BFP760

High Linearity Low Noise Amplifier for 5-6 GHz WLAN with 13dB Gain and On-off Mode Delta Gain 22.5 dB using Internal Diode of Transistor

Application Note AN323

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RF and Protection Devices

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Application Note AN323
Revision History: 2013-07-12

Previous Revision:

Page	Subjects (major changes since last revision)

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1 About Wireless Fidelity (Wi-Fi®) / Wireless LAN (WLAN)

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 5-6 GHzand 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.

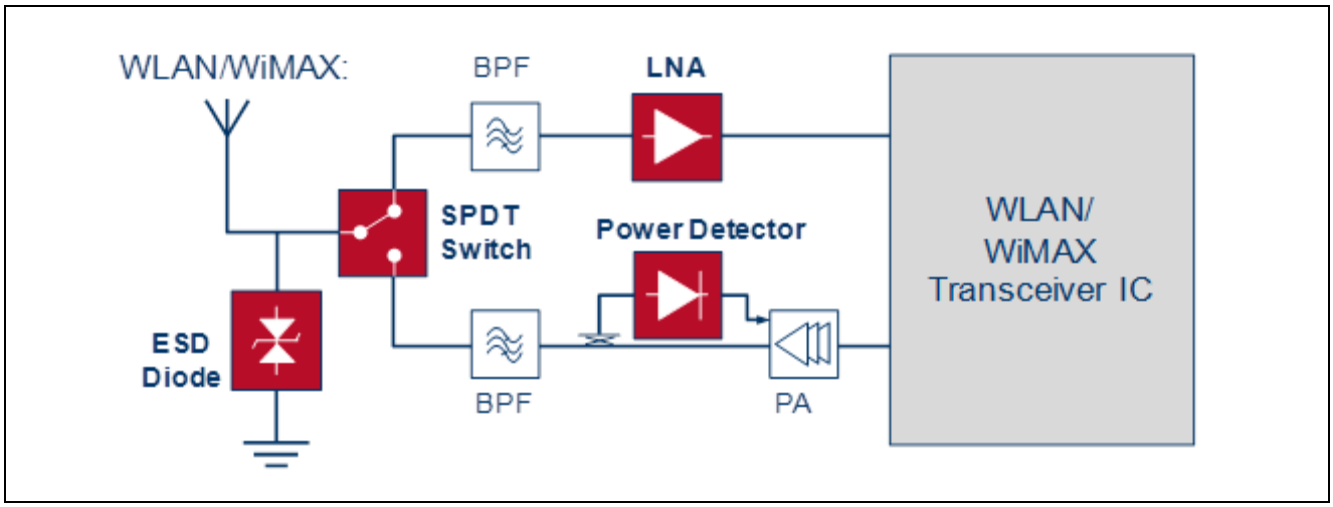

Figure 1 5-6 GHz Wi-Fi® Wireless LAN (WLAN, IEEE802.11b/g/n/a/c/ac) Front-End

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.

2 BFP760 Overview

2.1 Features

- Very low noise amplifier based on Infineon´s reliable, high volume SiGe:C technology.
- High linearity *OIP*3 = 27 dBm @ 5.5 GHz, 3 V, 30 mA.
- High transition frequency *f*T = 45 GHz @ 1 GHz, 3 V, 35mA.
- *NF*min = 0.95 dB @ 5.5 GHz, 3 V, 10 mA,
- Transducer gain |*S*21|2 = 16 dB @ 3.5 GHz, 3 V, 10 mA.
- Low power consumption, ideal for mobile applications.
- Easy to use Pb-free (RoHS compliant) and halogen-free standard package with visible leads
- Qualification report according to AEC-Q101 available.

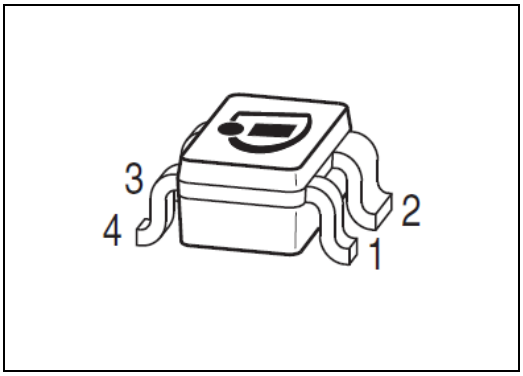

Figure 2 BFP760 in SOT343

2.2 Key Applications of BFP760

- As Low Noise Amplifier (LNA) in
  - Mobile and fixed connectivity applications: WLAN 802.11a/b/c/g/n, WiMAX 2.5/3.5 GHz, Bluetooth
  - Satellite communication systems: Navigation systems (GPS, Glonass), satellite radio (SDARs, DAB) and C-band LNB
  - Multimedia applications such as mobile/portable TV, CATV, FM Radio
  - UMTS/LTE mobile phone applications
  - ISM applications like RKE, AMR and Zigbee, as well as for emerging wireless applications

- As discrete active mixer, buffer amplifier in VCOs

2.3 Description

The BFP760 is a linear 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.

