BFP840ESD

Low Noise Amplifier for 5 to 6 GHz WLAN Application using BFP840ESD

Application Note AN316

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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®) plays a major role in today's communications by enabling constant connection in the 2.4 GHz bands, 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 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.

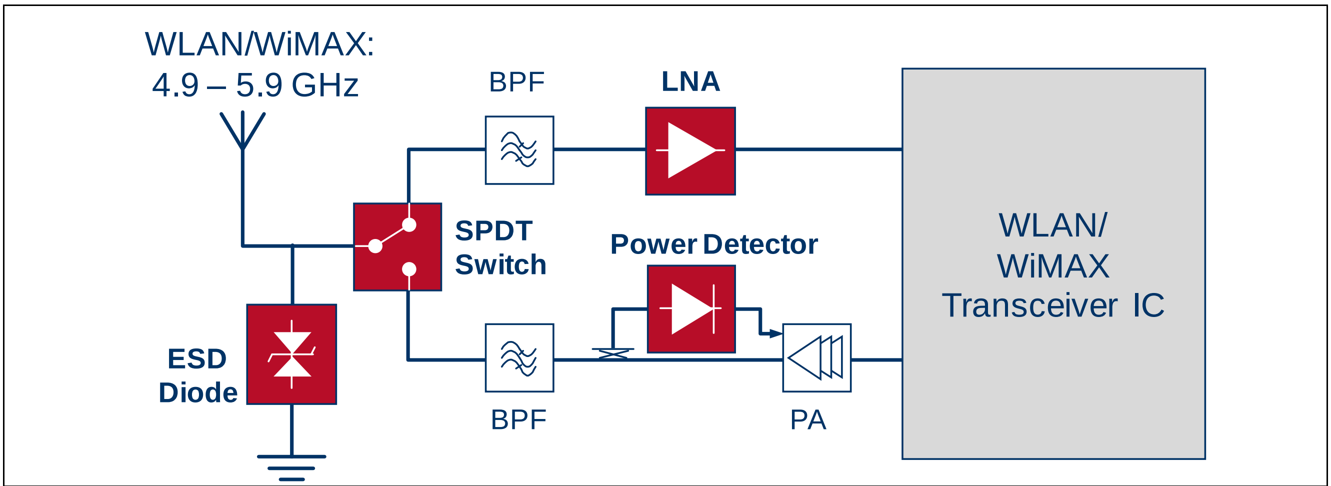

Figure 1 5 – 6 GHz Wi-Fi® Wireless LAN (WLAN, IEEE802.11a/n) and WiMAX (IEEE802.16e) Front-End

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 Single Pole, Double Throw (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.

2 BFP840ESD Overview

2.1 Features

- Robust very low noise amplifier based on Infineon´s reliable, high volume SiGe:C technology
- Unique combination of high end RF performance and robustness: 20 dBm maximum RF input power, 1.5 kV HBM ESD hardness
- Very high transition frequency f_T = 80 GHz enables very low noise figure at high frequencies: NF_{min} = 0.85 dB at 5.5 GHz, 1.8 V, 6 mA
- High gain $|S21|^2$ = 18.5 dB at 5.5 GHz, 1.8 V, 10 mA
- *OIP3* = 23 dBm at 5.5 GHz, 1.5 V, 6 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

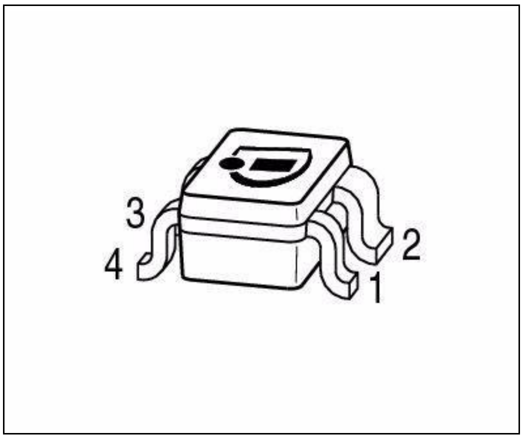

Figure 2 BFP840ESD in SOT343

2.2 Key Applications of BFP840ESD

As 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 (e.g. GPS, GLONASS) 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 Low Noise Amplifier for 5 to 6 GHz WLAN with BFP840ESD

3.1 Description

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 technique 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 in 5 GHz band together with a low noise figure performance.

The BFP840ESD has an integrated 1.5 kV 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 low energy consumption 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.

Figure 3 shows the pin assignment of package of BFP840ESD in the top view:

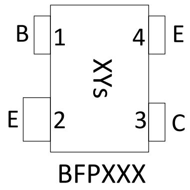

Figure 3 Package and pin connections of BFP840ESD in Topview

This application note presents the measurement results of the LNA using BFP840ESD for 5100 MHz to 5900 MHz WLAN applications. Proper RF grounding on PCB has to be ensured in order to achieve stability k-factor ≥ 1 above 8.5 GHz (Figure 20).

The application circuit requires 10 passive 0402 Surface Mounted Device (SMD) components and achieves the gain from 16 dB to 15 dB over the frequency band. The NF varies from 1.09 dB to 1.18 dB (SMA and PCB losses are subtracted) over the frequency band. The circuit achieves an input and output return loss better than 13.8 dB. Furthermore, the circuit is unconditionally stable from 10 MHz to 15 GHz.

At 5.5 GHz, -10.8 dBm input compression point (IP1dB) is achieved, together with the 14.6 dBm output third intercept point (OIP3) measured with 1MHz tone spacing.

