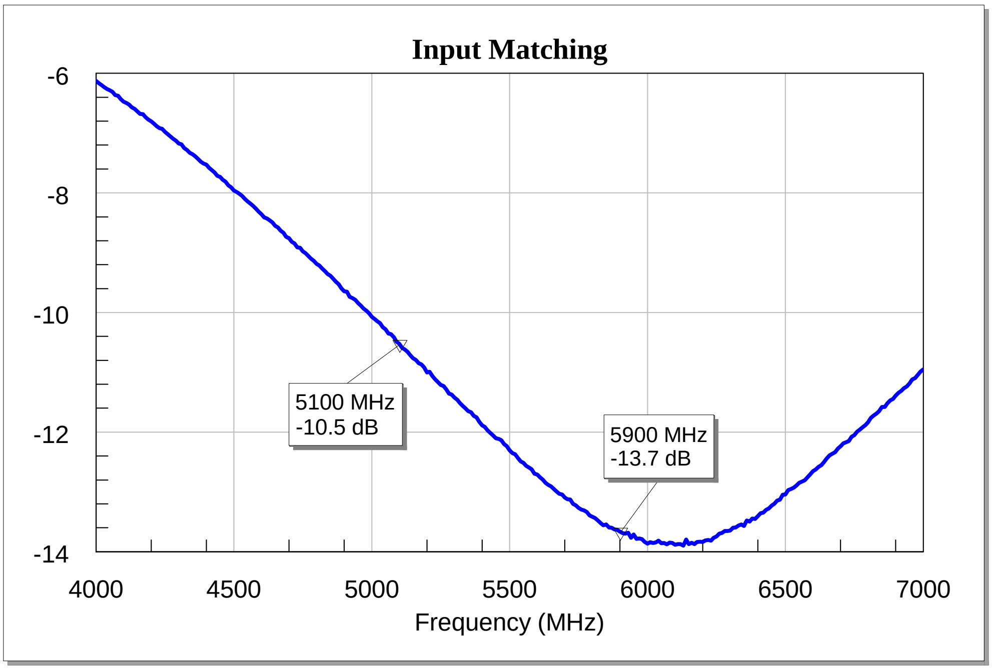

Figure 7 Input Matching of the 5-6GHz WLAN LNA with BFR840L3RHESD

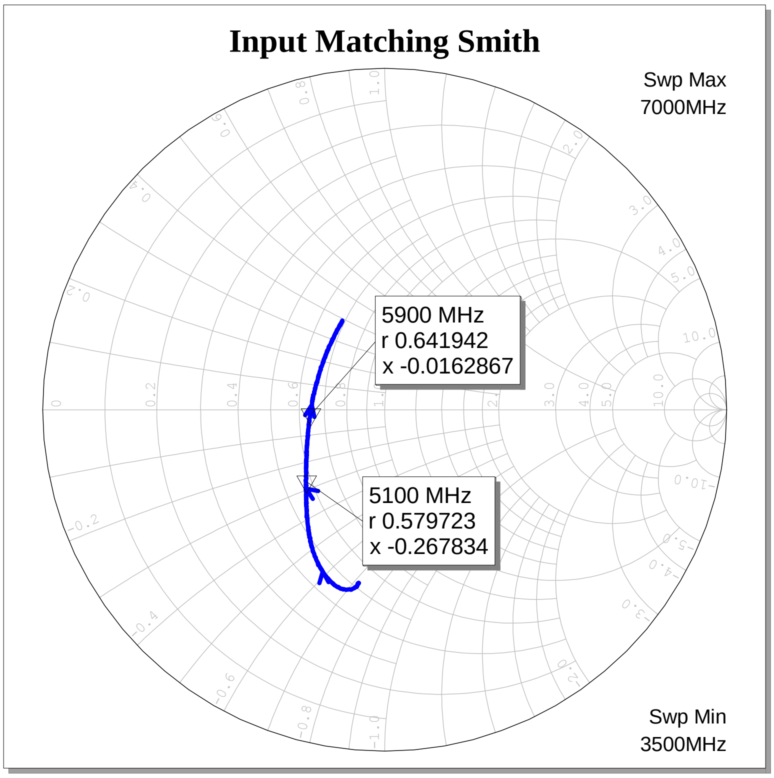

Figure 8 Input Matching of the 5-6GHz WLAN LNA with BFR840L3RHESD (Smith Chart)