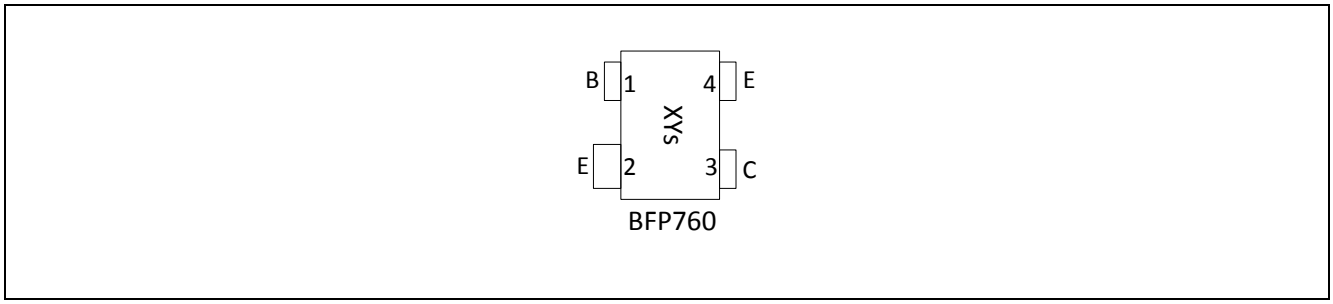

Figure 3 Package and pin definations of BFP760

Table 1 Pin Assignment of BFP760

Pin No.	Symbol	Function
1	B	Transitor base
2	E	Transitor emitter
3	C	Transitor collector
4	E	Transitor emitter

3 Application Circuit and Performance Overview

Device: BFP760
Application: Low Noise Amplifier for 5-6 GHz WLAN with bypass
PCB Marking: M130225

3.1 Summary of Measurement Results

Table 2 On-Mode Electrical Characteristics (at room temperature)

Parameter	Symbol	Value			Unit	Comment/Test Condition
DC Voltage	Vcc	3			V	
DC Current	Icc	11.8			mA	
Frequency Range	Freq	5.1	5.5	5.9	GHz	
Gain (on mode)	G_{on}	13	12.6	11.8	dB	
Noise Figure	NF	0.91	1.07	1.11	dB	SMA and PCB losses (~0.15 dB) are subtracted
Input Return Loss	RLin	13	14	9.6	dB	
Output Return Loss	RLout	13.8	14.7	13.9	dB	
Reverse Isolation	IRev	19.7	19	18.8	dB	
Input P1dB (On mode)	$IP1dB_{on}$	-3.8	-3.9	-1.6	dBm	
Output P1dB(On mode)	$OP1dB_{on}$	8.2	7.7	9.2	dBm	
Input IP3	IIP3	7.4			dBm	Power @ Input: -30 dBm f_1= 5500 MHz, f_2= 5501 MHz
Output IP3	OIP3	20			dBm	Power @ Input: -30 dBm f_1= 5500 MHz, f_2= 5501 MHz
Stability	k	>1			--	Stability measured from 10MHz to 15GHz

Table 3 Off-Mode Electrical Characteristics (at room temperature)

Parameter	Symbol	Value			Unit	Comment/Test Condition
DC Voltage	Vcc	3			V	
DC Current	Icc	60			uA	
Frequency Range	Freq	5.1	5.5	5.9	GHz	
Gain (off mode)	G_{off}	-9.7	-9.9	-10.7	dB	
Noise Figure	NF	9.7	9.9	10.7	dB	SMA and PCB losses (~0.15 dB) are subtracted
Input Return Loss	RLin	8.7	11.7	10	dB	
Output Return Loss	RLout	9.9	8.8	7.6	dB	
Reverse Isolation	IRev	9.7	9.9	10.7	dB	
Input P1dB (On mode)	$IP1dB_{on}$	>10	>10	>10	dBm	
Stability	k	>1			--	Stability measured from 10MHz to 15GHz

3.2 BFP760 as Low Noise Amplifier for 5-6 GHz WLAN

This application note presents the high gain low noise amplifier with novel bypass solution, using BFP760 for 5-6 GHz WLAN applications.

The circuit requires only ten 0402 passive components. It has in band gain of 13 dB. The circuit achieves an input return loss better than 9.6 dB and output return loss better than 13.8 dB. The noise figure is about 0.91 dB (SMA and PCB losses are subtracted) for 5.1 GHz and 1.11 dB for 5.9 GHz. Furthermore, the circuit is unconditionally stable till 15 GHz. At 5500 MHz, using two tones spacing of 1 MHz, the output third order intercept point OIP3 reaches 20 dBm. And Input 1dB compression point IP1dB reaches -3.9 dBm for the same frequency.

