BFR840L3RHESD

Low Noise Amplifier for 2.4 GHz - 2.5 GHz Wireless LAN Application

Application Note AN339

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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 Wi-Fi

Wireless-Fidelity (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 Wi-Fi function is one of the most important connectivity functions in notebooks, smart phones and tablet PCs. 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.

In the 2.4 GHz frequeny band, the 802.11b/g/n wireless LAN devices suffer from interference from other devices operating in this ISM band, such as wireless keyboards or Bluetooth devices. In order 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. A general application diagram of 2.4 GHz wireless LAN system is shown in **Figure 1**.

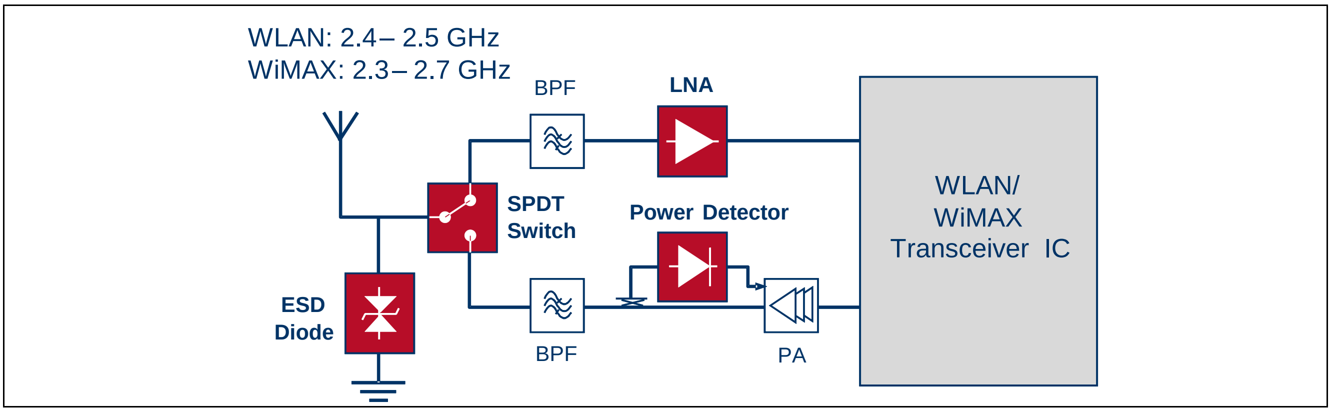

Figure 1 General block diagram 2.4 GHz Wi-Fi Wireless LAN (WLAN, IEEE802.11b/g/n) and WiMAX (IEEE802.16e) Front-End

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 approximately 2 dB can only be achieved by using a high-gain LNA.

This application note represents the results of Low Noise Amplifer for the 2.4 GHz to 2.5 GHz Wireless LAN application using BFR840L3RHESD. It achieves a NF level of approx. 1.3 dB, and the gain ranges from 20 dB to 21 dB over this frequency band. The circuit achieves an input return loss of approx. 15 dB and output return loss of 12 dB. The circuit requires 9 passive 0201 SMD components, and it is unconditionally stable from 10 MHz to 10 GHz.

At 2450 MHz, using two tones spacing of 1 MHz, the Output Third Order Intercept Point (OIP3) reaches +13.5 dBm. Besides, we obtain Input 1 dB Compression Point (IP1dB) of -18.6 dBm at 2450 MHz.

This application note focuses on the LNA block, but Infineon also supports RF-switches, TVS-diodes for ESD protection and RF Schottky diodes for power detection for this application.

2 Device description

The BFR840L3RHESD is a low noise SiGe:C HBT transistor. It provides inherently good input and output power match as well as noise match. Without lossy external matching components at the input leads to a low external parts count, to a very good noise figure and to a very high transducer gain in the 2.4 GHz and 5 GHz WLAN application. Integrated protection elements at in- and output make the device robust against ESD and excessive RF input power. The device offers its high performance at low current and voltage and is especially well-suited for portable battery powered applications. 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).

2.1 Features

• Based on Infineon´s reliable, high volume SiGe:C technology

• High end RF performance and robustness:

20 dBm maximum RF input power, 1.5 kV HBM ESD hardness

• Transition frequency f_T = 75 GHz enables best in class noise performance at high frequencies:

NF_{min} = 0.65 dB at 5.5 GHz, 1.1 dB at 12 GHz, 1.8 V, 5 mA

• High gain $|S21|^2$ = 19 dB at 5.5 GHz, 1.8 V, 10 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

• Easy to use Pb free (RoHS compliant) and halogen free industry standard package with visible leads

2.2 Key Applications

The BFR840L3RHESD's key applications include Low Noise Amplifier (LNA) in

• Mobile and fixed connectivity applications: WLAN 802.11, WiMAX and UWB

• Satellite communication systems: satellite radio (SDARs, DAB), navigation systems and C-band LNB (1st and 2nd stage LNA)

• Ku-band LNB front-end (2nd stage or 3rd stage LNA and active mixer)

• Ka-band oscillators (DROs)