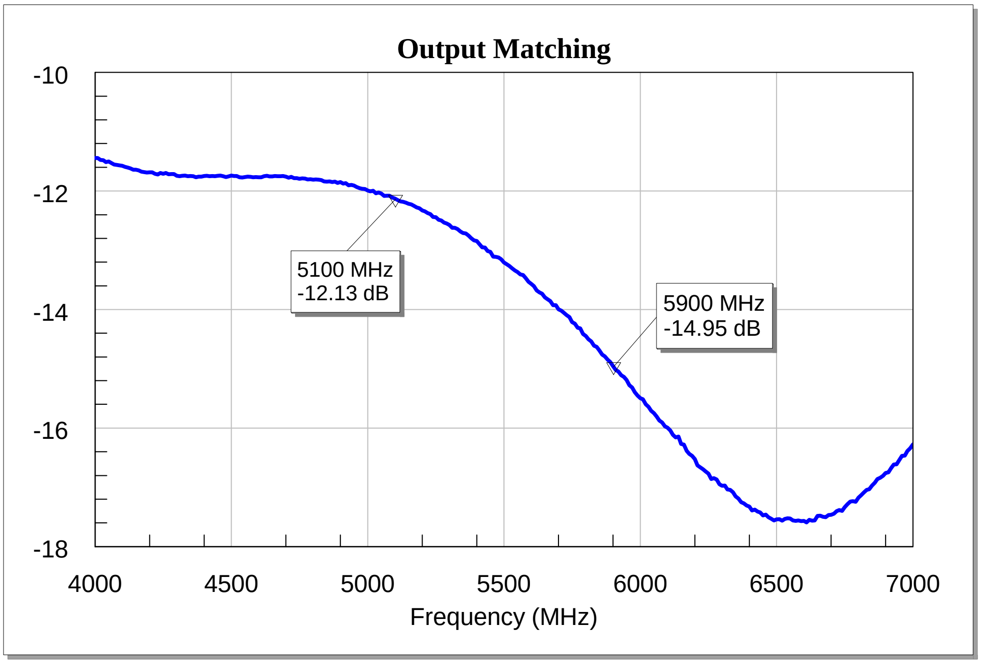

Figure 9 Output Matching of the 5-6GHz WLAN LNA with BFR840L3RHESD

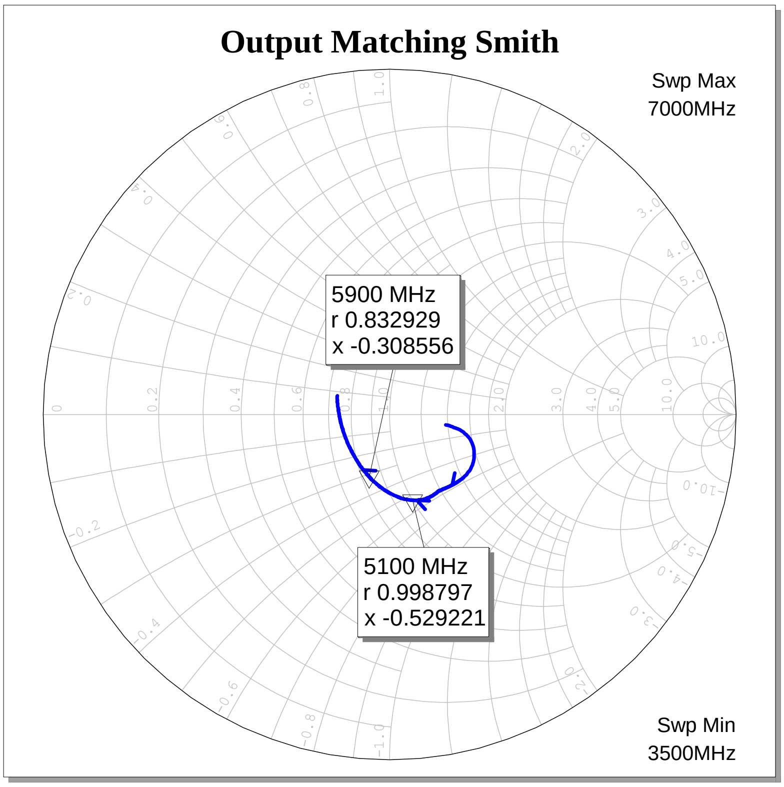

Figure 10 Output Matching of the 5-6GHz WLAN LNA with BFR840L3RHESD (Smith Chart)