3.2 Performance Overview

Device: BFP840ESD
Application: Low Noise Amplifier for 5 to 6 GHz WLAN Application
PCB Marking: M130121 BFP840ESD SOT343 (0.4mm x 2)

Table 1 Summary of Measurement Results

Parameter	Symbol	Value			Unit	Note/Test Condition
DC Voltage	V_{CC}	3.0			V	
DC Current	I_{CC}	9.2			mA	
Frequency Range	Freq	5100	5500	5900	MHz	
ON-Mode Gain	G_{ON}	16	15.5	15	dB	
OFF-Mode Gain	G_{OFF}	-26.2	-26.8	-27.7	dB	Vcc = 0 V, Icc = 0 mA
Noise Figure	NF	1.09	1.13	1.18	dB	SMA and PCB losses (~0.12 dB) are subtracted
Input Return Loss	RL_{in}	13.8	17.1	19.2	dB	
Output Return Loss	RL_{out}	22.1	23.5	17.4	dB	
Reverse Isolation	IR_{ev}	26.3	25.4	24.7	dB	
ON-Mode Input P1dB	$IP1dB_{ON}$		-10.8		dBm	
OFF-Mode Input P1dB	$IP1dB_{OFF}$		>10		dBm	Vcc = 0 V, Icc = 0 mA
Output P1dB	OP1dB		3.6		dBm	
Input IP3	IIP3	-1			dBm	
Output IP3	OIP3	14.6			dBm	Power @ Input: -30 dBm f_1= 5500 MHz, f_2= 5501 MHz
Stability	k	≥ 1.0			--	Stability measured from 10 MHz to 15 GHz

3.3 Schematics and Bill-of-Materials

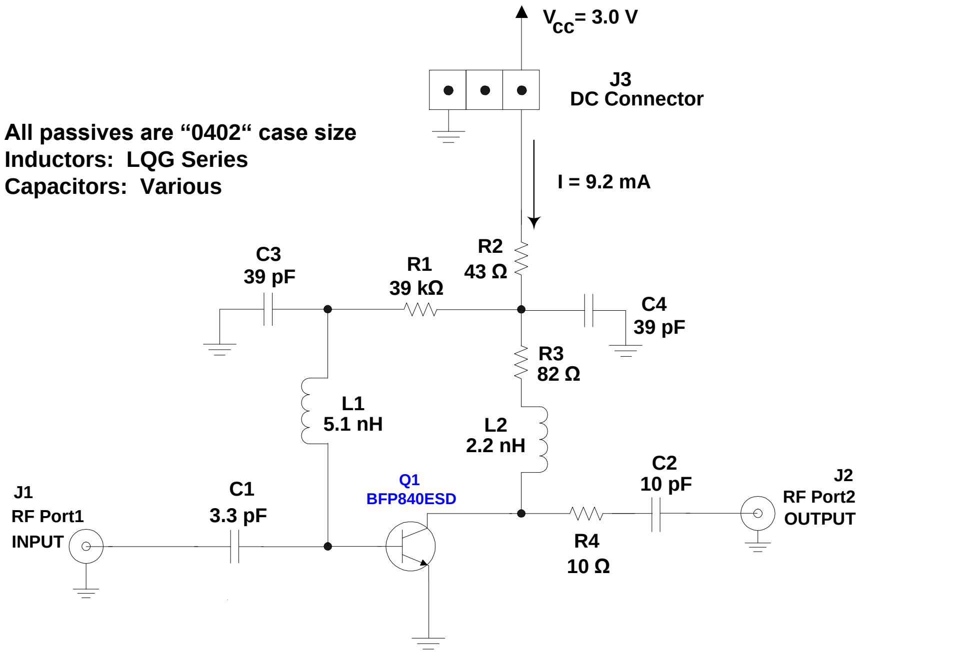

Figure 4 Schematic Diagram of the used Circuit

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	3.3	pF	0402	Various	Input DC block, Noise & input matching
C2	10	pF	0402	Various	Output DC block & output matching
C3, C4	39	pF	0402	Various	RF decoupling / blocking cap
L1	5.1	nH	0402	Murata LQG series	Noise & input matching
L2	2.2	nH	0402	Murata LQG series	Output matching & high frequency stability improvement
R1	39	kΩ	0402	Various	DC biasing
R2	43	Ω	0402	Various	DC biasing (provides DC negative feedback to stabilize DC operating point over temperature variation, transistor h_{FE} variation, etc.)
R3	82	Ω	0402	Various	Stability improvement & output matching
R4	10	Ω	0402	Various	High frequency stability improvement
Q1			SOT343	Infineon Technologies	BFP840ESD SiGe:C HBT