3 Application Circuit

3.1 Schematic Diagram

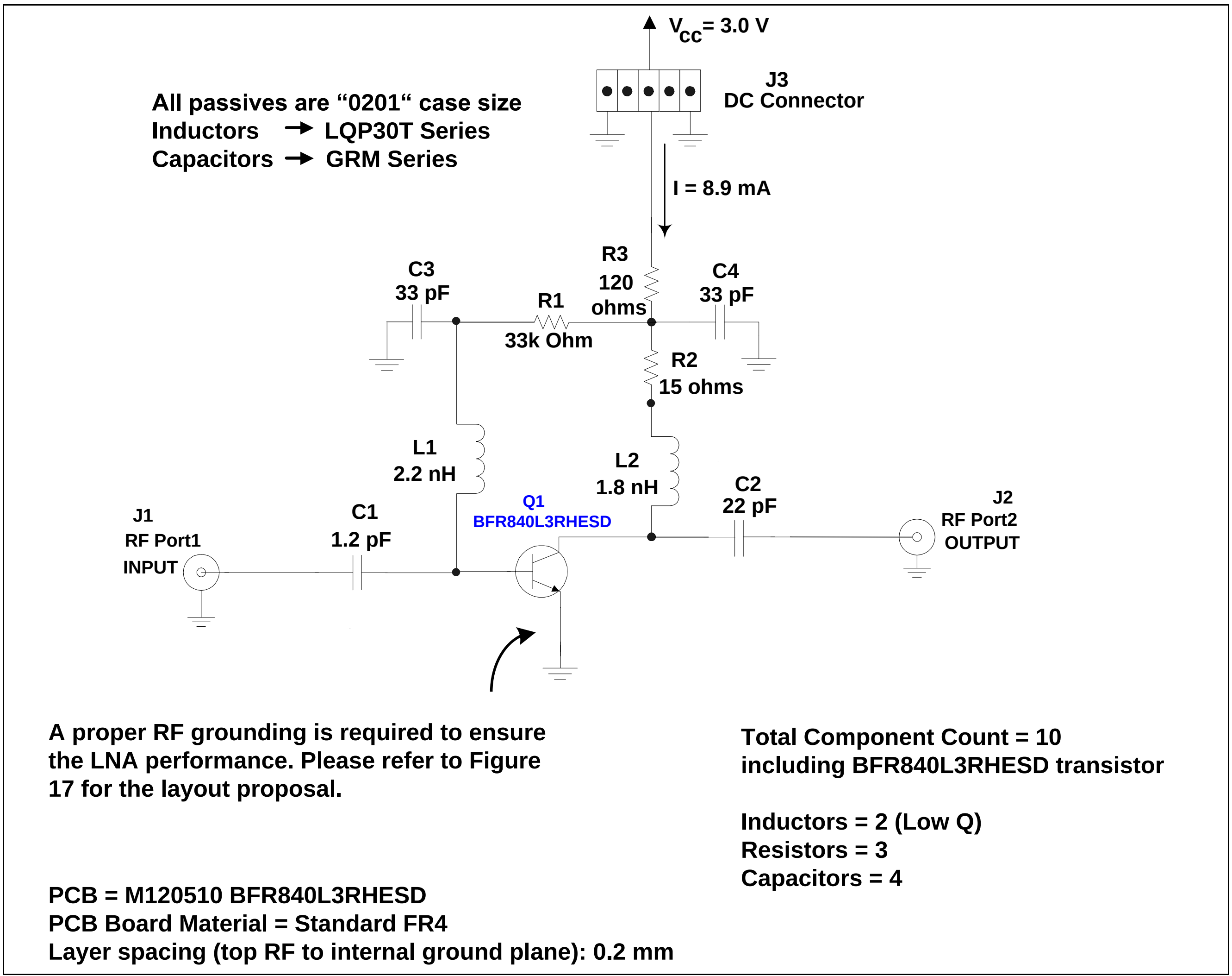

Figure 2 Application circuit of 2.4 GHz – 2.5 GHz WLAN LNA with BFR840L3RHESD

3.2 Bill of Materials

Table 1 Bill-of-Materials

Symbol	Value	Unit	Package	Manufacturer	Comment
C1	1.2	pF	0201	Murata GRM0335 series	Input matching and DC blocking
C2	22	pF	0201	Murata GRM0335 series	Output DC blocking
C3	33	pF	0201	Murata GRM0335 series	RF decoupling
C4	33	pF	0201	Murata GRM0335 series	RF decoupling
R1	33	kΩ	0201	Various	DC biasing
R2	15	Ω	0201	Various	Output matching and 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.)
L1	2.2	nH	0201	Murata LQP30T	Input matching
L2	1.8	nH	0201	Murata LQP30T	Output matching
Q1	BFR840L3RHESD		TSLP-3-9	Infineon Technologies	SiGe:C Heterojunction Bipolar RF Transistor

4 Performance Overview

Device: BFR840L3RHESD

Application: Low Noise Amplifier for 2.4 - 2.5 GHz Wireless LAN with BFR840L3RHESD using 0201 SMDs

PCB Marking: BFR840L3RHESD TSLP-3-9 M120510

Table 2 Electrical Characteristics (at room temperature)

Parameter	Symbol	Value		Unit	Comment / Test Condition
DC Voltage	Vcc	3.0		V	
DC Current	Icc	9.0		mA	
Frequency Range	Freq	2400	2500	MHz	
Gain	G	20.8	20.5	dB	
Noise Figure	NF	1.38	1.26	dB	PCB and SMA connector losses of 0.1 dB subtracted
Input Return Loss	RLin	16.3	15.1	dB	
Output Return Loss	RLout	12.2	13.5	dB	
Reverse Isolation	IRev	26.5	26.3	dB	
Input P1dB	IP1dB	-18.6		dBm	f = 2450 MHz
Output P1dB	OP1dB	+1.1		dBm	f = 2450 MHz
Input IP3	IIP3	-7.2		dBm	f_1 = 2450 MHz, f_2 = 2451 MHz, Pin = -30 dBm each tone
Ouput IP3	OIP3	13.5		dBm	f_1 = 2450 MHz, f_2 = 2451 MHz, Pin = -30 dBm each tone
Stability	k	> 1		--	Unconditionally stable from 10 MHz to 10 GHz