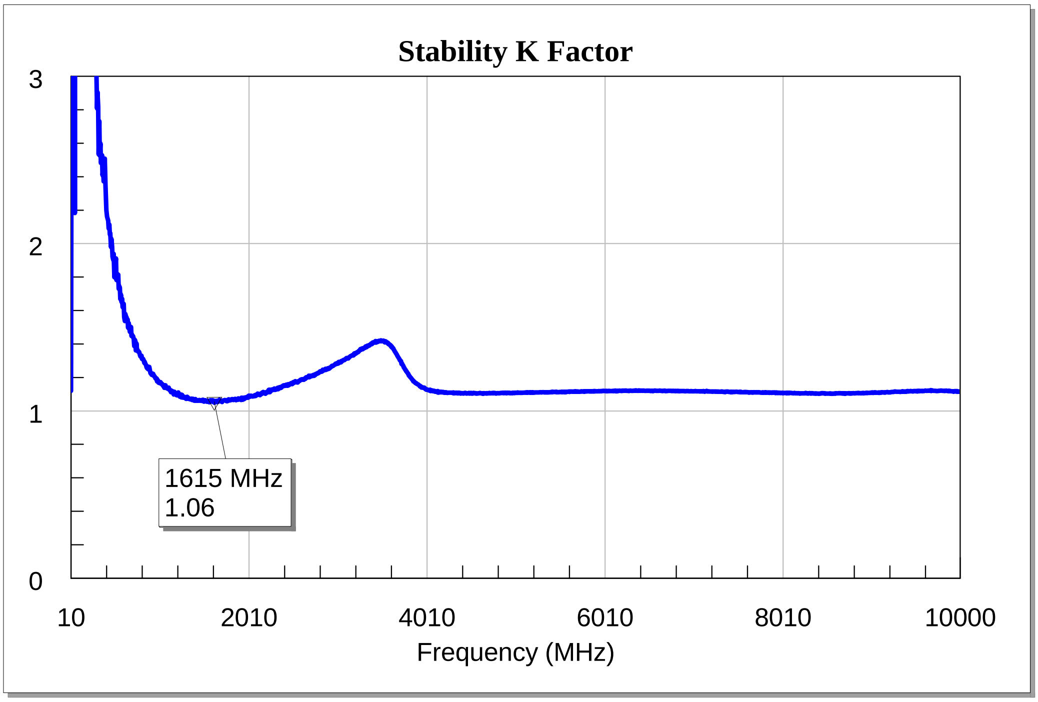

Figure 11 Wideband Stability K Factor of the 5-6GHz WLAN LNA with BFR840L3RHESD

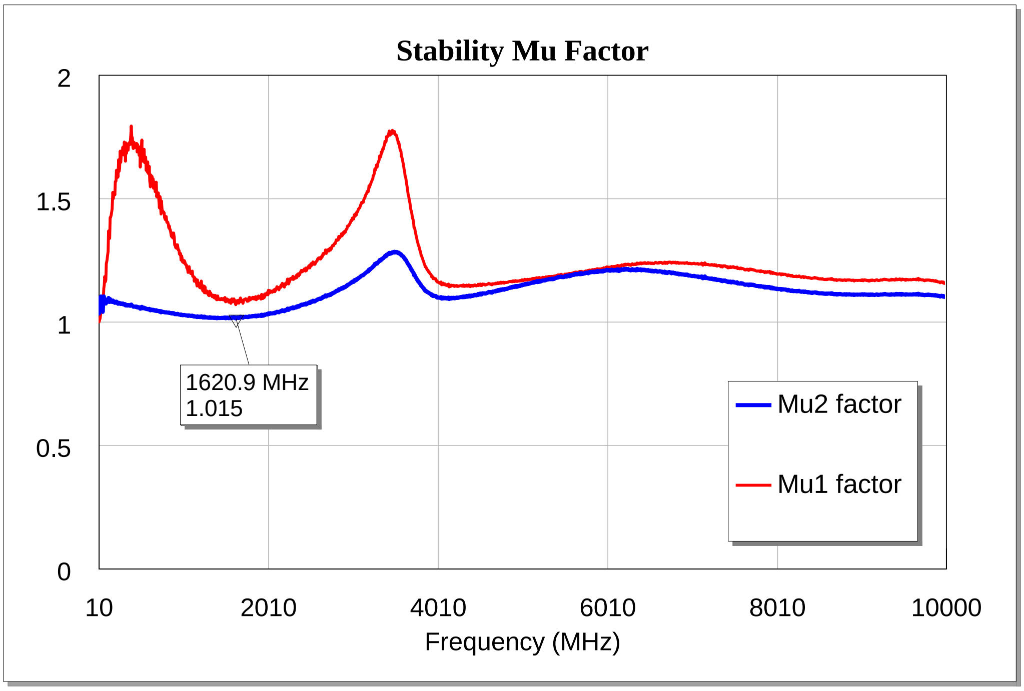

Figure 12 Wideband Stability Mu Factor