BFP760

High Linearity Low Noise Amplifier using BFP760 for 5 - 6 GHz WLAN Applications with 12 dB Gain, 25dB Gain Step and Minimum 2.4 GHz Interference

Application Note AN303

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Application Note AN303
Revision History: 2012-12-18

Previous Revision: No previous revision

Page	Subjects (major changes since last revision)

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1 Introduction

1.1 Overview of Wi-Fi® Applications

Wireless Fidelity (Wi-Fi®) or well-known as wireless LAN (WLAN) 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 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.

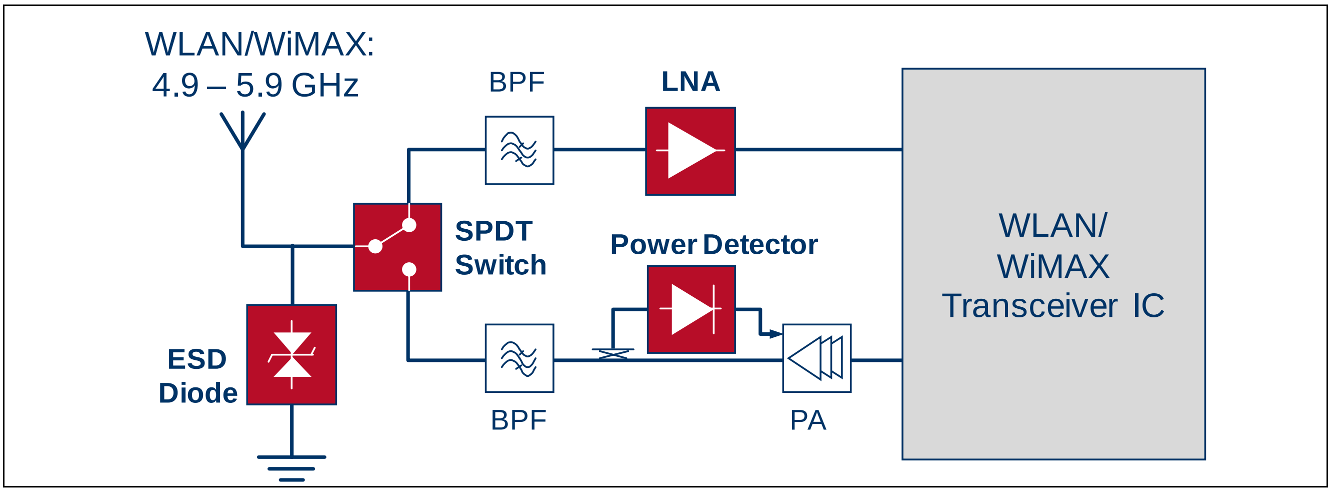

Figure 1 5 – 6 GHz Wi-Fi® Wireless LAN (WLAN, IEEE802.11a/n/ac) Front-End

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 (LNA).

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: BFP760

The BFP760 is a high linearity low noise wideband NPN bipolar RF transistor. The device is based on Infineon's reliable high volume silicon germanium carbon (SiGe:C) heterojunction bipolar technology. The collector design supports voltages up to V_{CEO} = 4.0 V and currents up to I_C = 70 mA. With its high linearity at currents as low as 10 mA the device supports energy efficient designs. The typical transit frequency is approximately 45 GHz. The device is housed in an easy to use plastic SOT-343 package with visible leads.

2 Low Noise Amplifier for 5 to 6 GHz WLAN with BFP760

This application note presents a high linearity low noise amplifier circuit using BFP760 for 5 – 6 GHz WLAN applications. The circuit features 12 dB gain in on-mode and -13 dB gain in off-mode/bypass mode resulting in 25 dB on- to off-mode gain step. An L-C network (L1, C2), as shown in Figure 2, is used simultaneously for input matching and as a 2.4 GHz notch filter to minimize jammer leakage of 2.4 GHz WLAN signal into the 5 GHz WLAN receiver path.

The circuit requires only 10 passive components (only 2 low Q coils from LQG series) and is operated at 11 mA. It shows a gain flatness of 0.8 dB over the complete frequency band in both on- and off- mode.

The input and output return losses are better than 10 dB over the 5 -6 GHz frequency band. Especially the output return loss is higher than 14.5 dB. The noise figure is extremely low of 1.0 dB (SMA and PCB losses subtracted) over the 5 – 6 GHz frequency band. Furthermore, the circuit is unconditionally stable and immune against RF grounding layout changes.

The minimum in-band input 1dB compression point IP1dB is -4 dBm in on-mode (5100 MHz) and 12.5 dBm in off-mode (5900 MHz). When switched off into the so called bypass mode, the transistor can work with input power levels as high as 2.5 dBm, assuming a healthy 10 dB back-off to the compression point. The high out-of-band rejection results in an input P1dB as high as 13 dBm at 2400 MHz. Besides, using two tones spacing of 1 MHz, the input third order intercept point IIP3 reaches 9.2 dBm.

The BFP760 could help you build a high-performance cost-effective solution for your upcoming 5GHz WLAN IEEE802.11a/n/ac designs requiring a narrow gap in gain between on- and off- modes.

3 Application Circuit and Performance

3.1 Overview

Device: BFP760
Application: Low Noise Amplifier for 5 to 6 GHz WLAN with 2.4 GHz Rejection
PCB Marking: BFP760 SOT343 **M12101004**

3.2 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	11.2				mA	
Frequency Range	Freq	2400	5100	5500	5900	MHz	
Gain (ON-Mode)	G_{on}	-13.9	12.1	11.9	11.4	dB	
Gain (OFF-Mode)	G_{off}	--	-13.8	-13.0	-13.1	dB	0V Vcc for off- / bypass- mode
Noise Figure	NF	--	1.00	1.06	1.05	dB	SMA and PCB losses (~0.15 dB) are subtracted
Input Return Loss	RLin	--	10.0	13.0	11.6	dB	
Output Return Loss	RLout	--	14.6	17.6	24.2	dB	
Reverse Isolation	IRev	--	18.7	17.7	17.1	dB	
Input P1dB (ON)	$IP1dB_{on}$	13.0	-4.0	-2.7	-1.2	dBm	
Output P1dB (ON)	OP1dB	-1.9	7.1	8.1	9.2	dBm	
Input P1dB (OFF)	$IP1dB_{off}$	--	14.5	13.4	12.5	dBm	0V Vcc for off- / bypass- mode
Input IP3	IIP3	--	9.2			dBm	Power @ Input: -25 dBm f_1= 5900 MHz, f_2= 5901 MHz
Output IP3	OIP3	--	20.6			dBm	Power @ Input: -25 dBm f_1= 5900 MHz, f_2= 5901 MHz
Stability	k	≥ 1.0				--	Stability measured from 10MHz to 15GHz