5 Measured Graphs

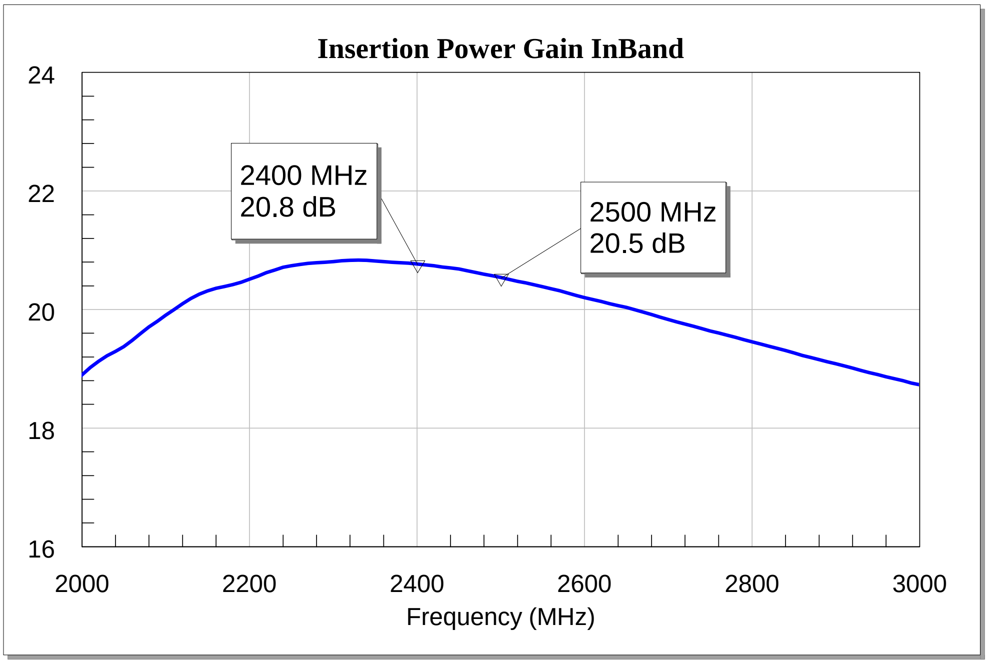

Figure 3 Narrowband Isertion Power Gain of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

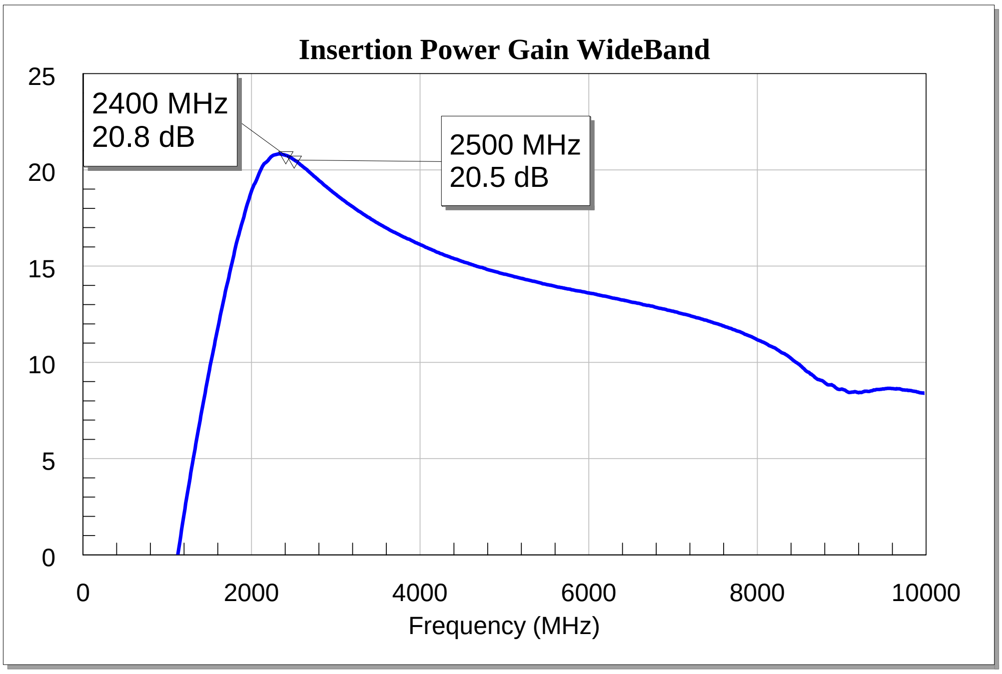

Figure 4 Wideband Insertion Power Gain of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