4 Measured Graphs

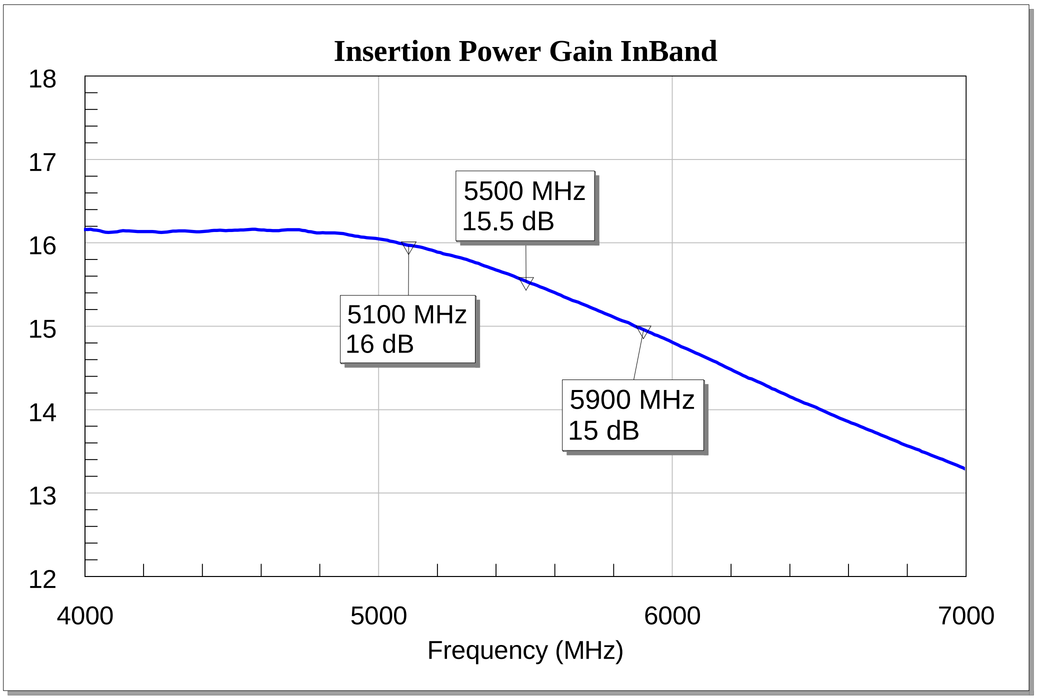

Figure 5 Insertion Power Gain of the 5-6 GHz WLAN LNA with BFP840ESD

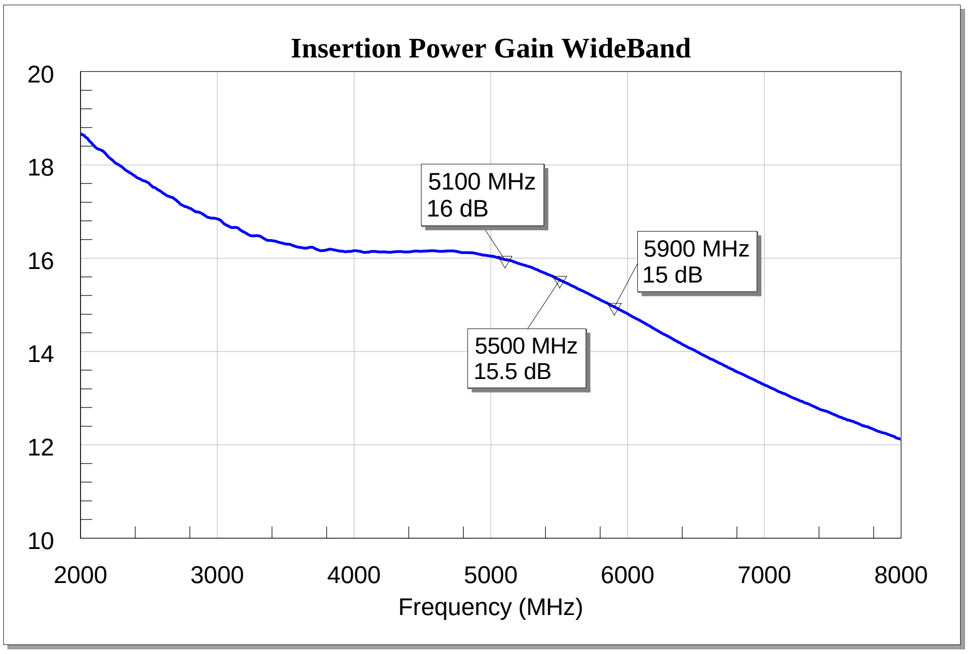

Figure 6 Wideband Insertion Power Gain of the 5-6 GHz WLAN LNA with BFP840ESD

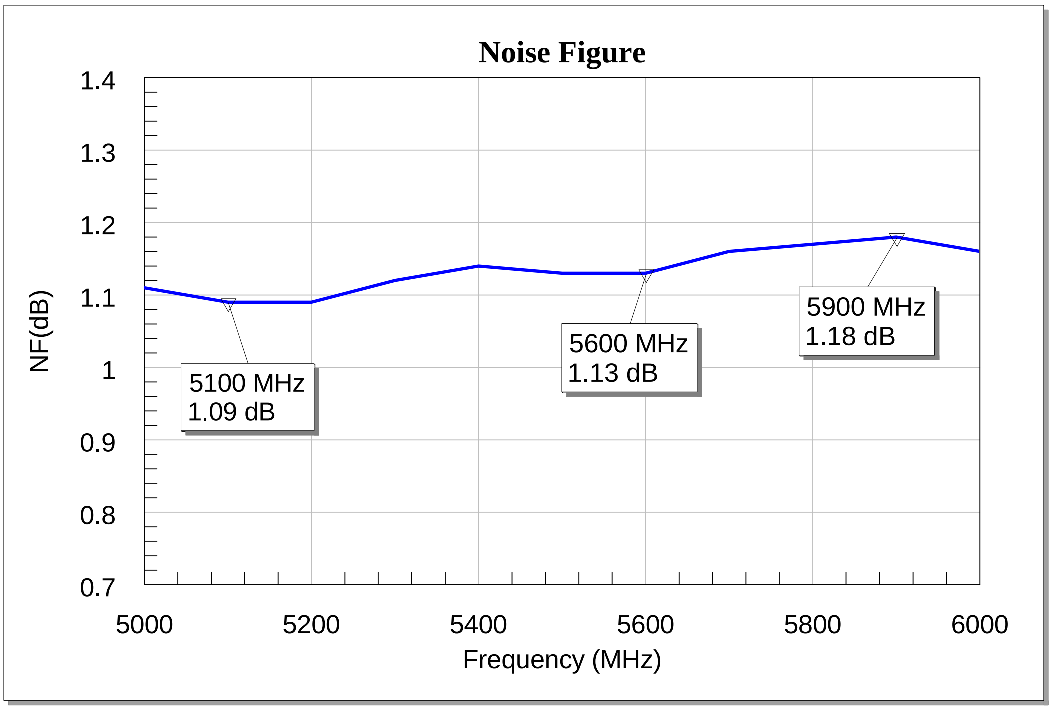

Figure 7 Noise Figure of BFP840ESD LNA for 5100 - 5900 MHz