3.3 Schematics

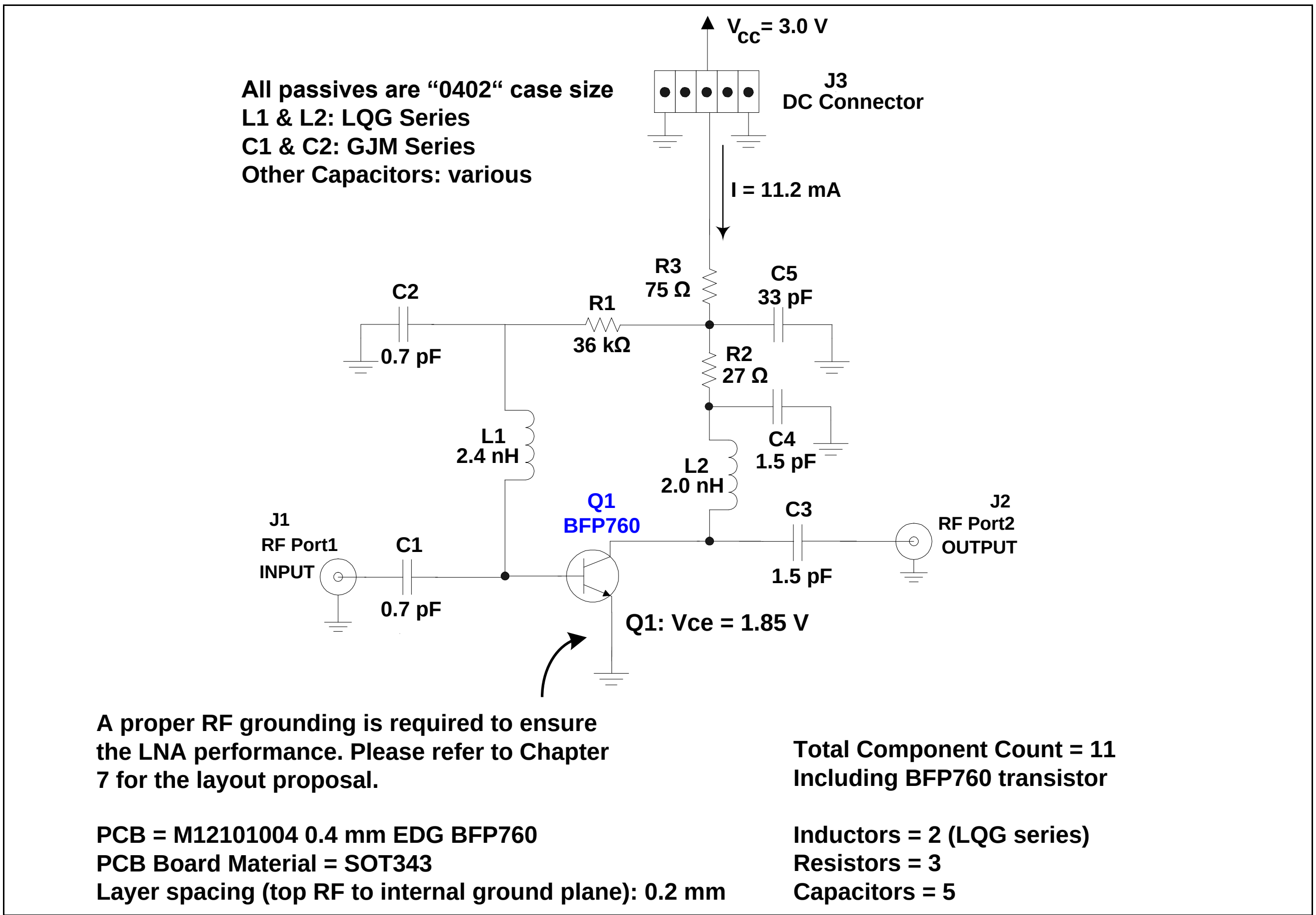

Figure 2 Schematic Diagram of the Application Circuit

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	0.7	pF	0402	GJM Series	Input DC block & input matching
C2	0.7	pF	0402	GJM Series	Input matching & 2.4 GHz rejection
C3	1.5	pF	0402	Various	Output DC block & output matching
C4	1.5	pF	0402	Various	Output matching
C5	33	pF	0402	Various	RF decoupling / blocking cap
L1	2.4	nH	0402	Murata LQG series	Input matching & 2.4 GHz rejection
L2	2.0	nH	0402	Murata LQG series	Output matching & Collector biasing
R1	36	kΩ	0402	Various	DC biasing
R2	27	Ω	0402	Various	Stability improvement
R3	75	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	BFP760 SiGe: C Heterojunction Bipolar RF Transistor