of the 5-6GHz WLAN LNA with BFR840L3RHESD

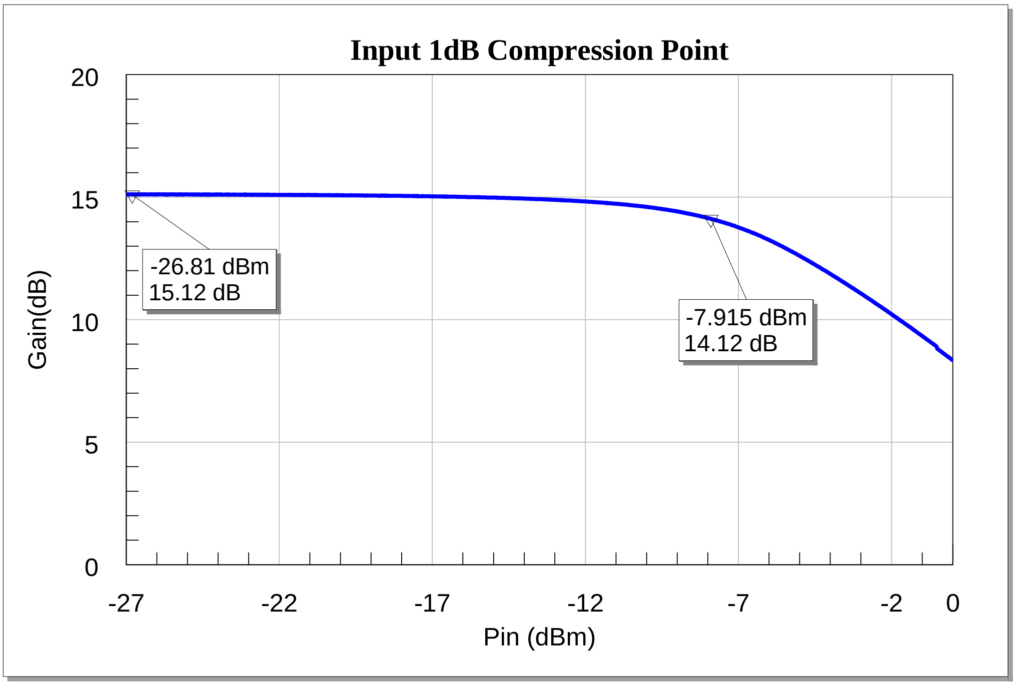

Figure 13 Input 1dB compression point of the BFR840L3RHESD circuit at 5500 MHz

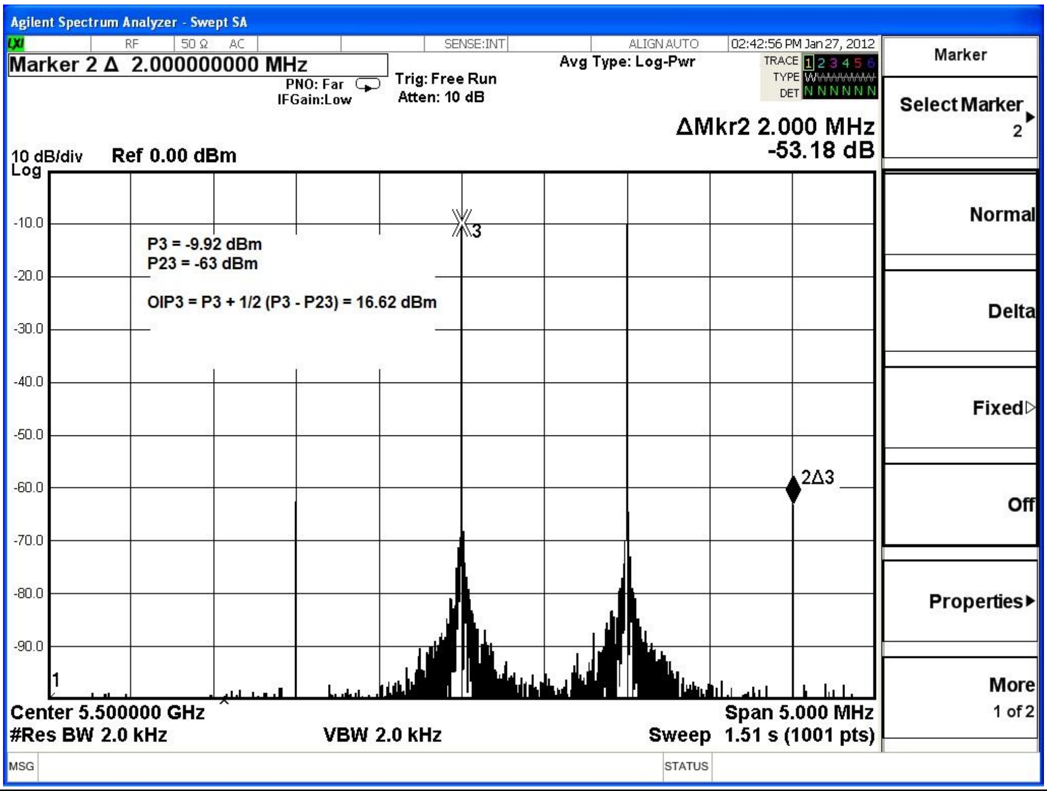