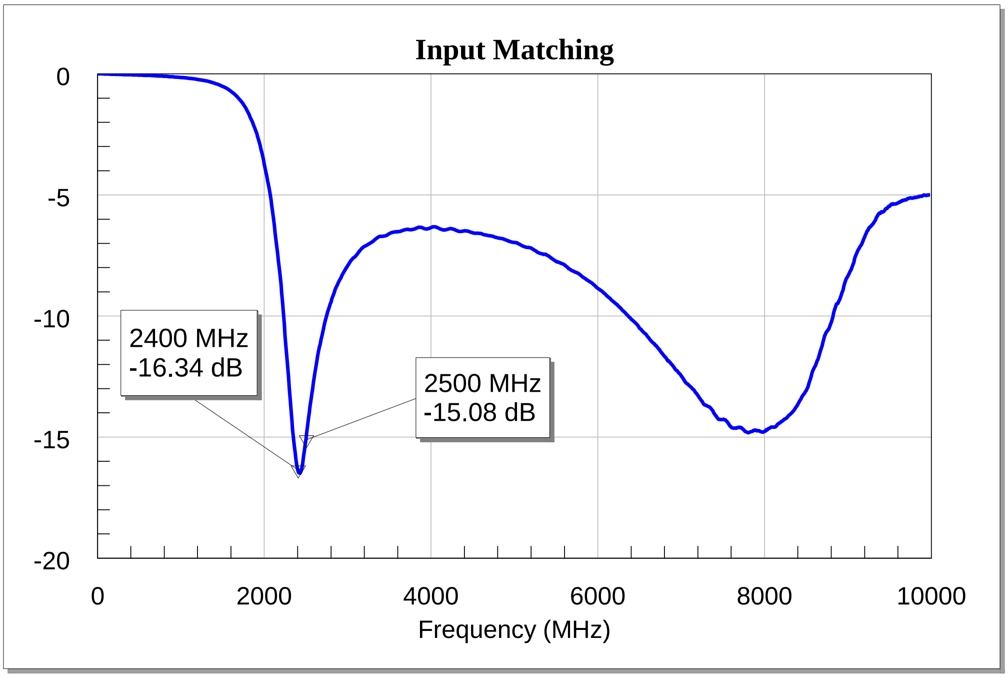

Figure 5 Input Matching of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

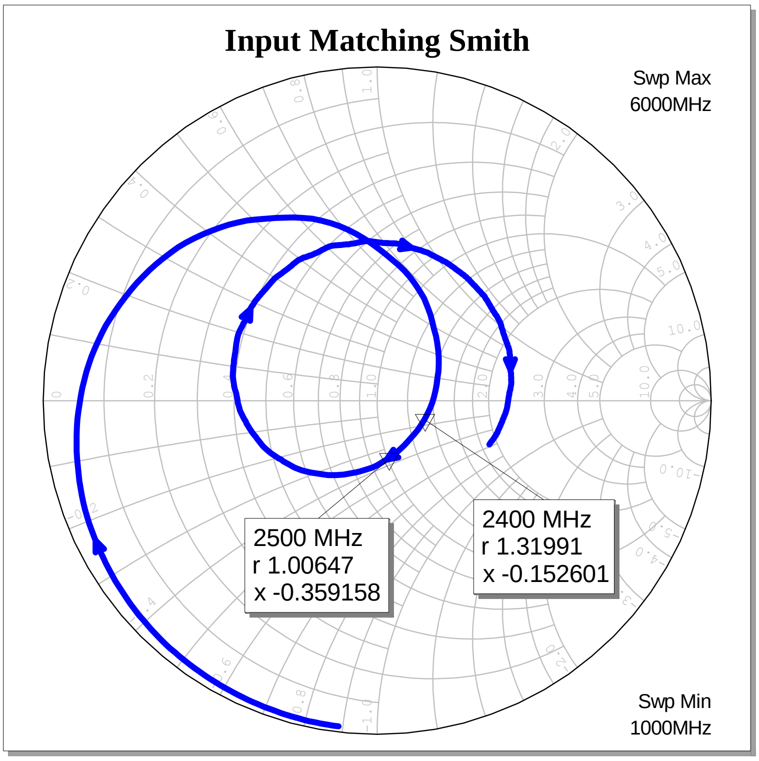

Figure 6 Input Matching of 2.4 GHz – 2.5 GHz WLAN LNA with BFR840L3RHESD in Smith Chart

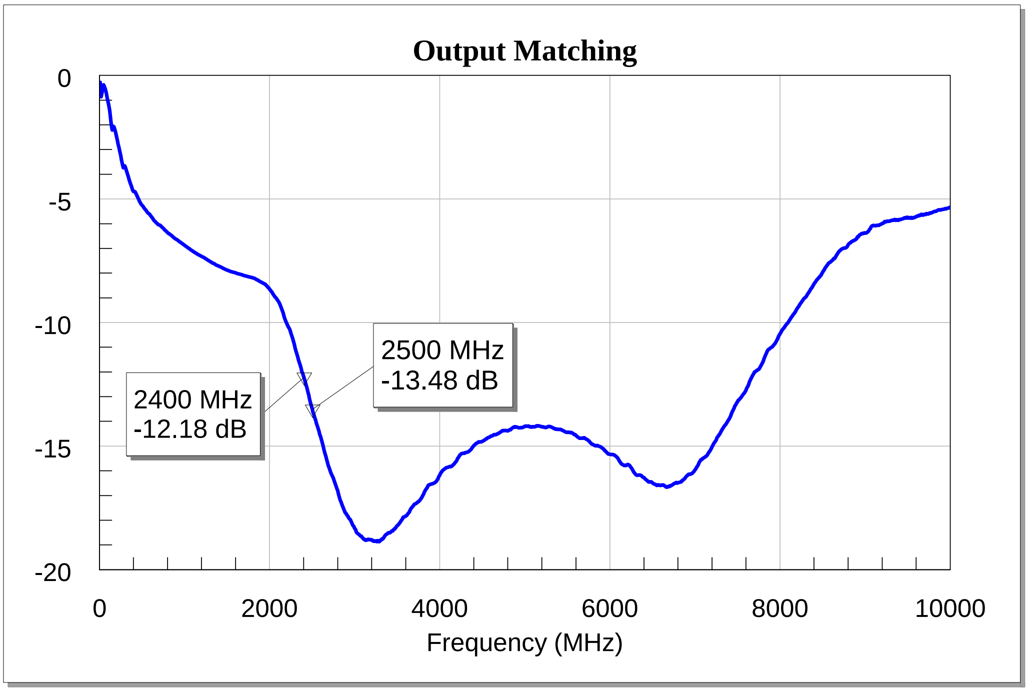

Figure 7 Output Matching of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

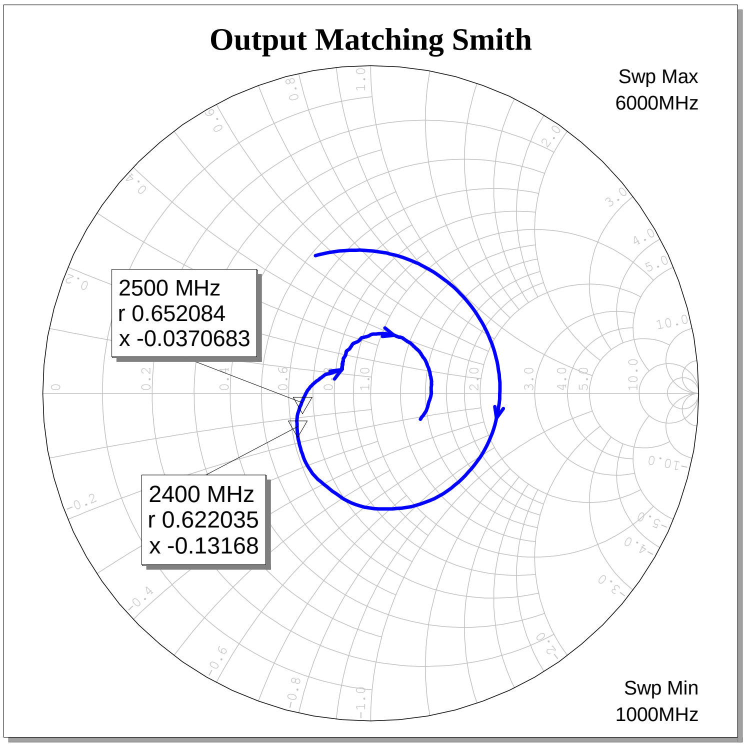

Figure 8 Output Matching of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD in Smith Chart