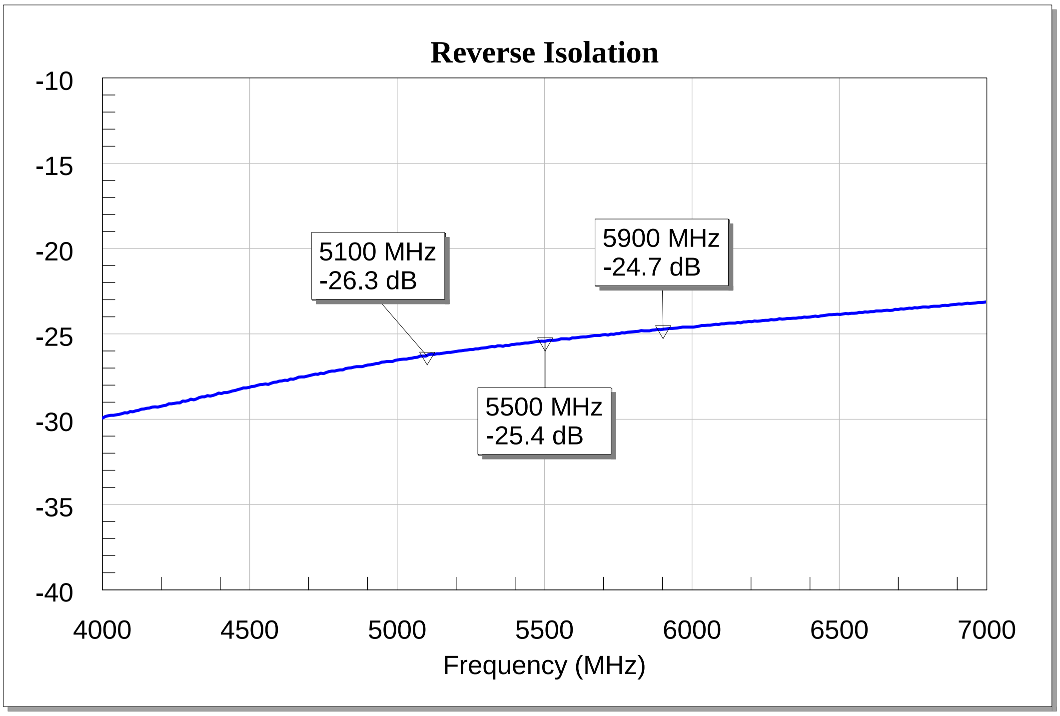

Figure 8 Reverse Isolation of the 5-6 GHz WLAN LNA with BFP840ESD

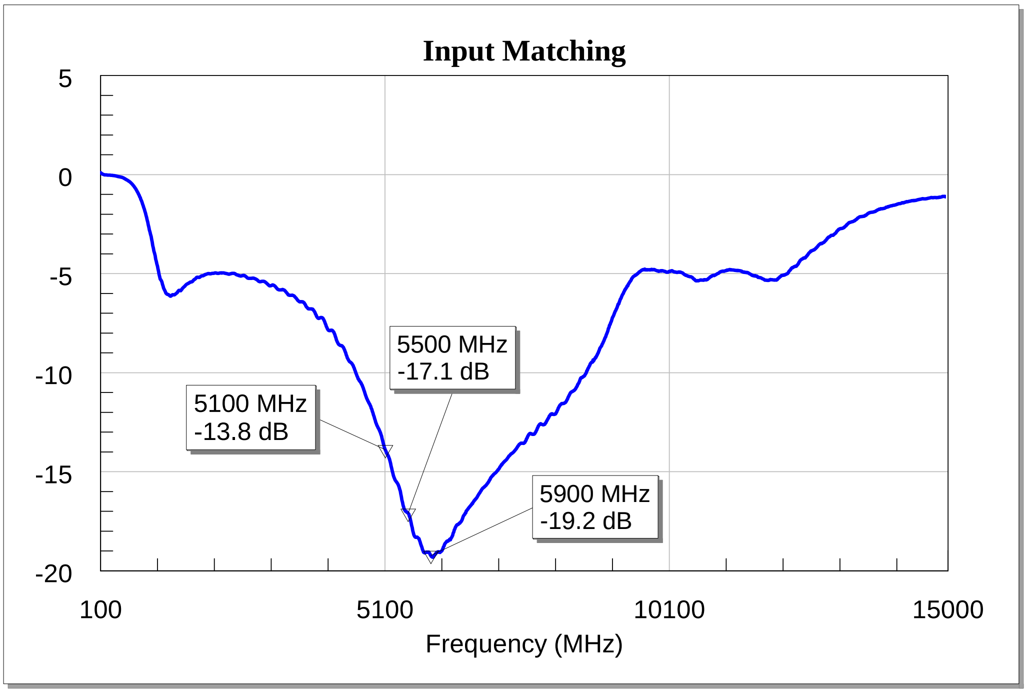

Figure 9 Input Matching of the 5-6 GHz WLAN LNA with BFP840ESD

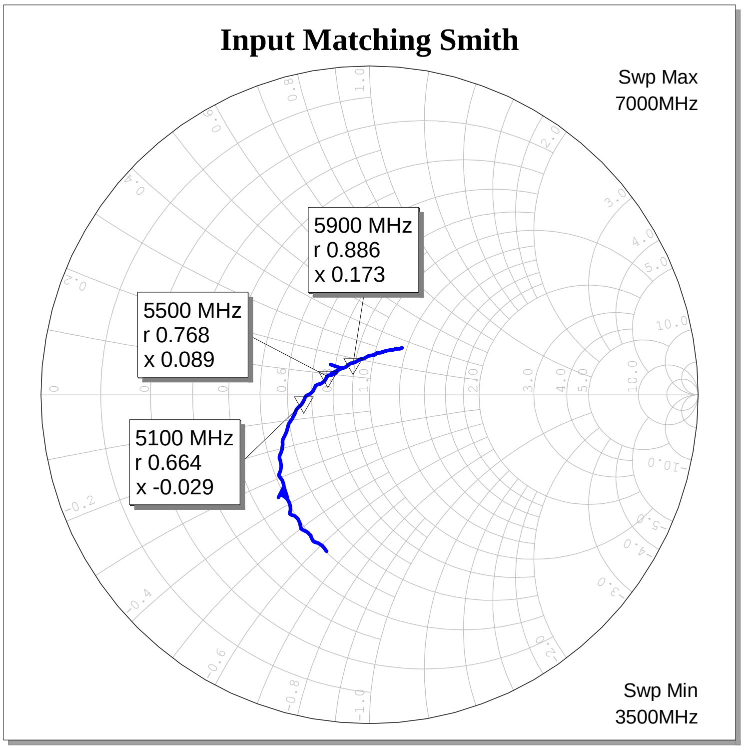

Figure 10 Input Matching of the 5-6 GHz WLAN LNA with BFP840ESD (Smith Chart)