4 Measured Graphs

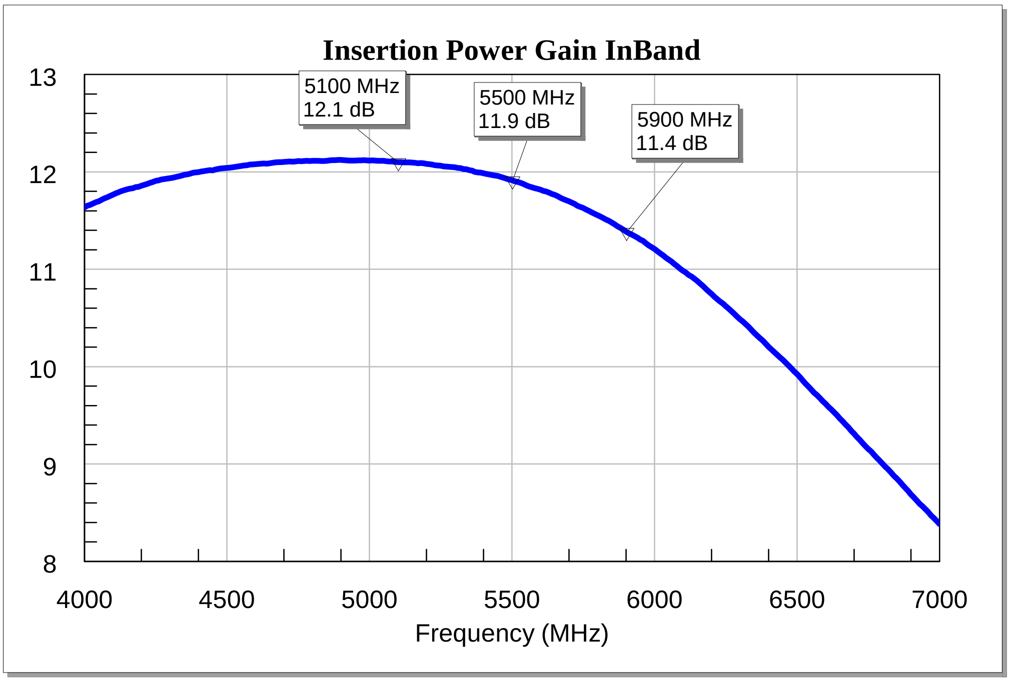

Figure 3 Insertion Power Gain of the 5-6 GHz WLAN LNA with BFP760

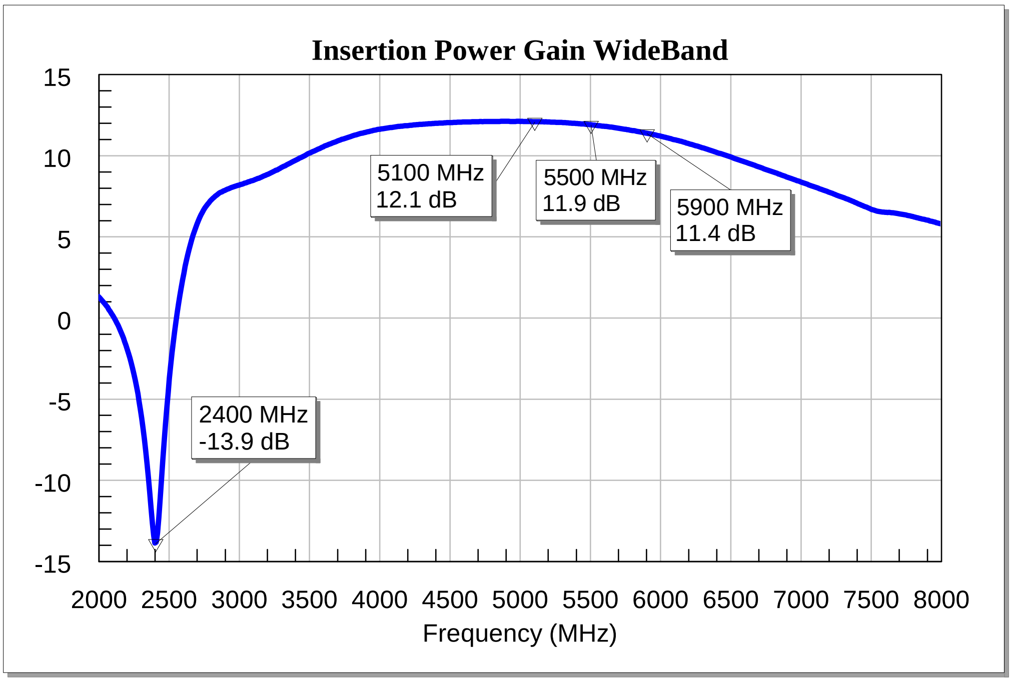

Figure 4 Wideband Insertion Power Gain of the 5-6 GHz WLAN LNA with BFP760

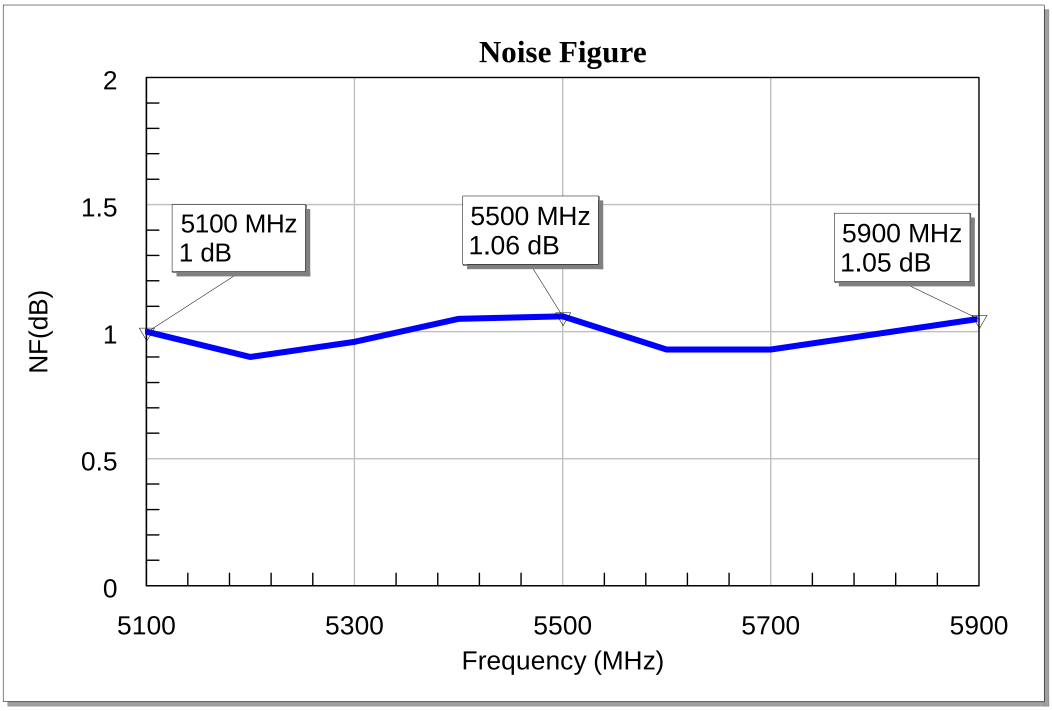

Figure 5 Noise Figure of BFP760 LNA for 5100 - 5900 MHz