In Off-mode, this circuit shows good performance with On-Off mode delta gain 22.5 dB. This circuit has an input matching of -11.7 dB and output matching of -8.8 dB in off mode condition. The input P1dB compression in the off-mode for the whole frequency range is more than 10 dBm.

3.3 Schematics and Bill-of-Materials

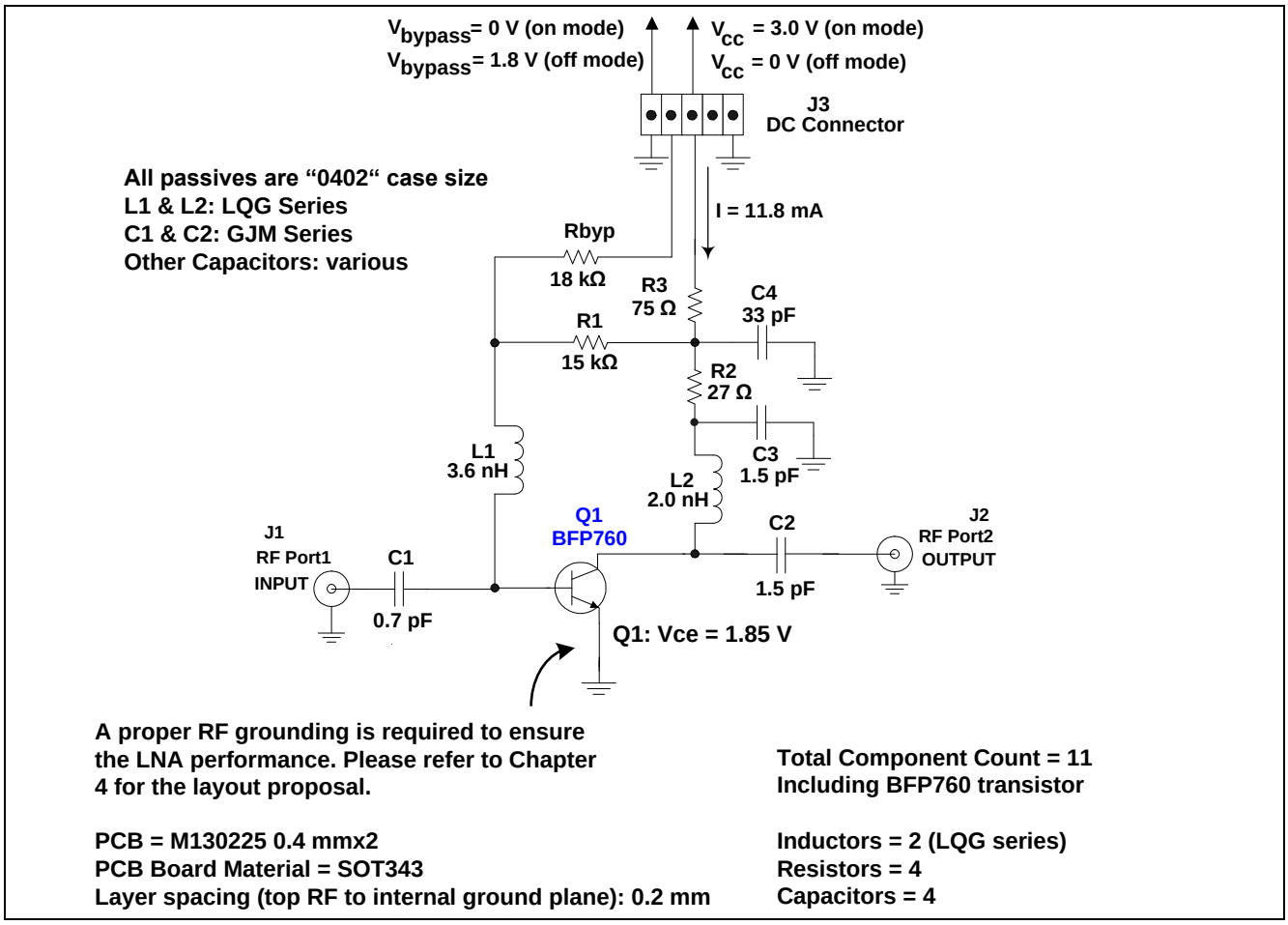

Figure 4 Schematics of the BFP760 Application Circuit

Table 4 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	0.7	pF	0402	Various	Input DC block & input matching
C2	1.5	pF	0402	Various	Output DC block & output matching
C3	1.5	pF	0402	Various	Output matching
C4	33	pF	0402	Various	RF decoupling / blocking cap
L1	3.6	nH	0402	Murata LQG series	Input matching
L2	2	nH	0402	Murata LQG series	Output matching & Collector biasing
R1	15	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.)
Rbyp	18	kΩ	0402	Various	Bypass mode DC biasing
Q1			SOT343	Infineon Technologies	BFP760 SiGe: C Heterojunction Bipolar RF Transistor