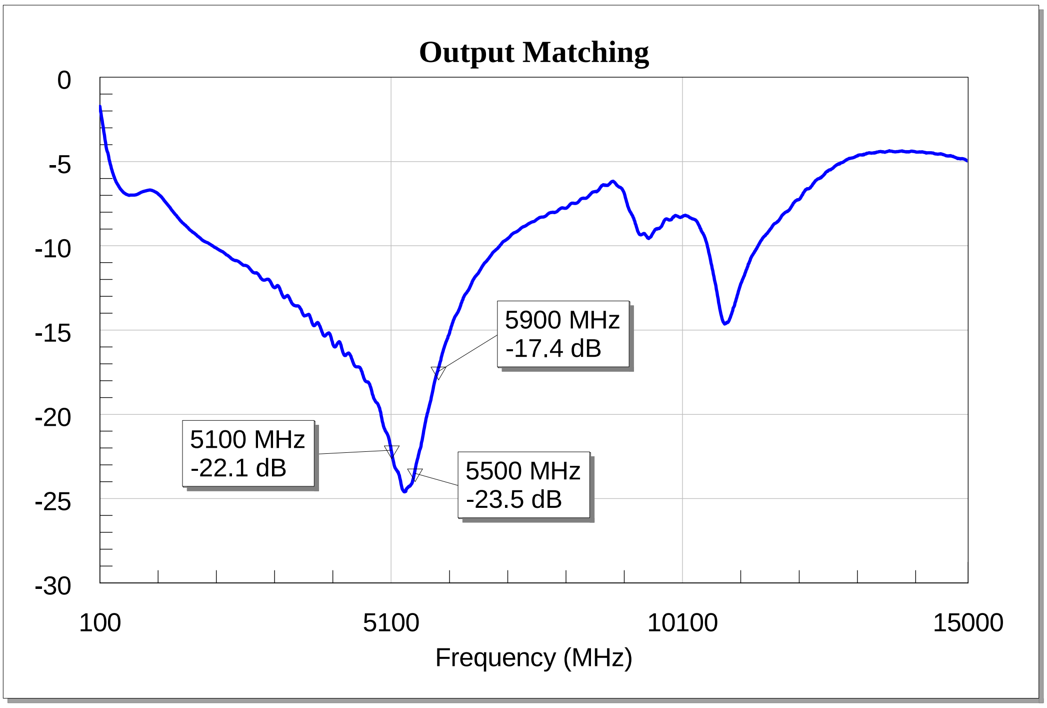

Figure 11 Output Matching of the 5-6 GHz WLAN LNA with BFP840ESD

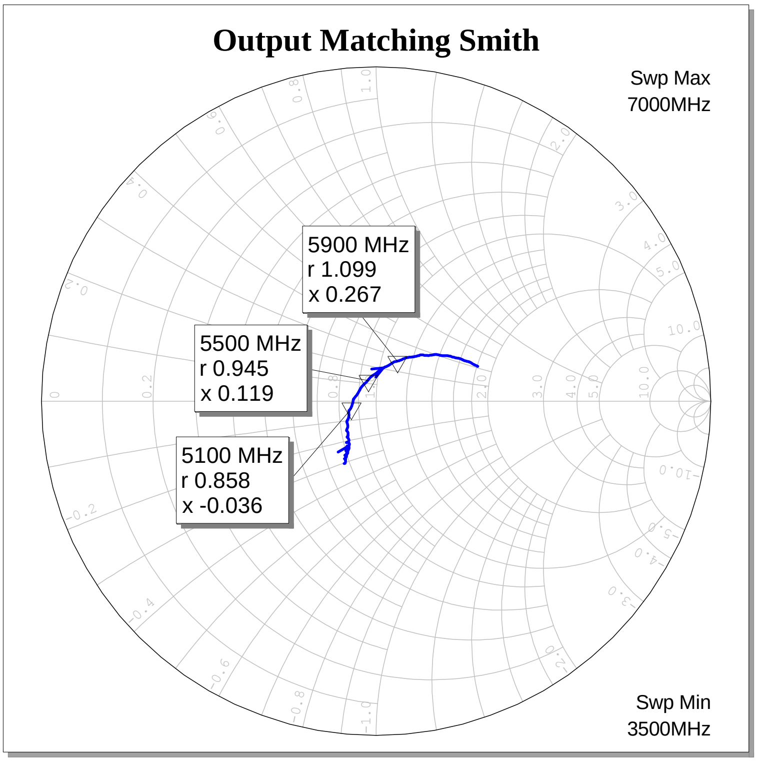

Figure 12 Output Matching of the 5-6 GHz WLAN LNA with BFP840ESD (Smith Chart)