Figure 14 Output 3[rd] Order Intercept Point of BFR840L3RHESD at 5500 MHz

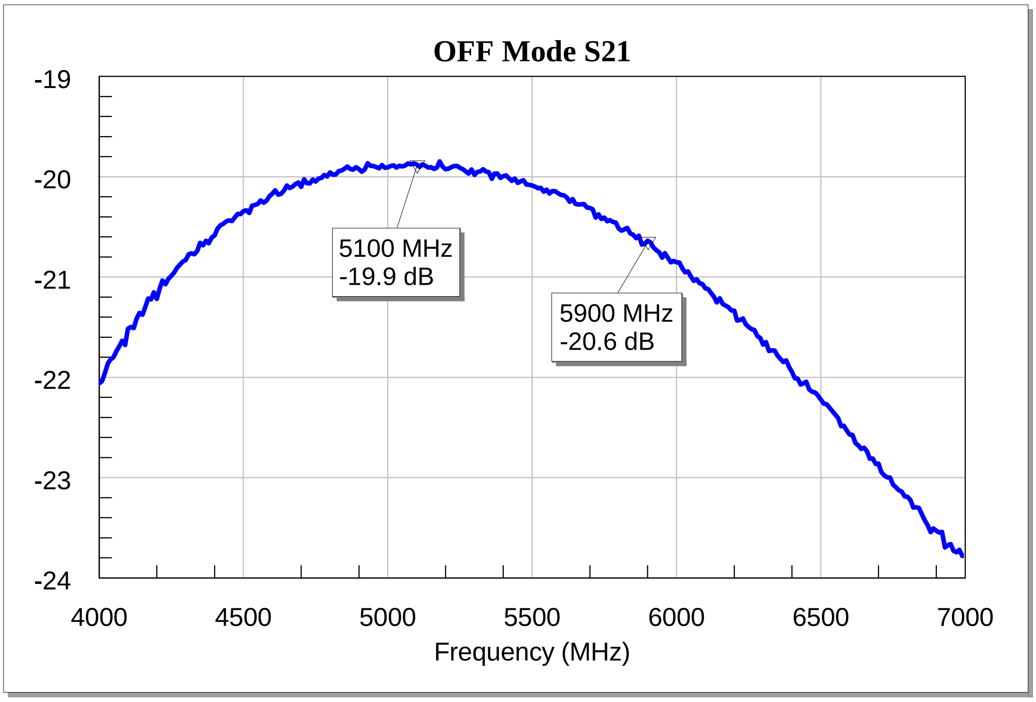

Figure 15 OFF-Mode (Vcc = 0V, Icc = 0mA) S21 of the 5-6GHz WLAN LNA with BFR840L3RHESD