Measurement Graphs

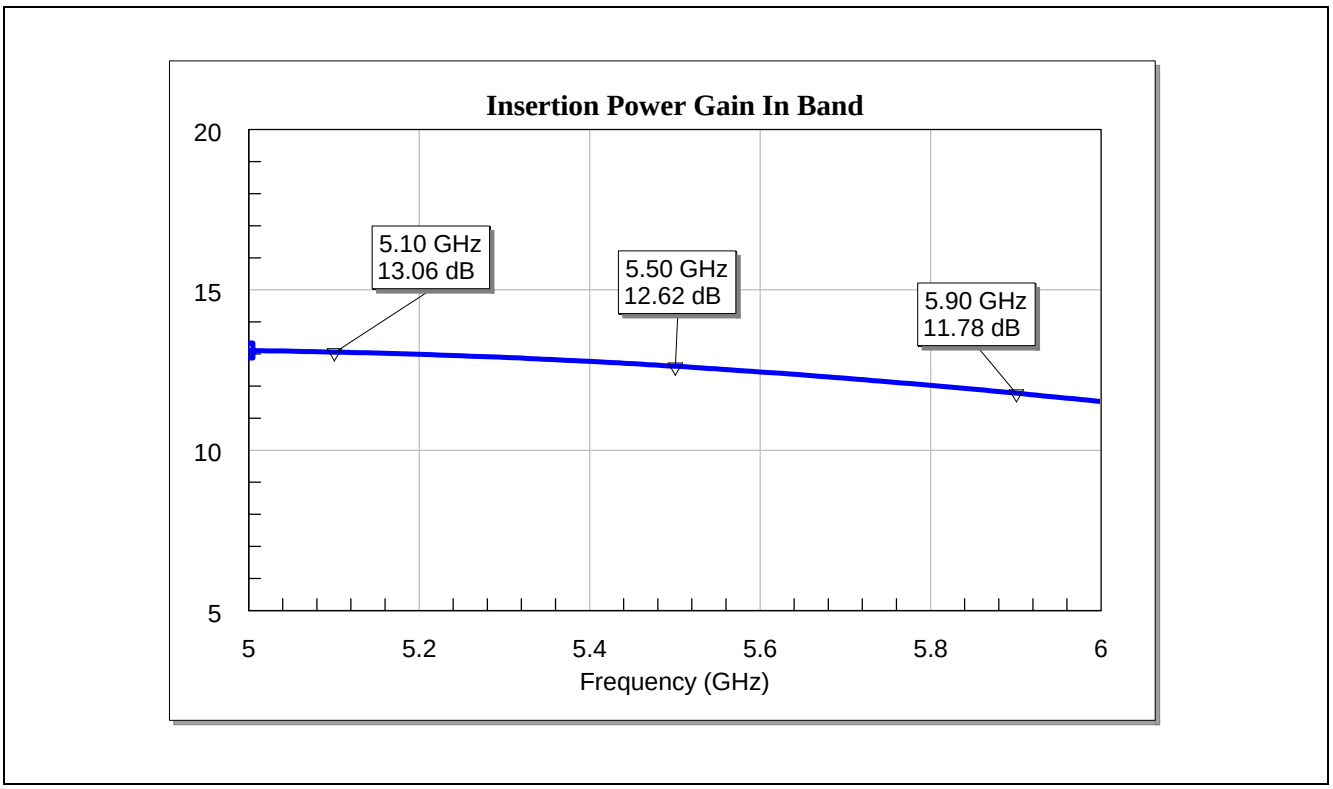

Figure 5 Insertion Power Gain of the 5-6 GHz WLAN LNA with BFP760

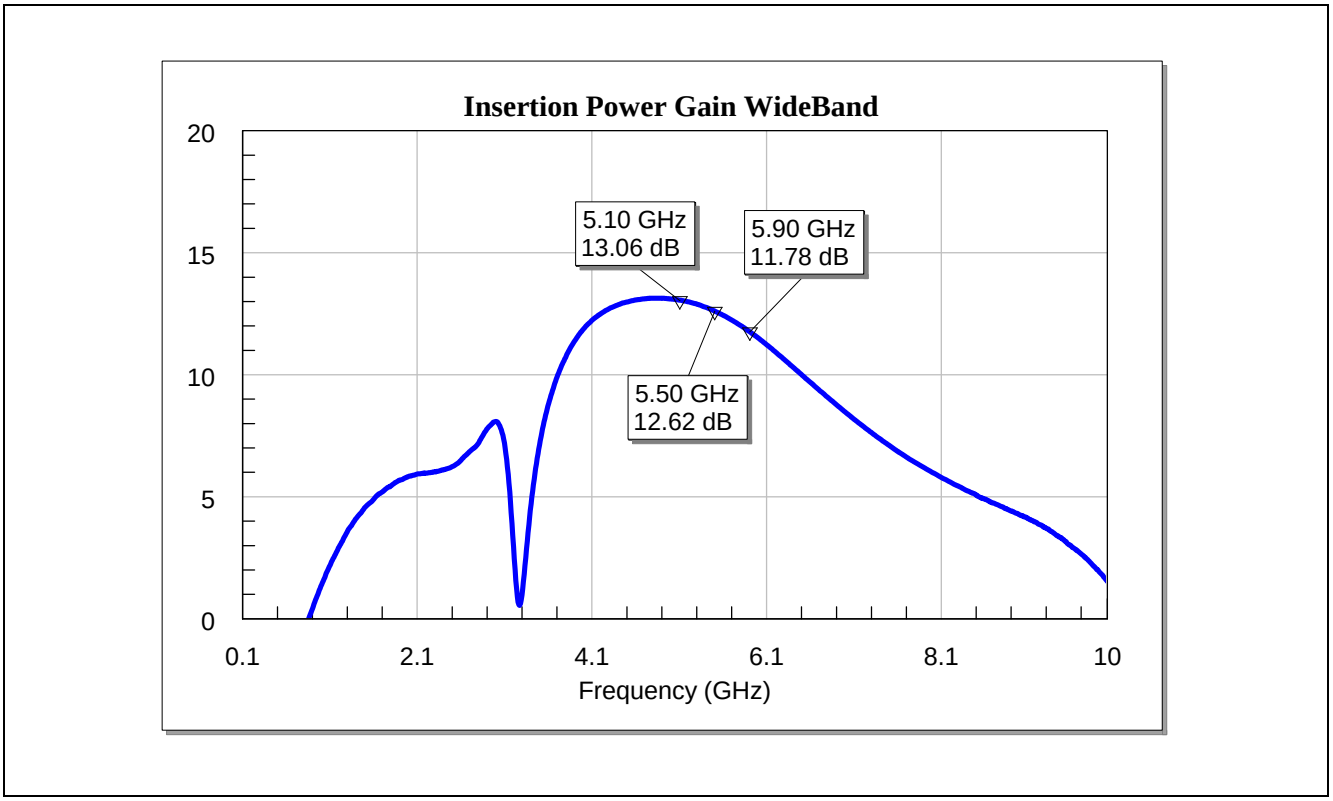