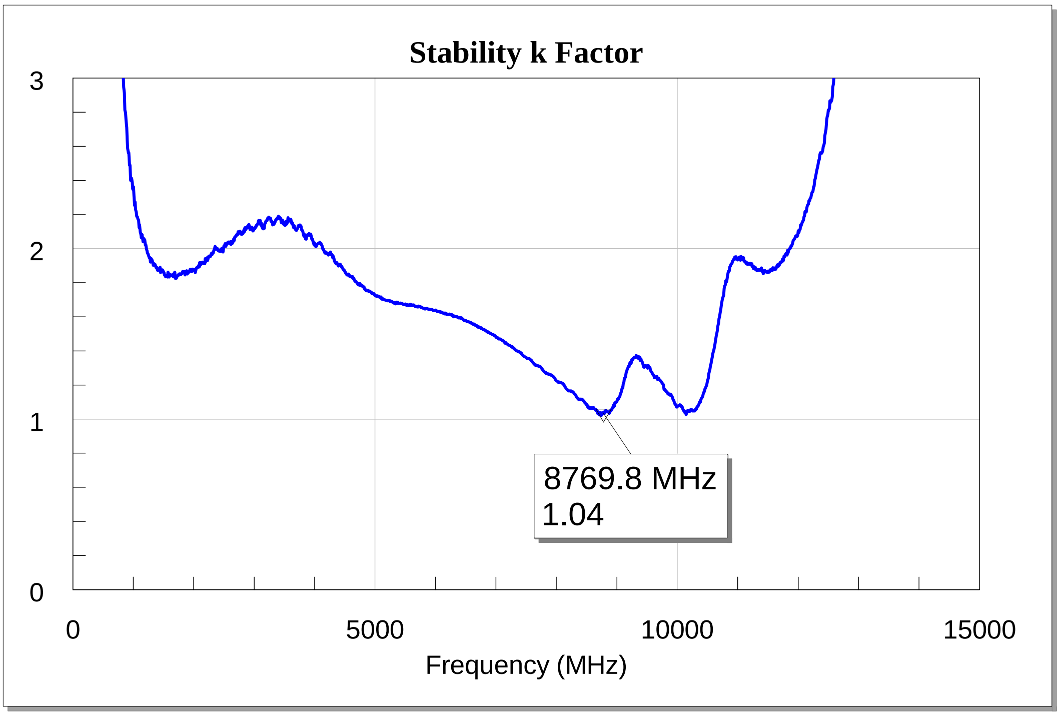

Figure 13 Wideband Stability k Factor of the 5-6 GHz WLAN LNA with BFP840ESD

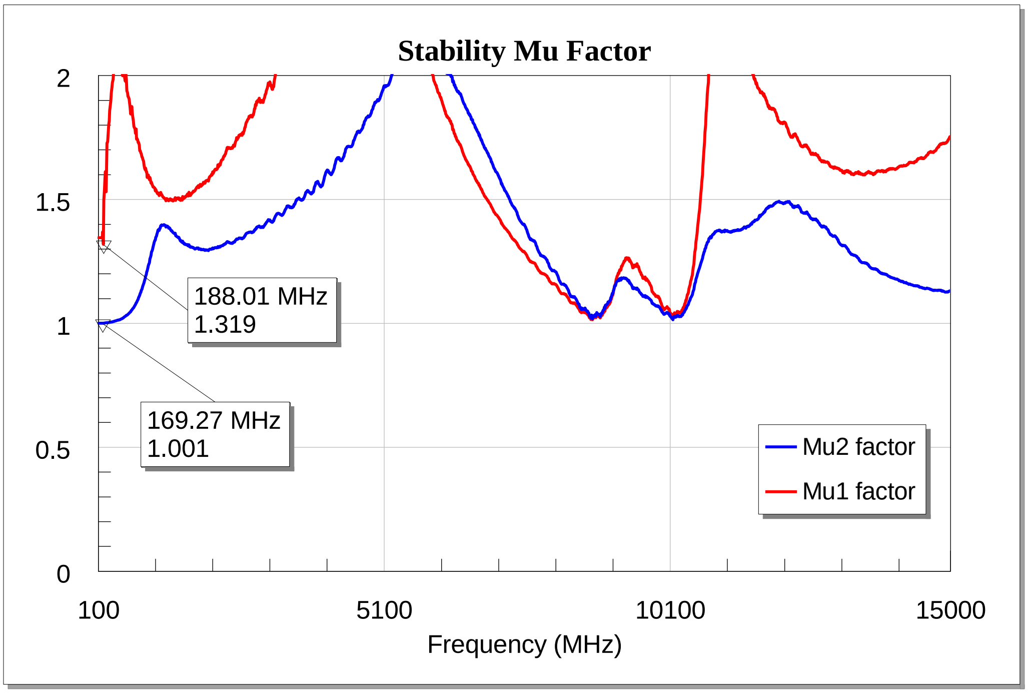

Figure 14 Wideband Stability Mu Factor of the 5-6 GHz WLAN LNA with BFP840ESD

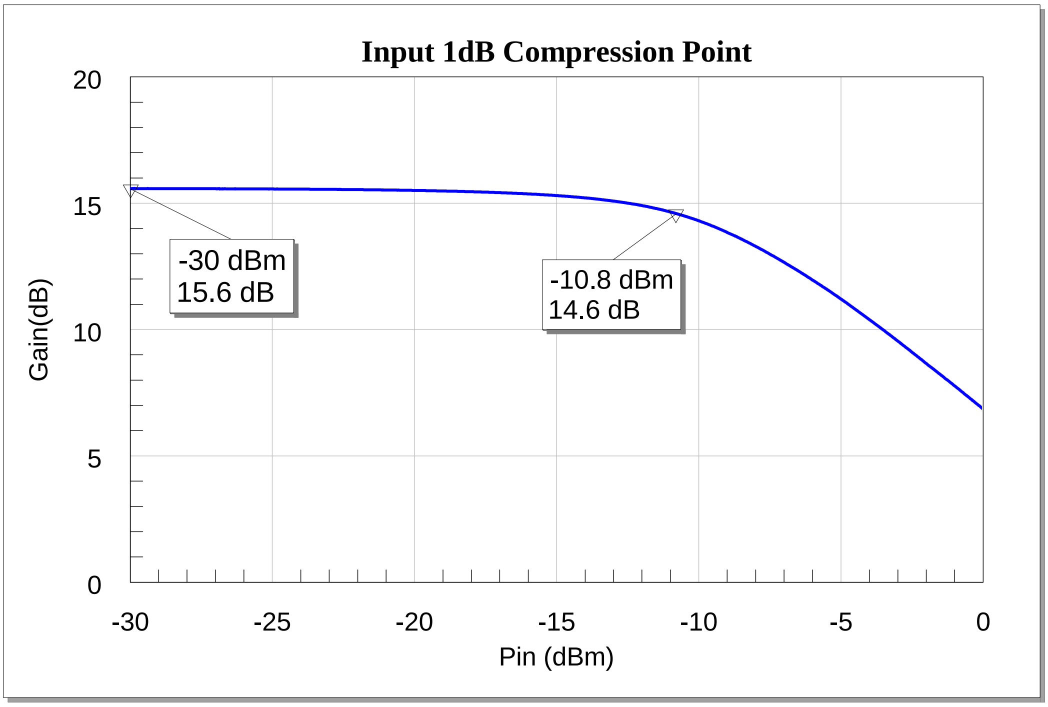