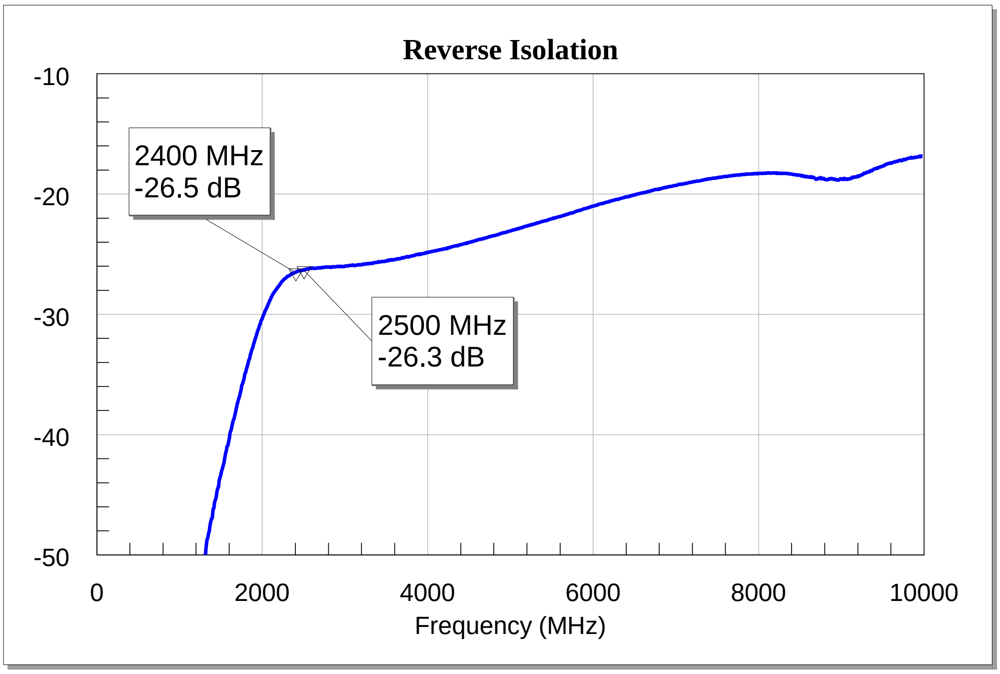

Figure 9 Reverse Isolation of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

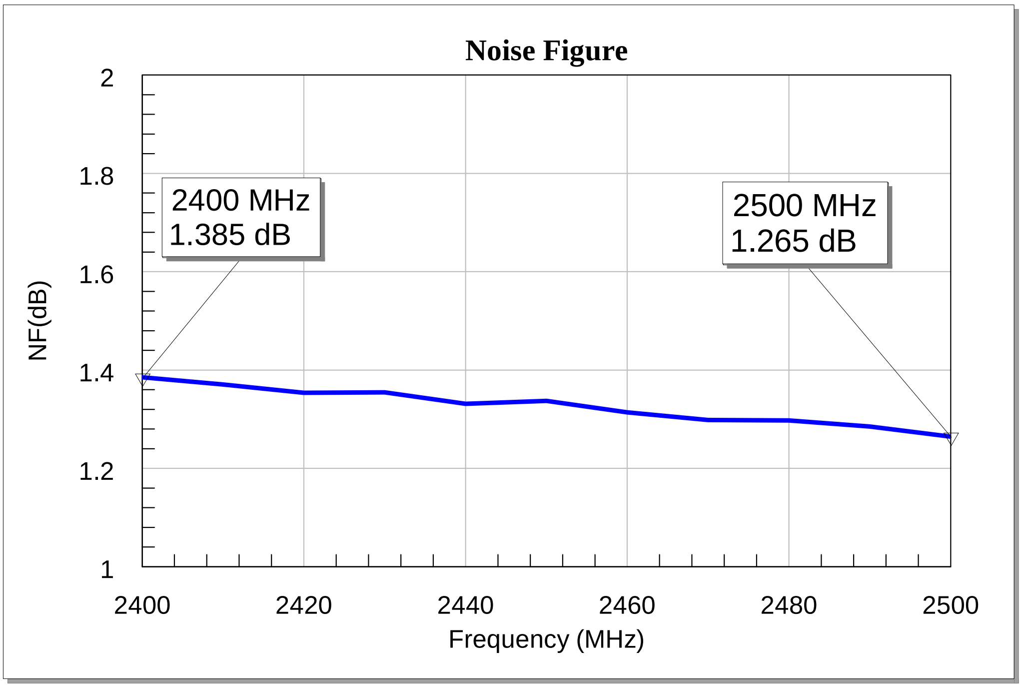

Figure 10 Noise Figure of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

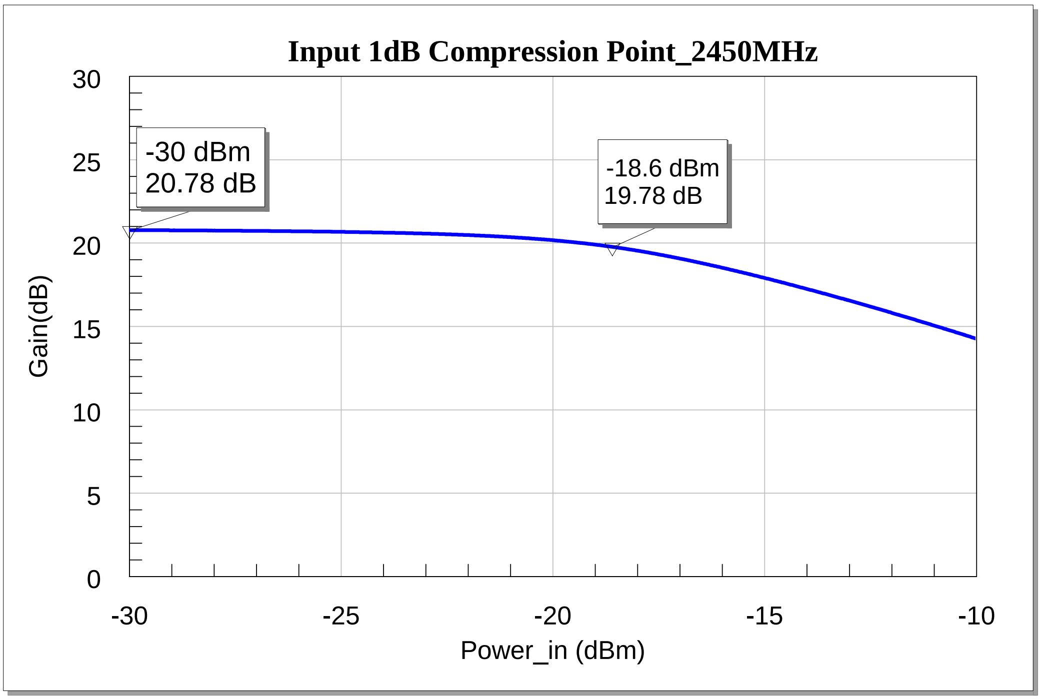

Figure 11 Input 1 dB Compression Point of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