Figure 6 Wideband Insertion Power Gain of the 5-6 GHz WLAN LNA with BFP760

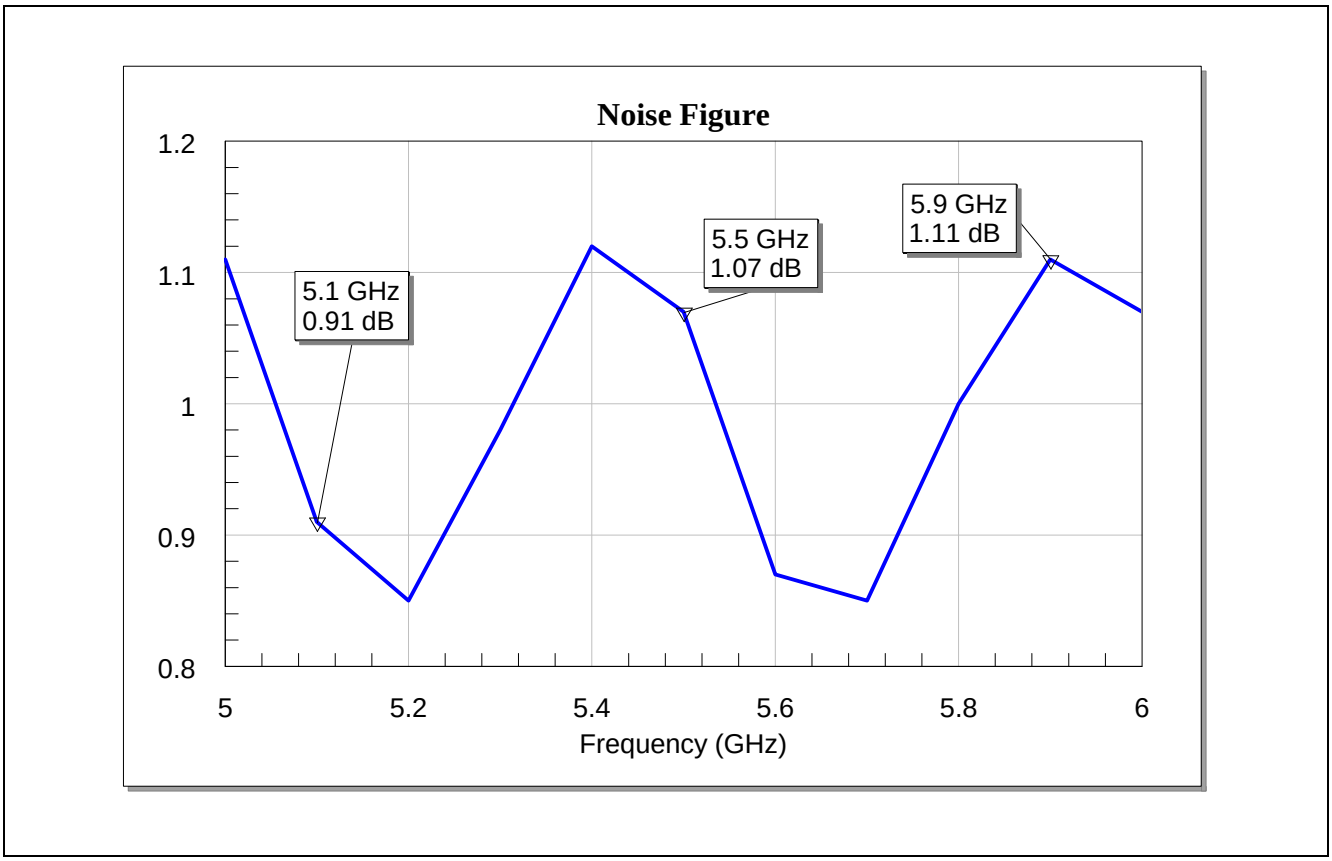

Figure 7 Noise Figure of BFP760 LNA for 5-6 GHz