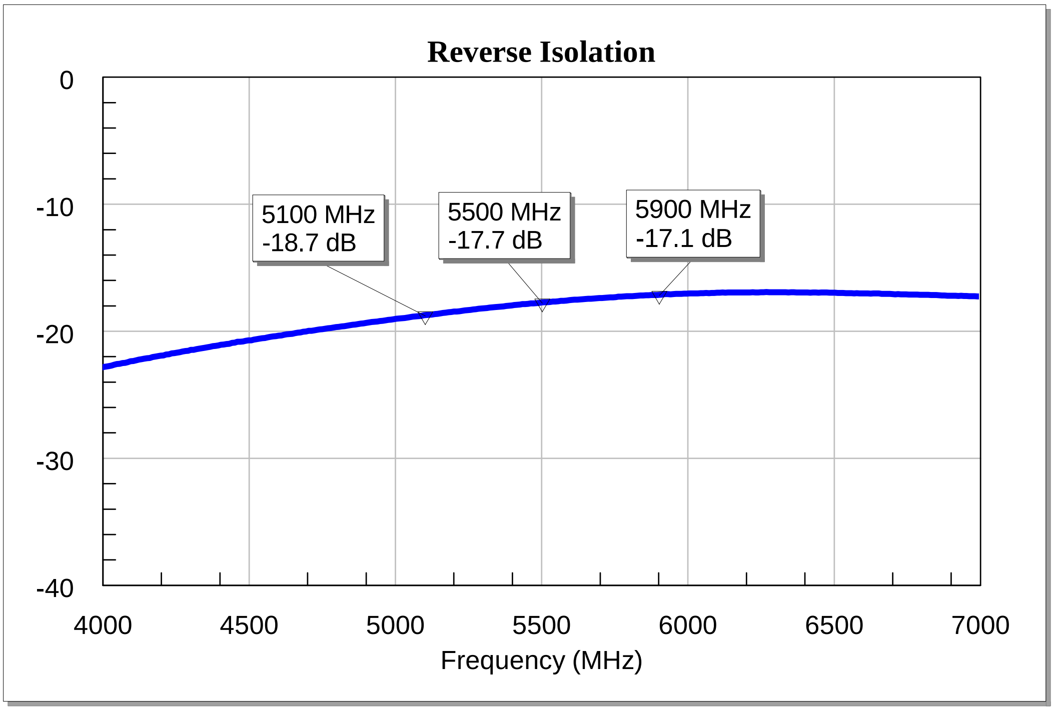

Figure 6 Reverse Isolation of the 5-6 GHz WLAN LNA with BFP760

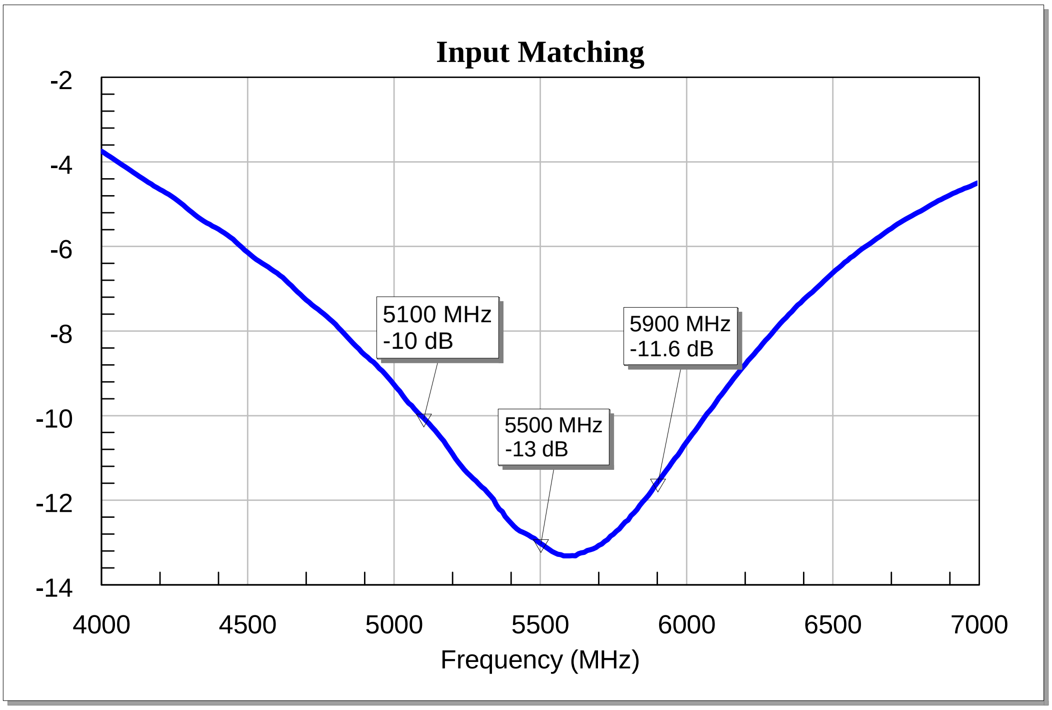

Figure 7 Input Matching of the 5-6 GHz WLAN LNA with BFP760

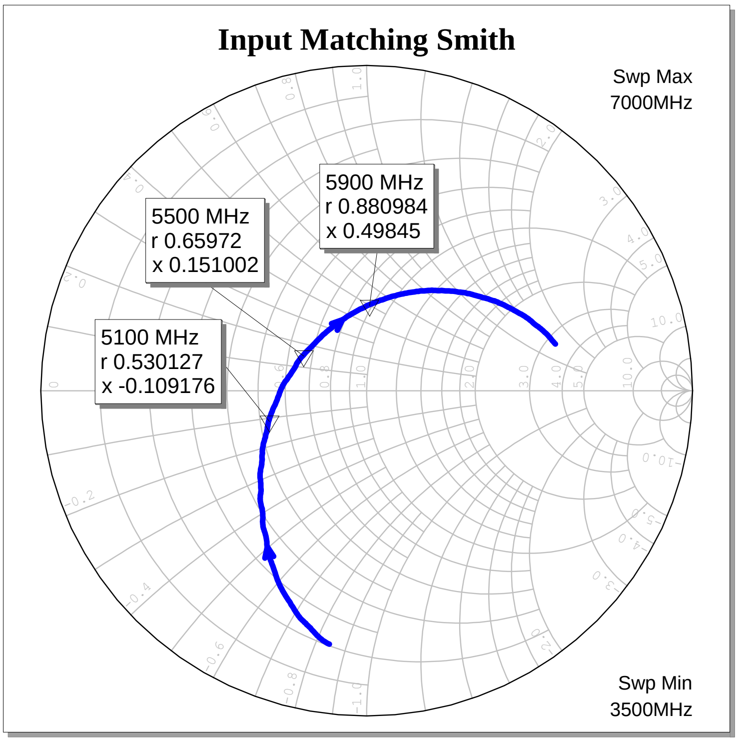

Figure 8 Input Matching of the 5-6 GHz WLAN LNA with BFP760 (Smith Chart)