7 Evaluation Board and Layout Information

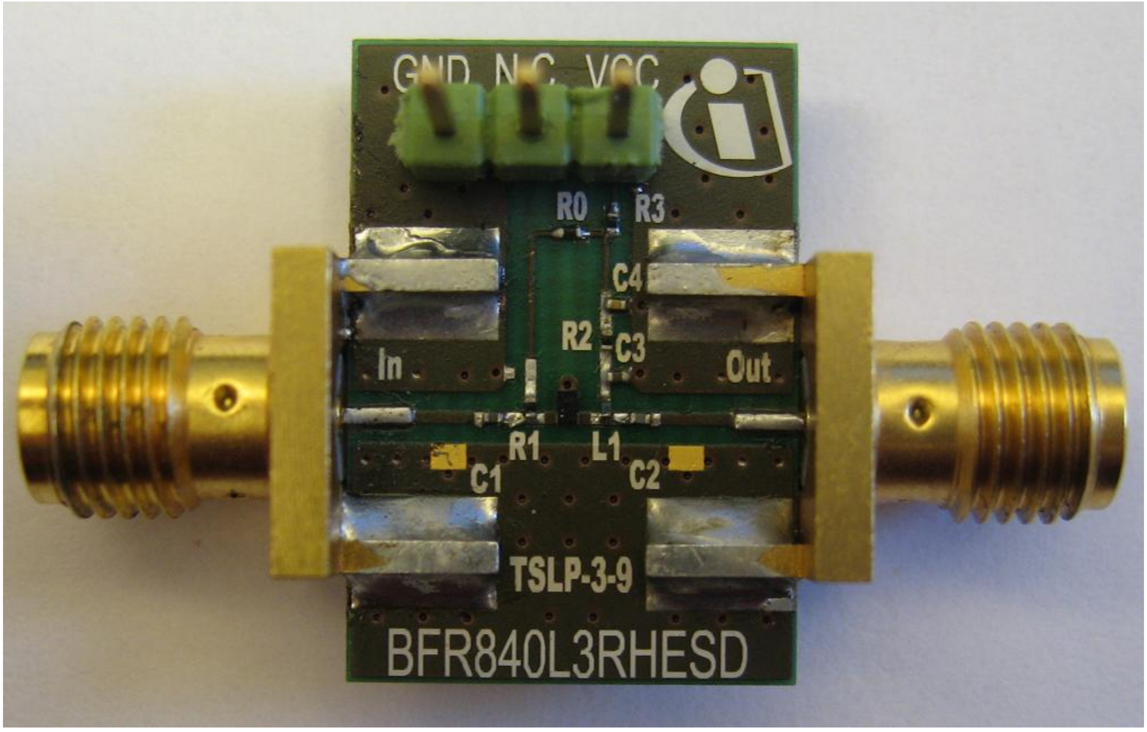

Figure 16 Photo Picture of Evaluation Board for the 5-6GHz WLAN LNA with BFR840L3RHESD

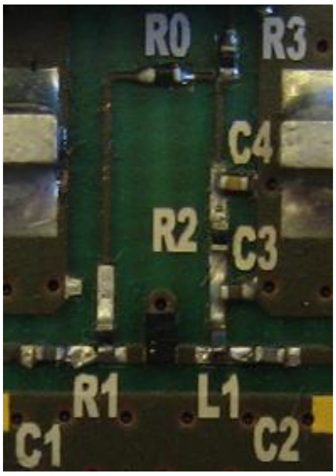

Figure 17 Zoom-In of Photo Picture of Evaluation Board the 5-6GHz WLAN LNA with BFR840L3RHESD