Figure 15 **Input 1dB Compression Point of the LNA with BFP840ESD at 5500 MHz**

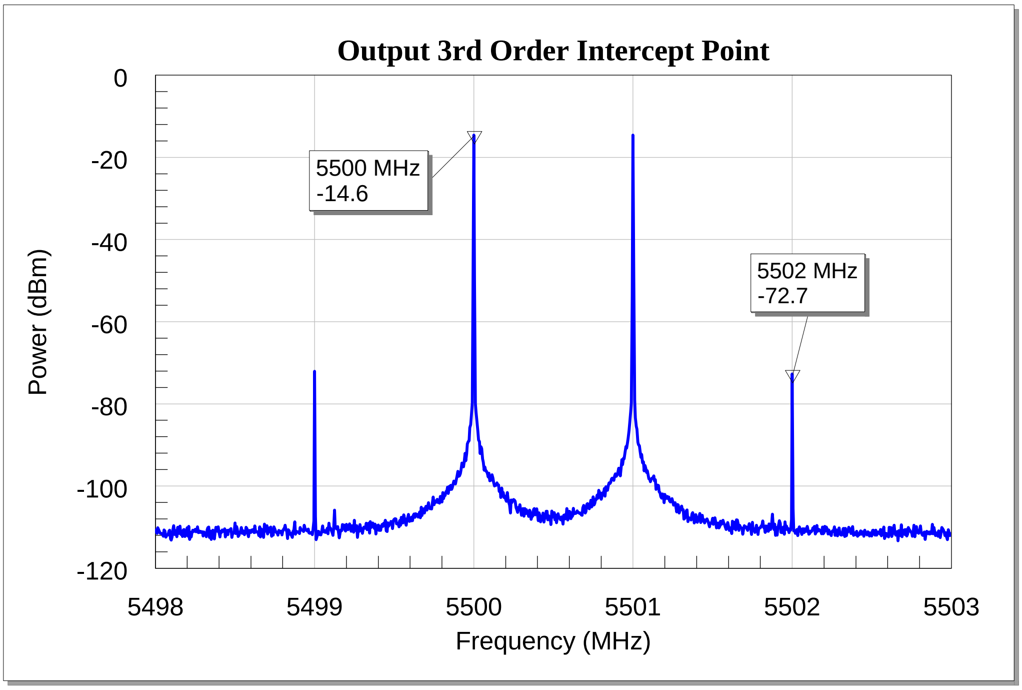

Figure 16 **Output 3rd Order Intercept Point of LNA with BFP840ESD at 5500 MHz (LNA input power = -30 dBm)**

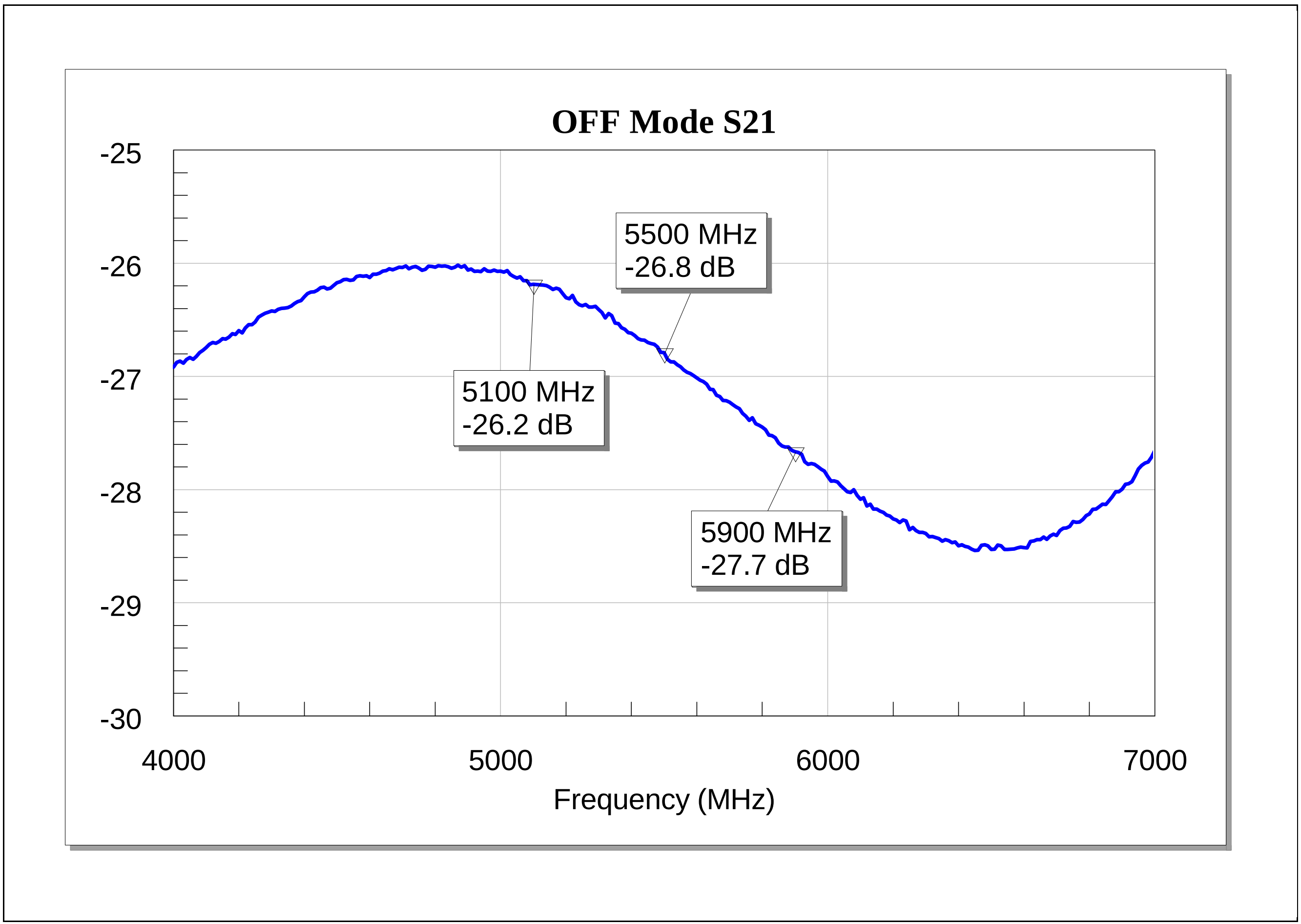

Figure 17 OFF-Mode (Vcc = 0V, Icc = 0mA) S21 of the 5-6 GHz WLAN LNA with BFP840ESD