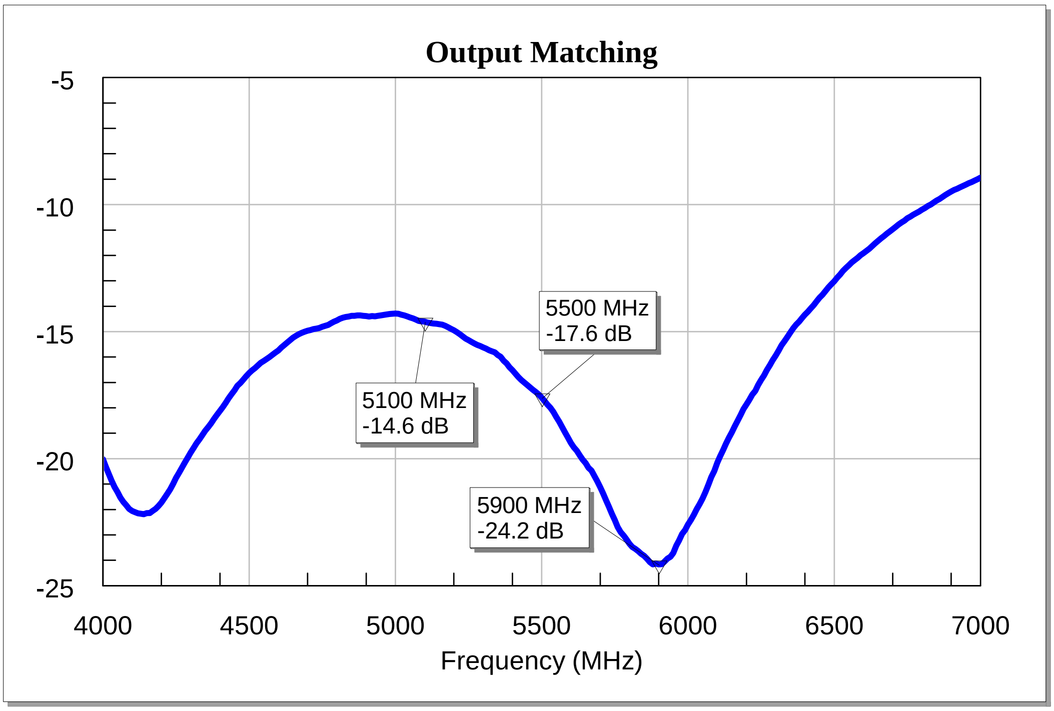

Figure 9 Output Matching of the 5-6 GHz WLAN LNA with BFP760

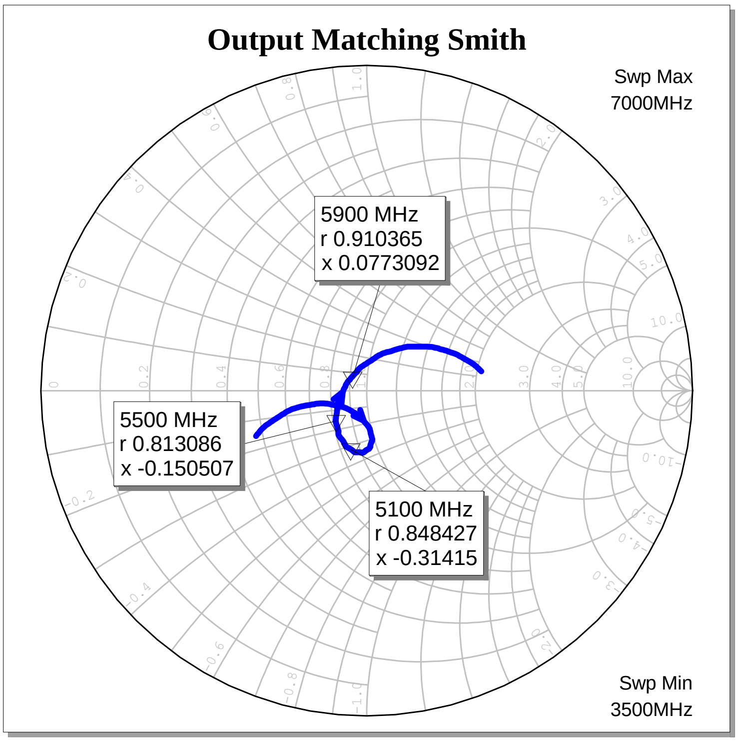

Figure 10 Output Matching of the 5-6 GHz WLAN LNA with BFP760 (Smith Chart)