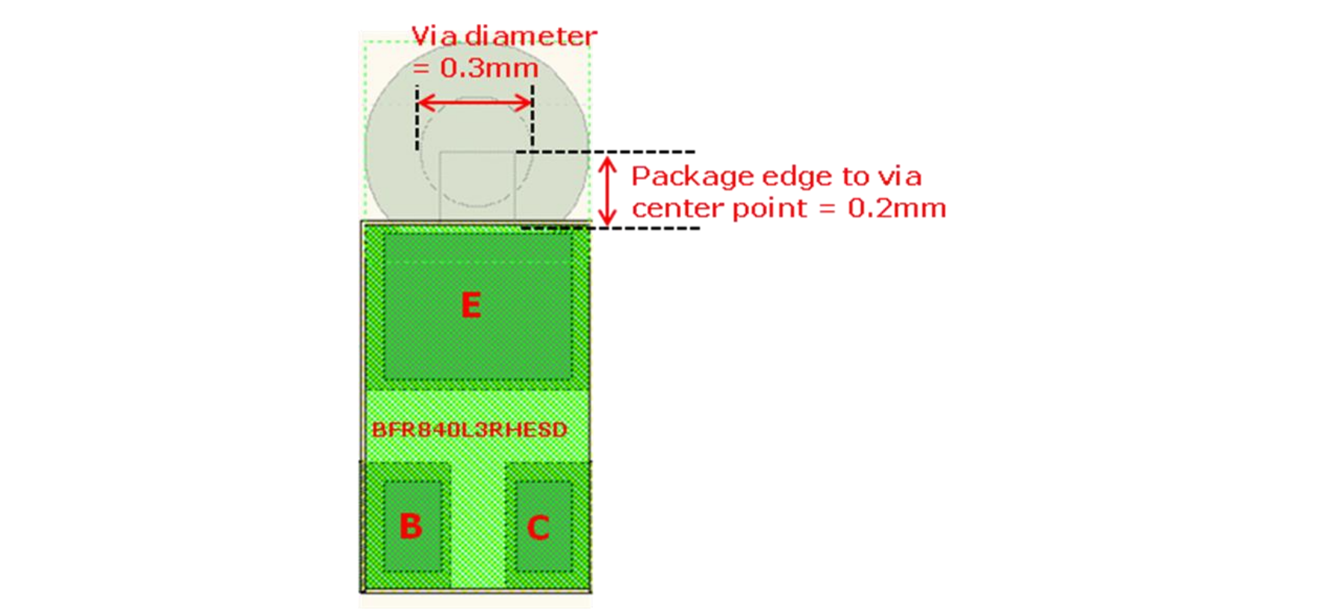

Figure 18 Layout Proposal for RF Grounding of the 5-6GHz WLAN LNA with BFR840L3RHESD

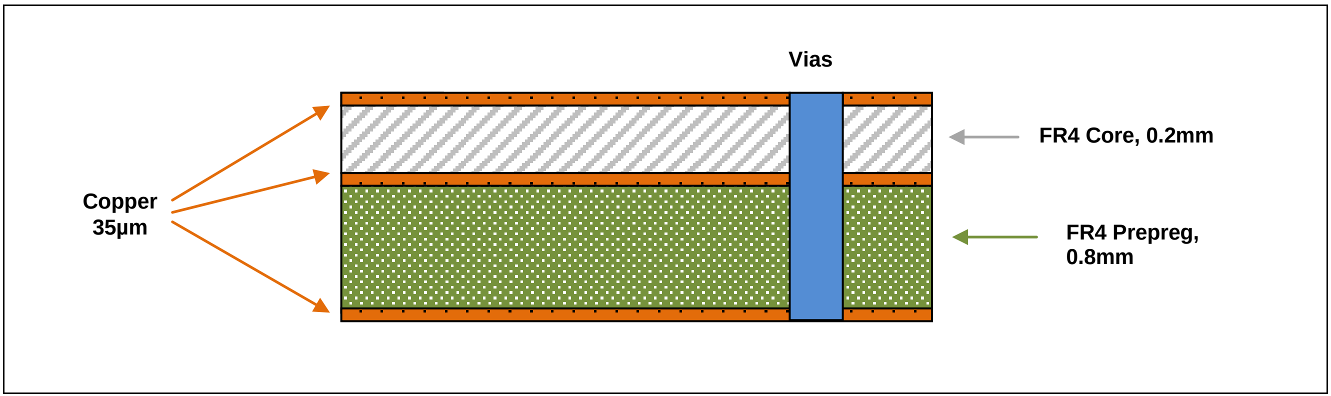

Figure 19 PCB Layer Information

8 Authors

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