5 Evaluation Board and Layout Information

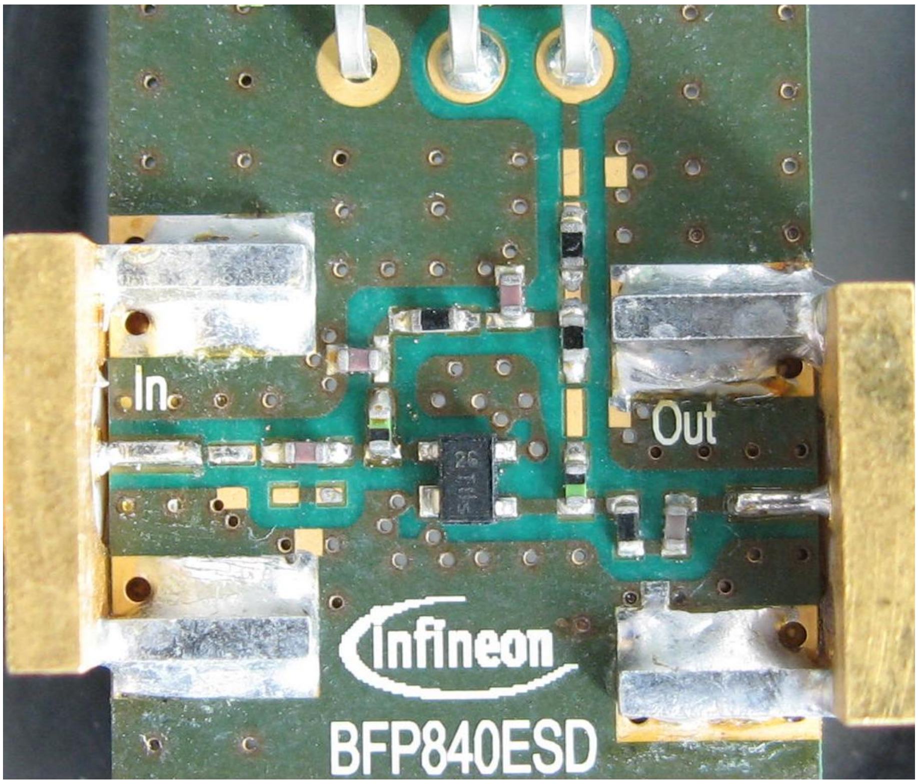

Figure 18 Photo of the BFP840ESD 5-6 GHz WLAN LNA Evaluation Board

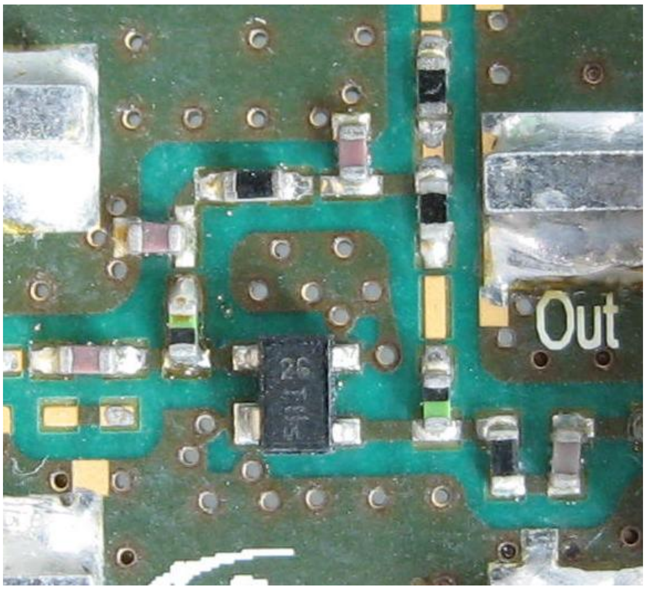

Figure 19 Zoom-In Picture of the BFP840ESD 5-6 GHz WLAN LNA Evaluation Board

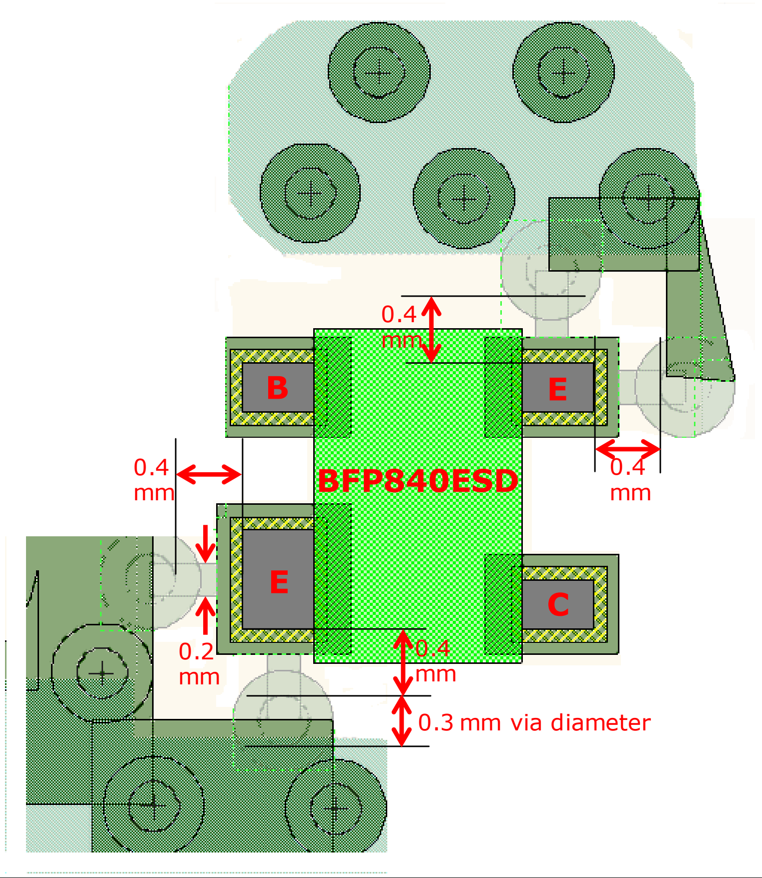

Figure 20 Layout Proposal for RF Grounding of the 5-6 GHz WLAN LNA with BFP840ESD

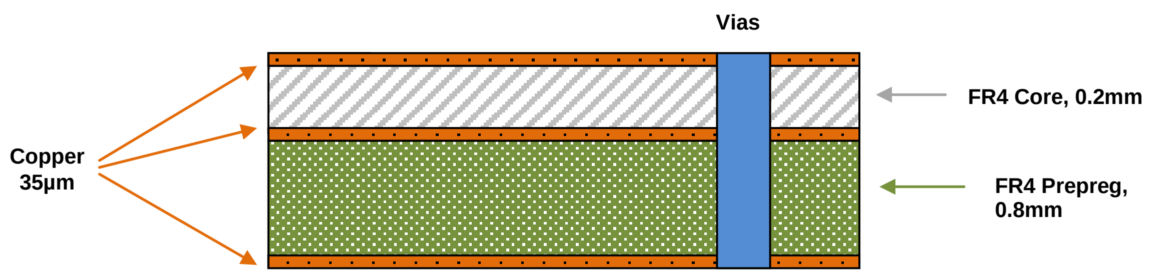

Figure 21 PCB Layer Information

6 Authors

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Dr. Chih-I Lin, Senior Staff Engineer/Technical Marketing RF of Business Unit “RF and Protection Devices”

7 Remark

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

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