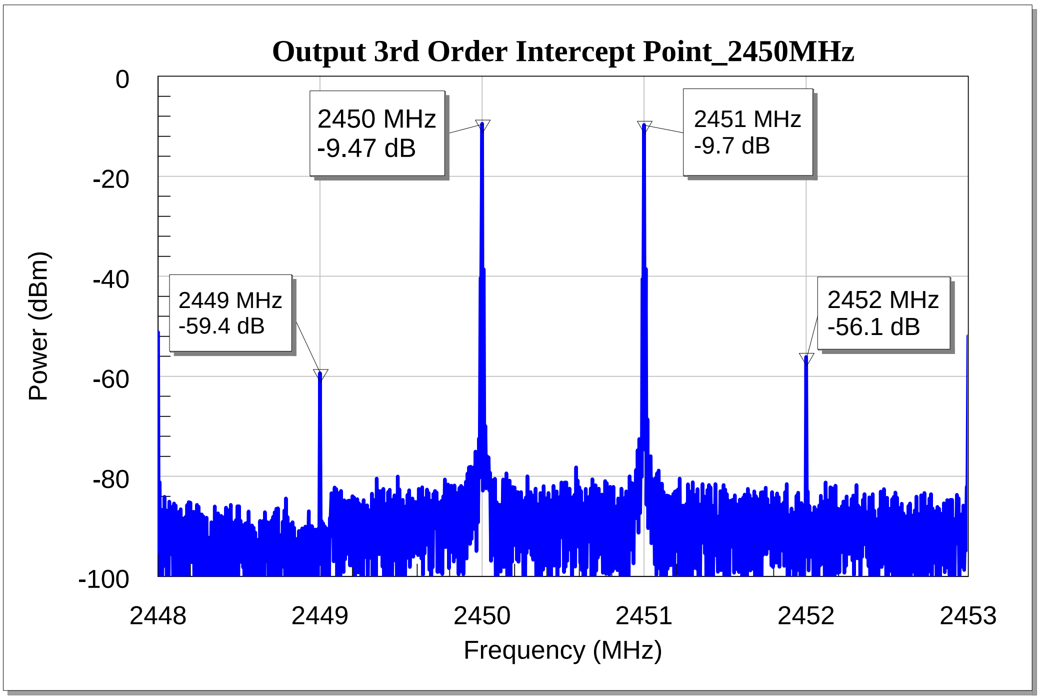

Figure 12 Output Third Order Interpoint of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

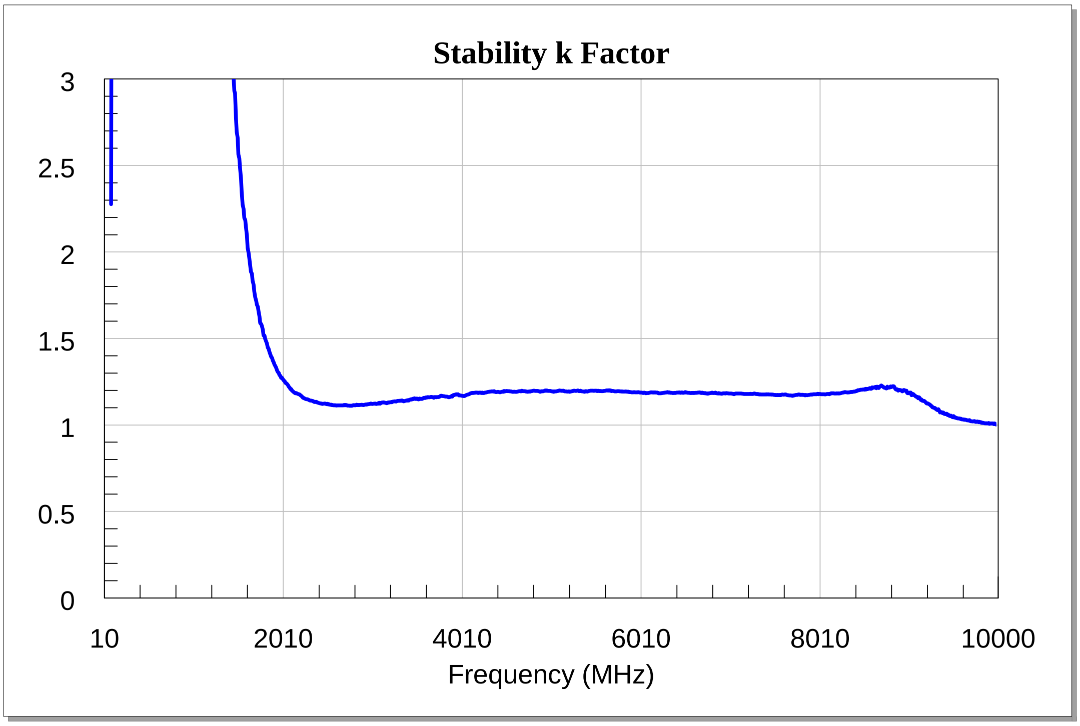

Figure 13 Stability factor k of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