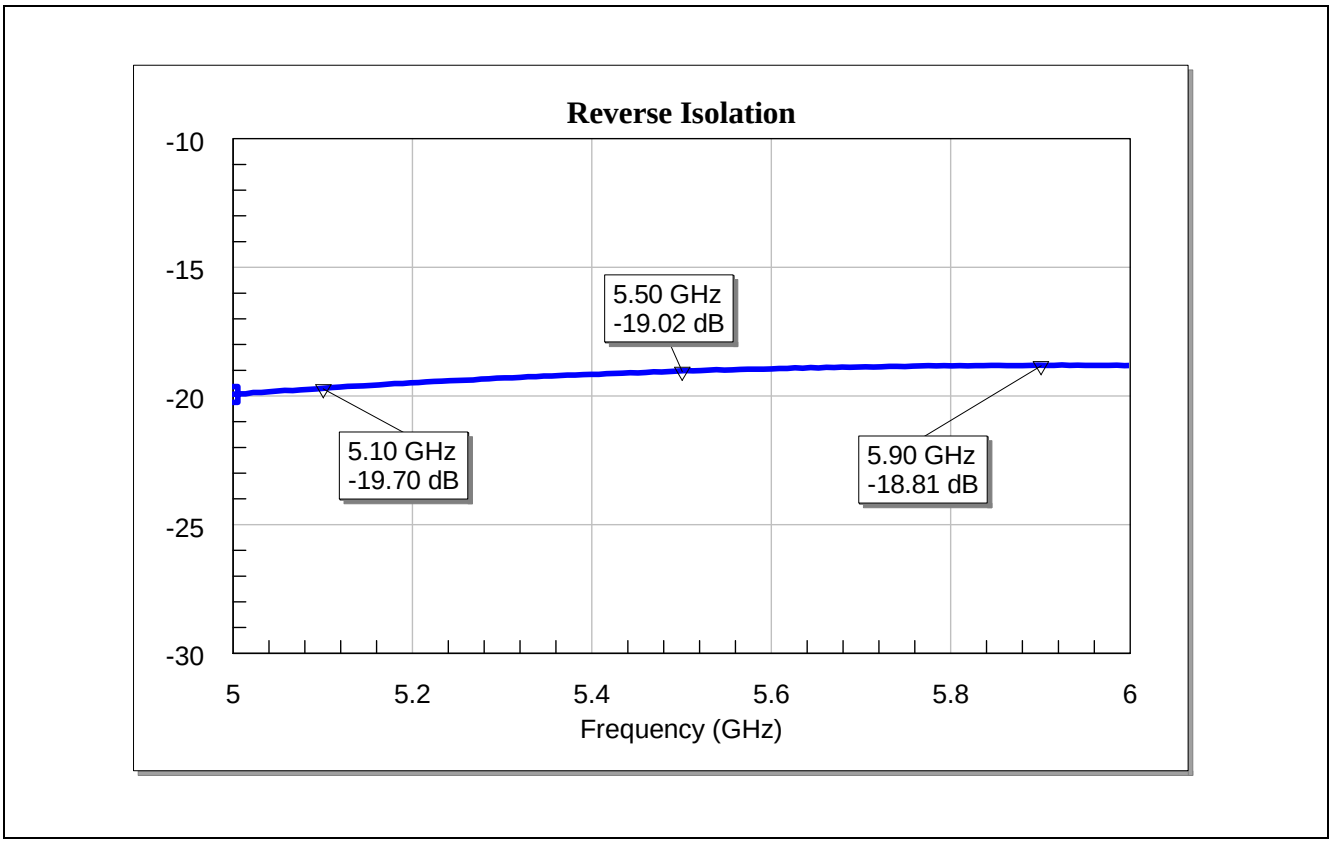

Figure 8 Reverse Isolation of the 5-6 GHz WLAN LNA with BFP760

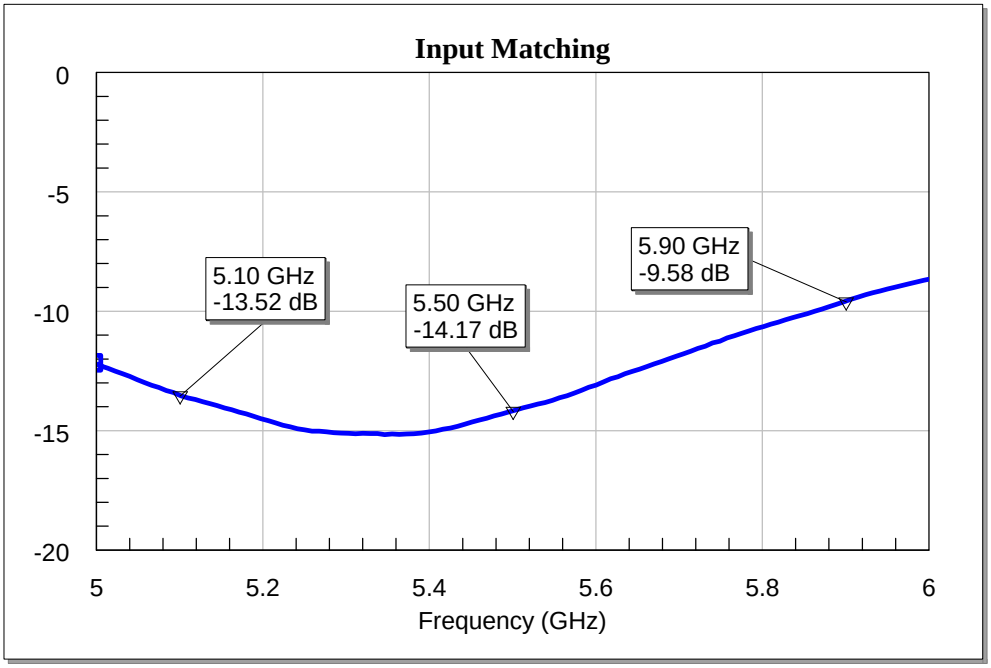