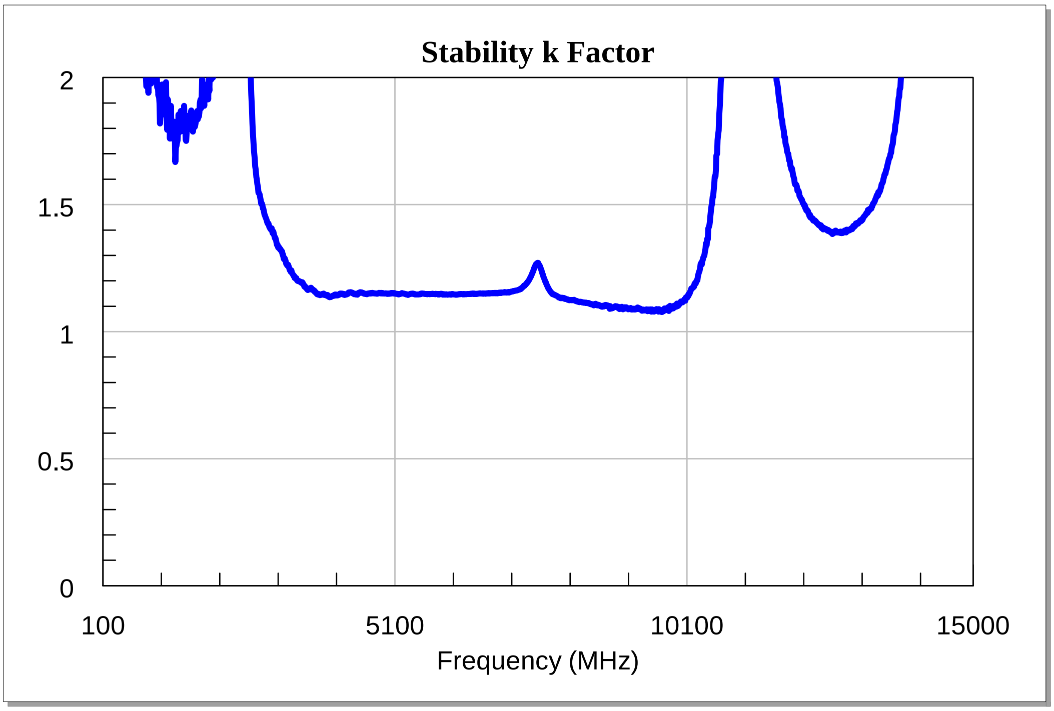

Figure 11 Wideband Stability k Factor of the 5-6 GHz WLAN LNA with BFP760

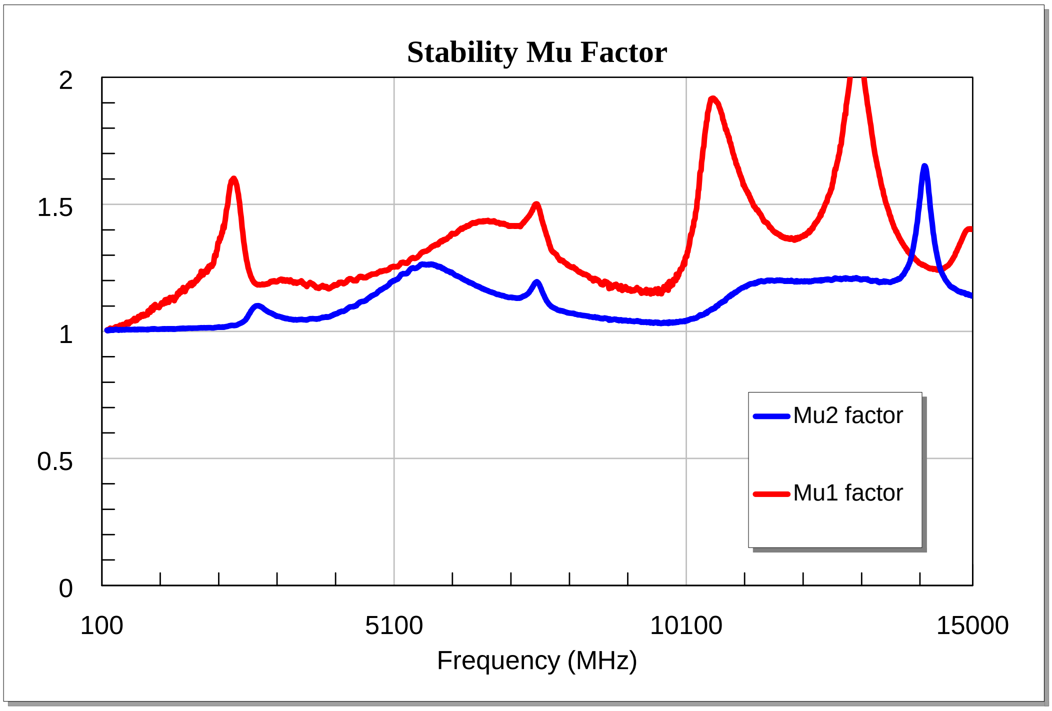

Figure 12 Wideband Stability Mu Factor of the 5-6 GHz WLAN LNA with BFP760

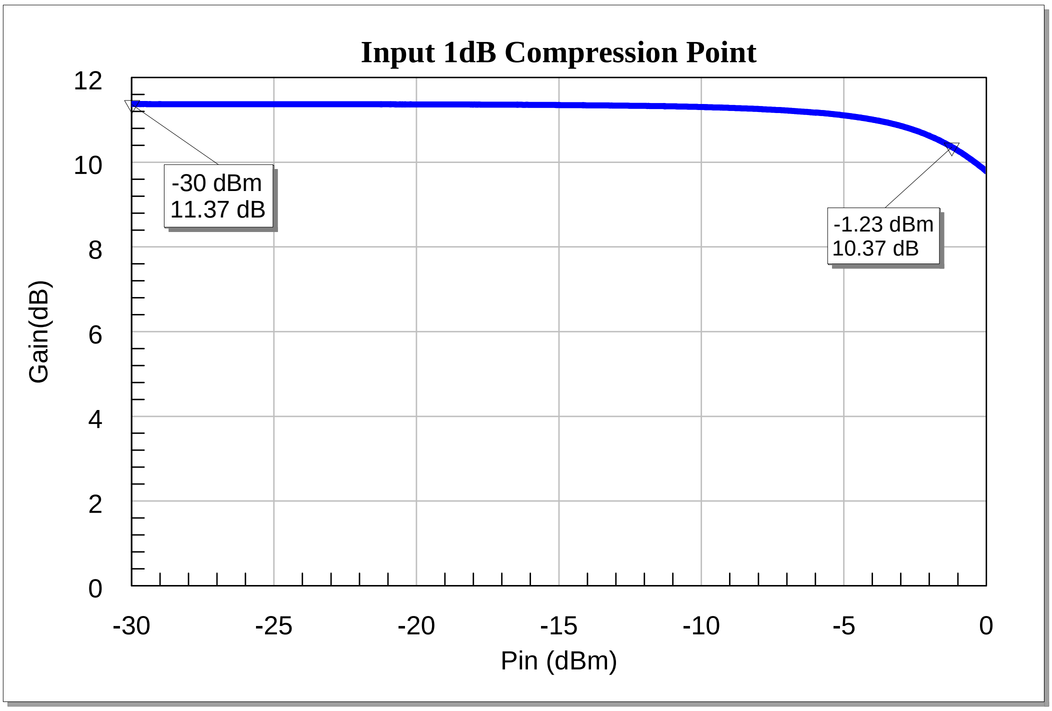

Figure 13 Input 1dB Compression Point of the BFP760 Circuit at 5900 MHz

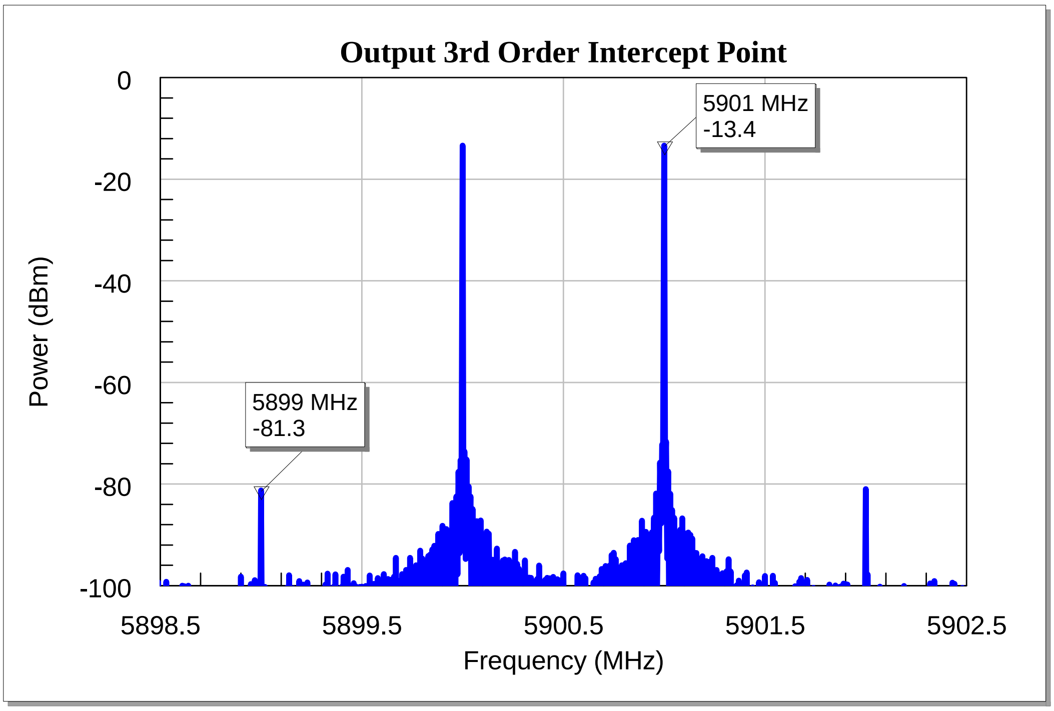

Figure 14 Output 3rd Order Intercept Point of BFP760 at 5900 MHz