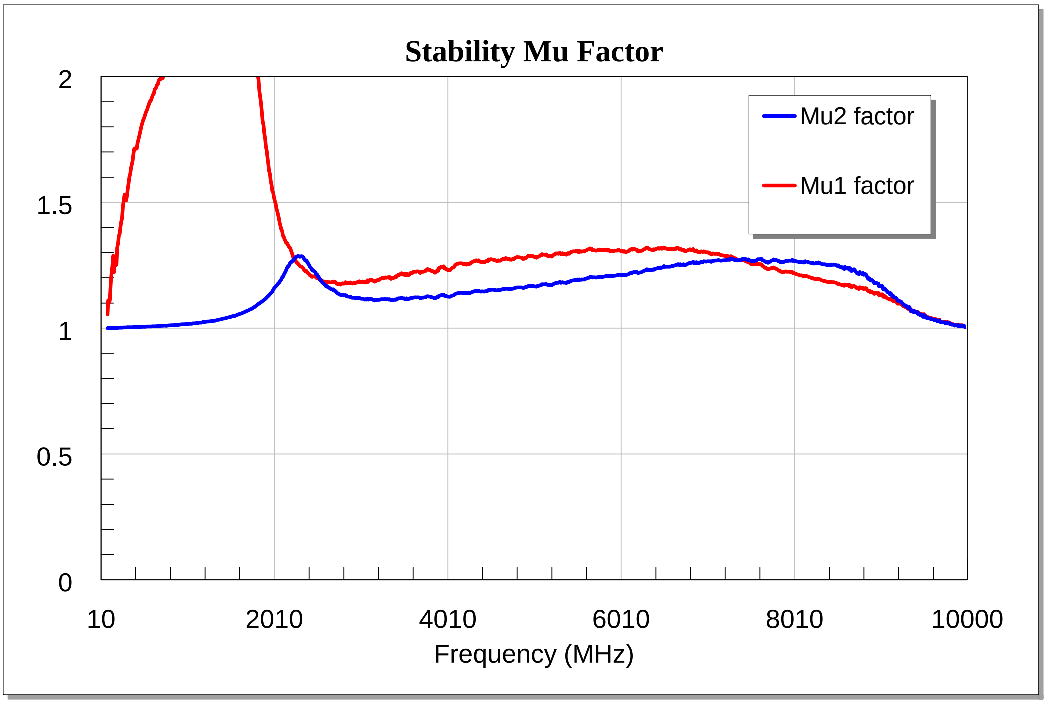

Figure 14 Stability factor μ1 and μ2 of 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

6 Evaluation Board

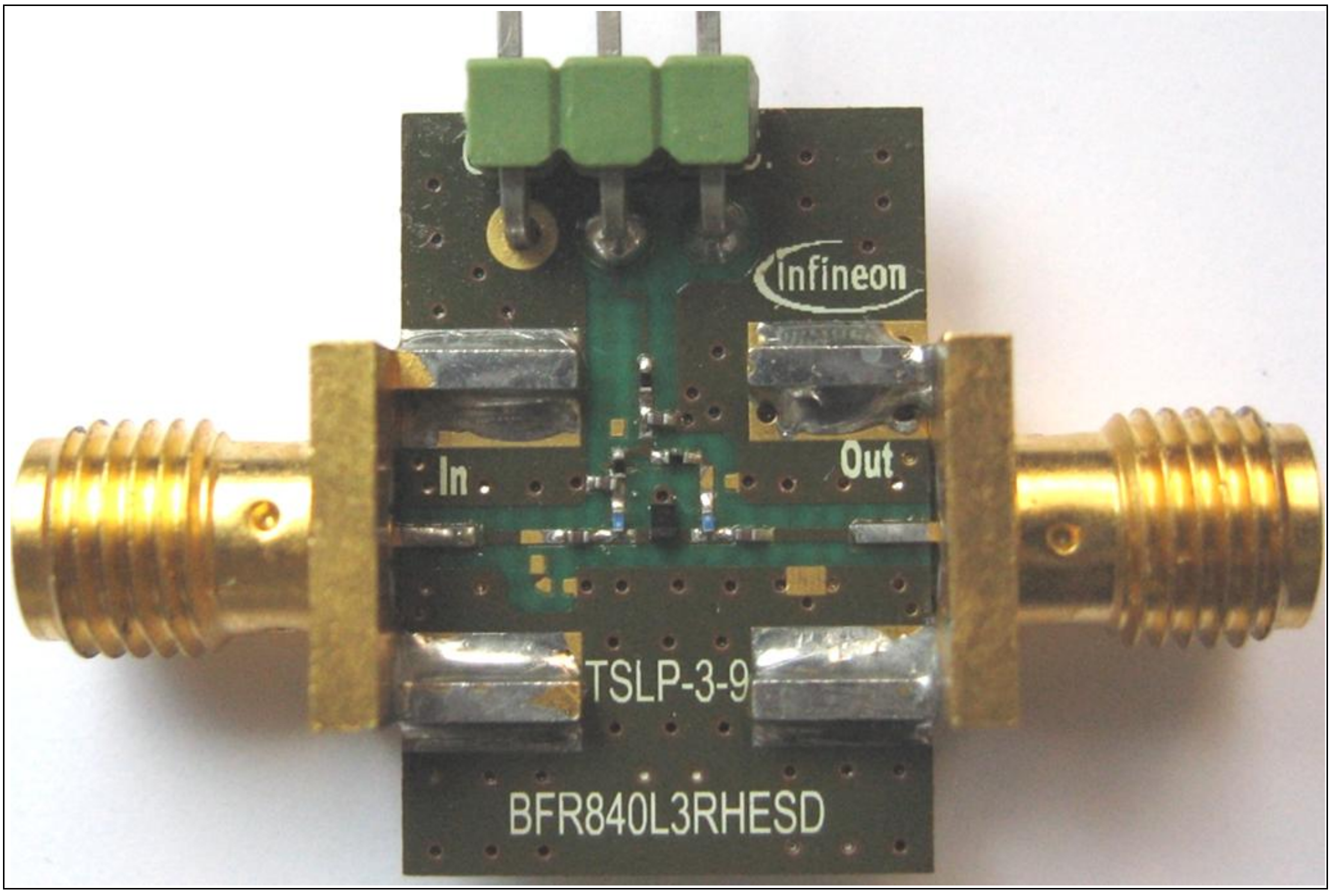

Figure 15 Picture of the populated board 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD (M120510)