Figure 9 Input Matching of the 5-6 GHz WLAN LNA with BFP760

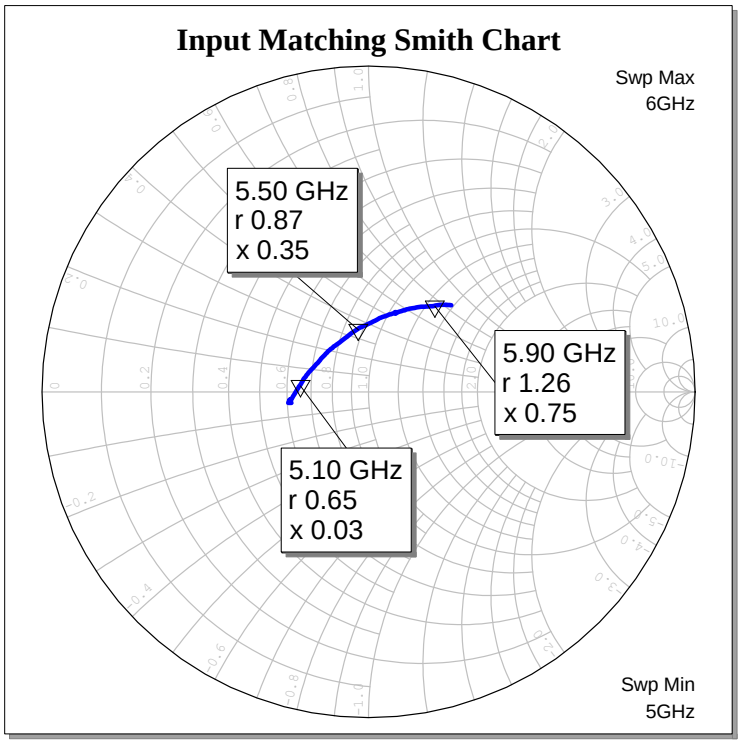

Figure 10 Input Matching of 5-6 GHz WLAN LNA with BFP760 (Smith Chart)