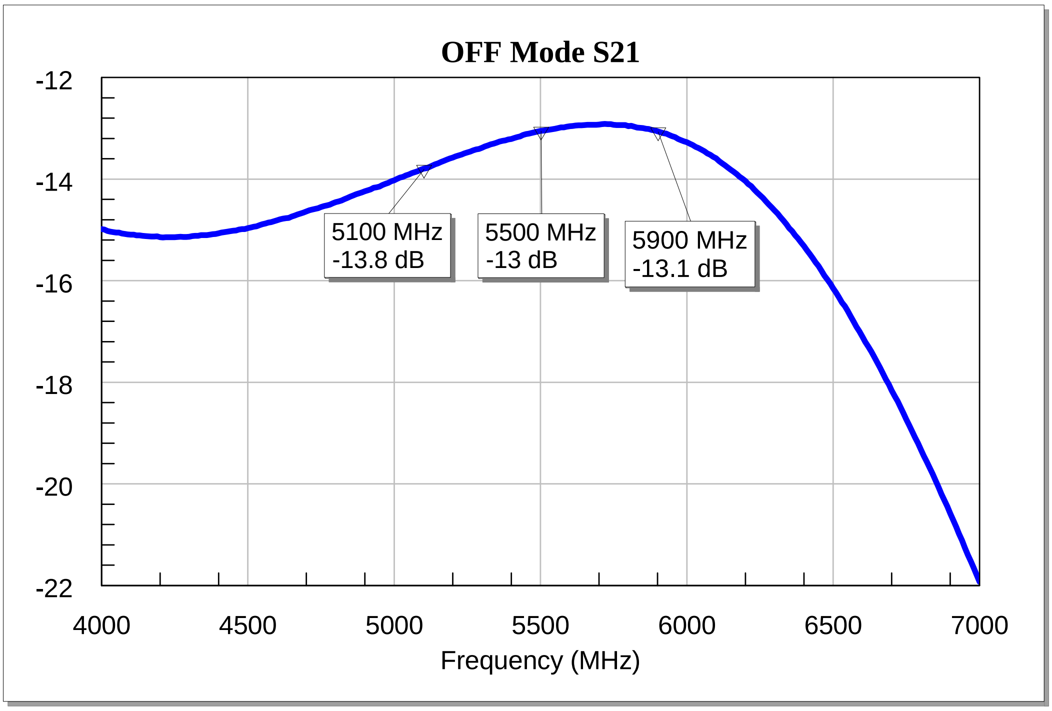

Figure 15 OFF-Mode (Vcc = 0V, Icc = 0mA) S21 of the 5-6 GHz WLAN LNA with BFP760

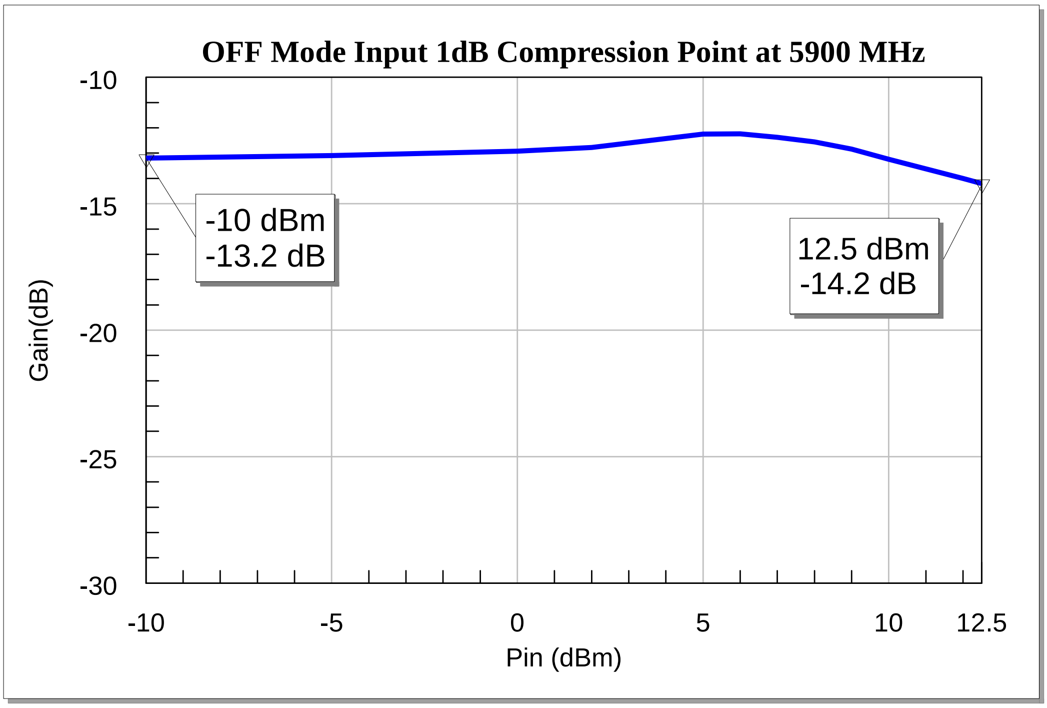

Figure 16 OFF-Mode Input 1dB Compression Point at 5900 MHz

5 Evaluation Board and Layout Information

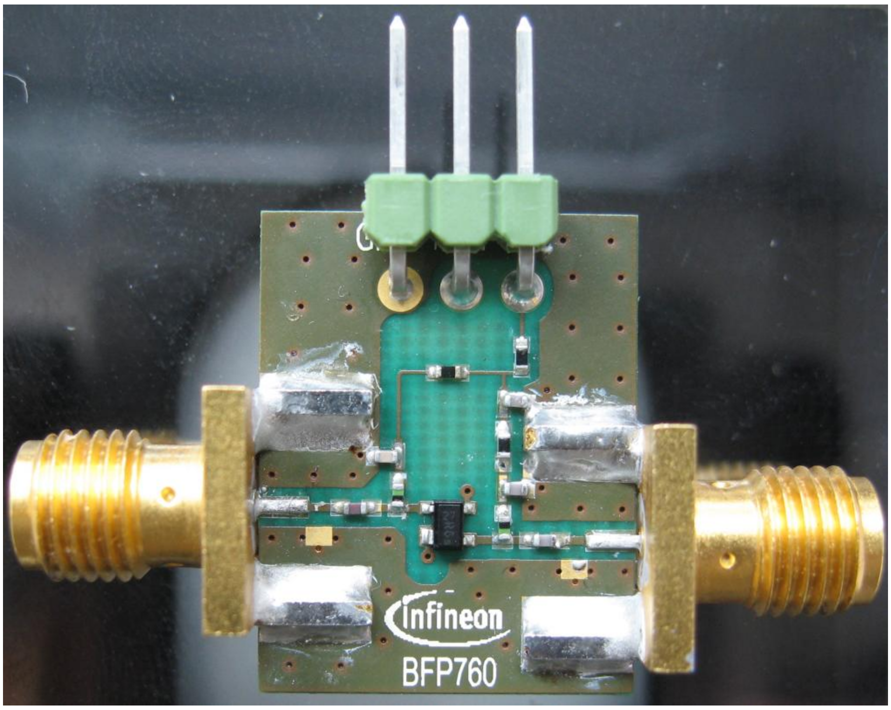

Figure 17 Photo of the BFP760 5-6 GHz WLAN LNA Evaluation Board

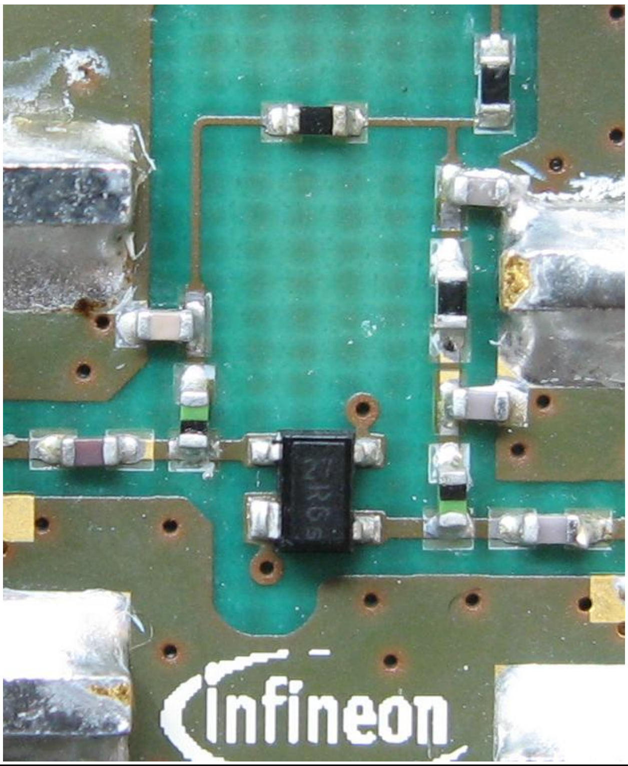