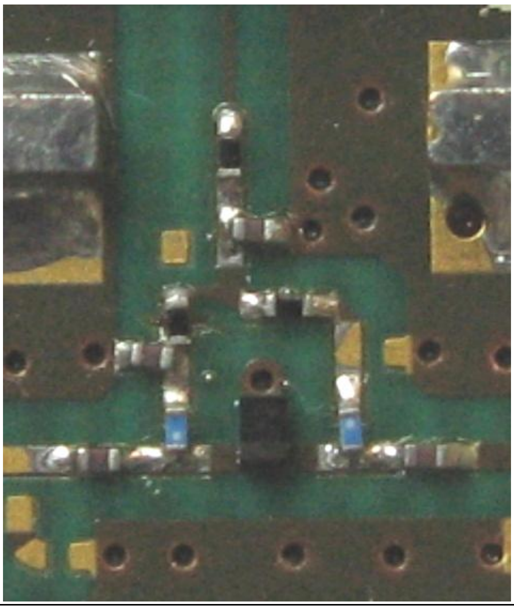

Figure 16 Zoom In picture of the populated board 2.4 GHz - 2.5 GHz WLAN LNA with BFR840L3RHESD

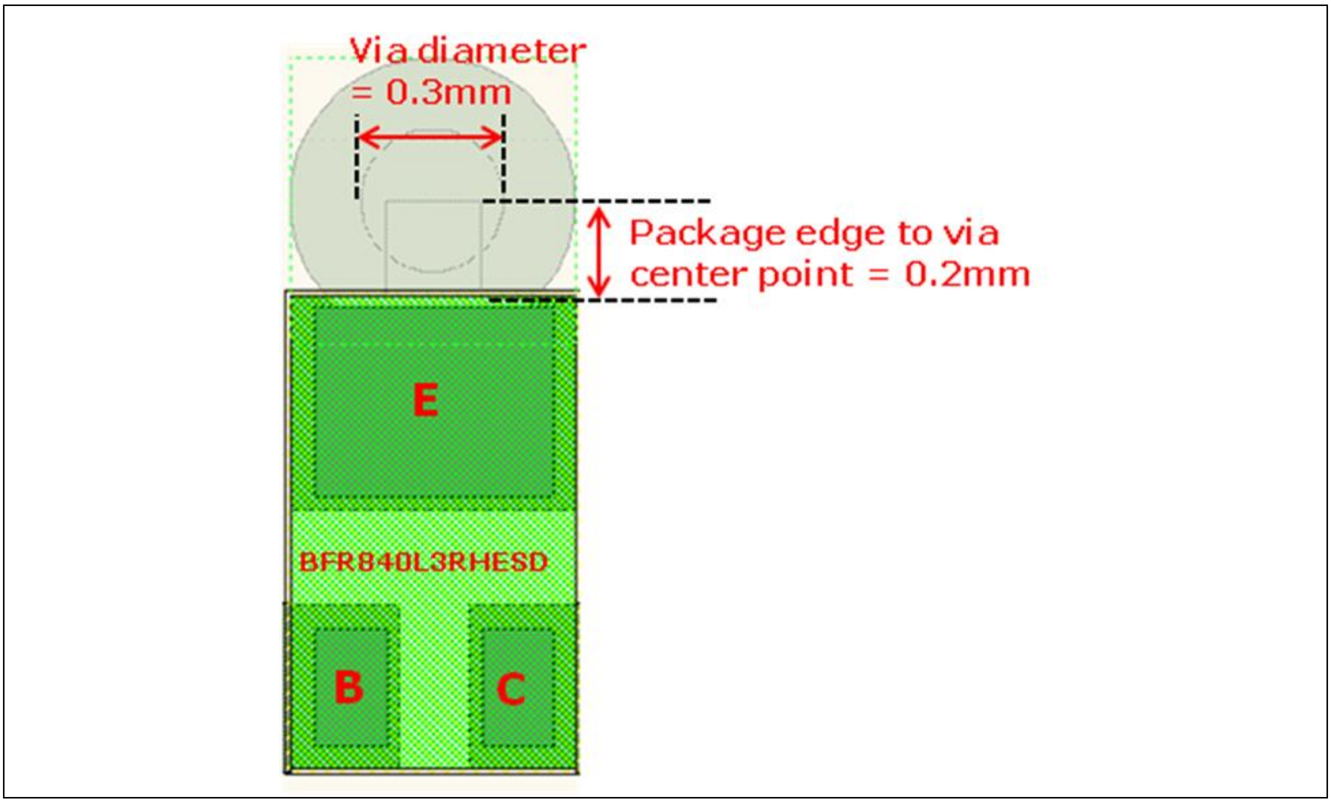

Figure 17 Layout Proposal for RF Grounding of the 2.4-2.5 GHz WLAN LNA with BFR840L3RHESD

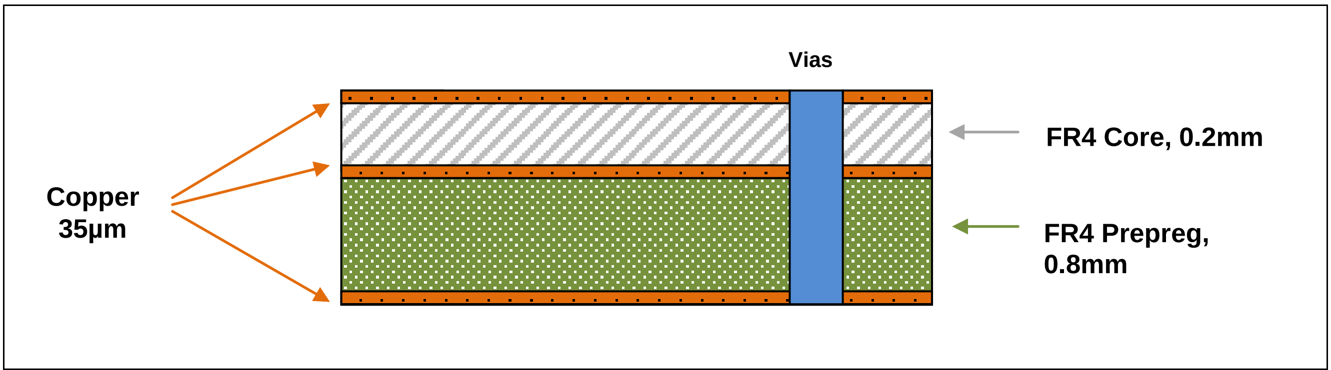

Figure 18 PCB layer stack

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