Figure 18 Zoom-In Picture of the BFP760 5-6 GHz WLAN LNA Evaluation Board

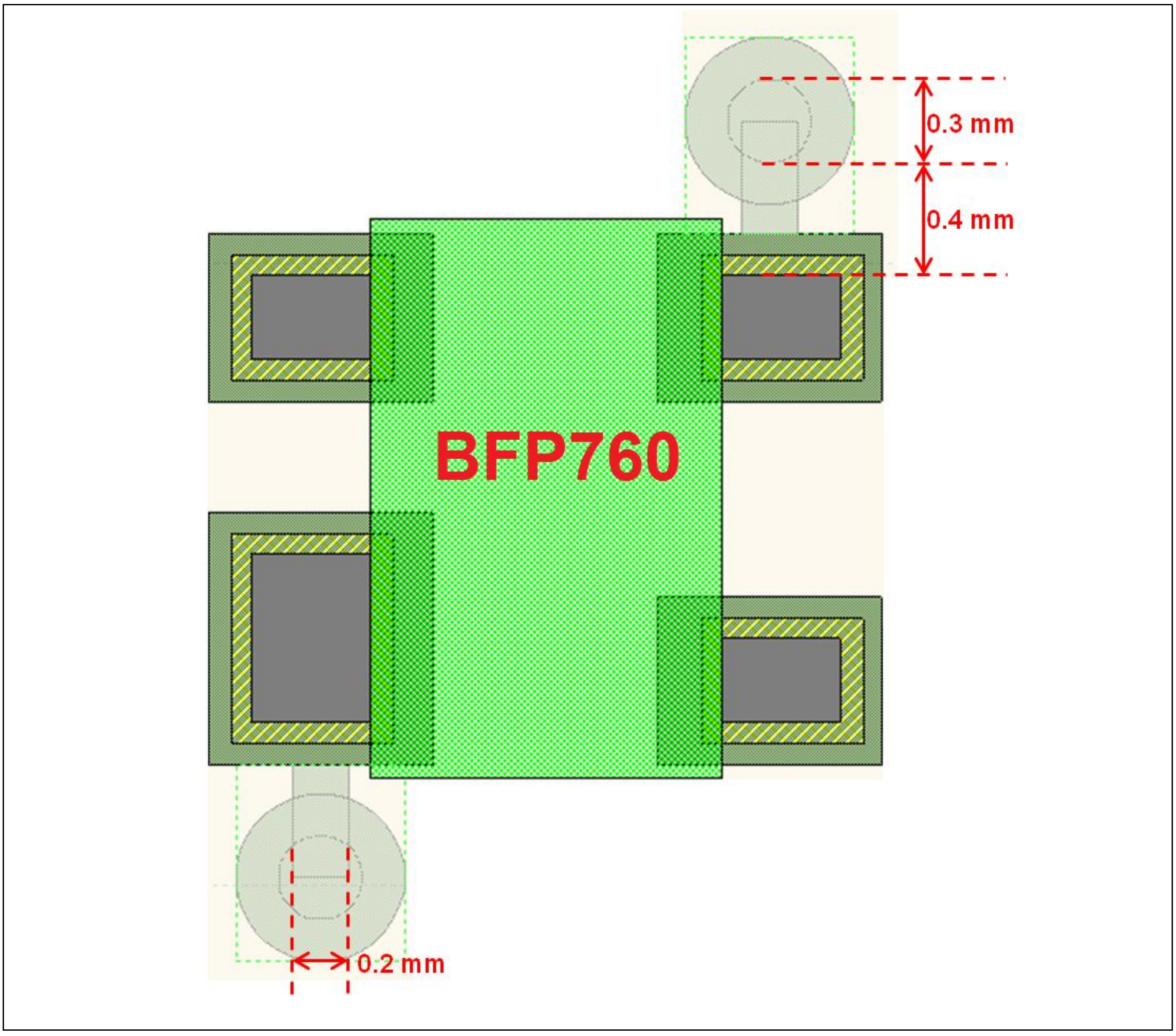

Figure 19 Layout Proposal for RF Grounding of the 5-6 GHz WLAN LNA with BFP760

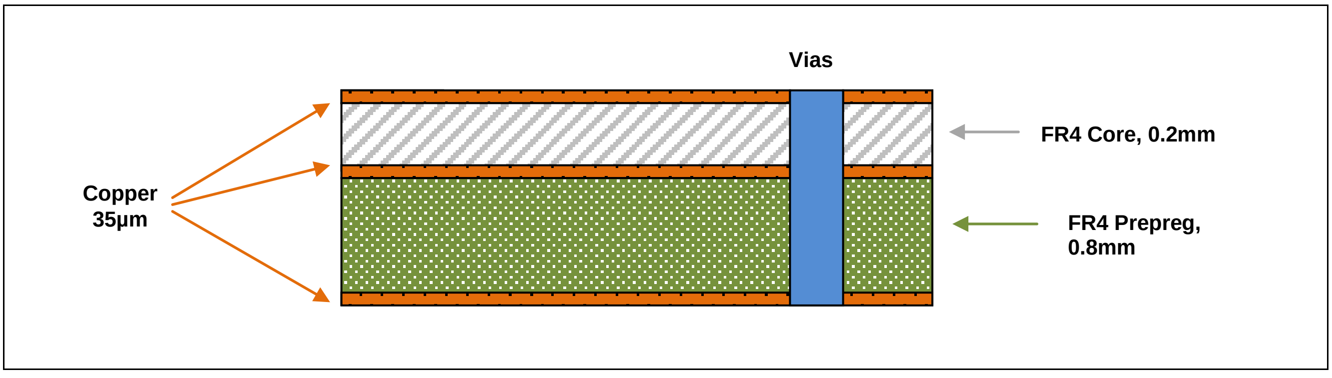

Figure 20 PCB Layer Information

6 Authors

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7 Remark

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

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