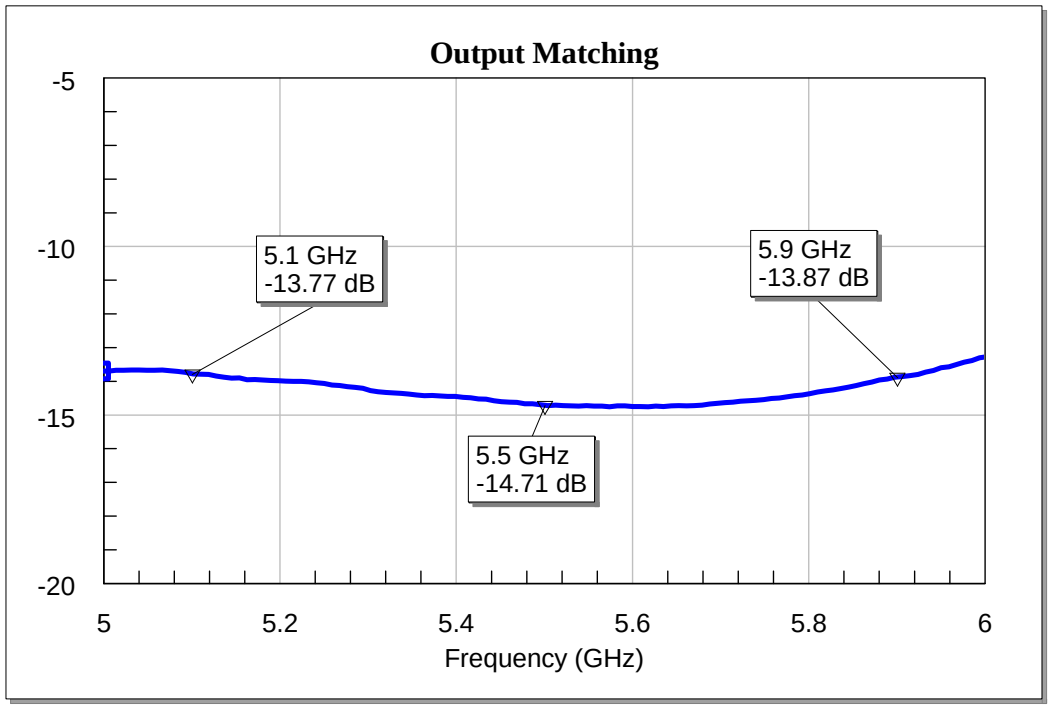

Figure 11 Output Matching of the 5-6 GHz WLAN LNA with BFP760

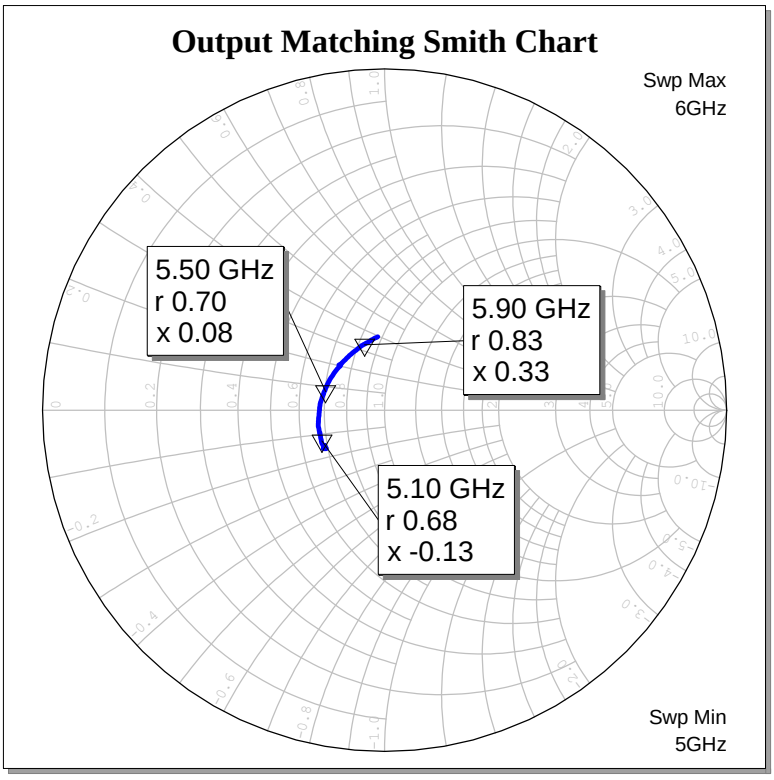

Figure 12 Output Matching of the 5-6 GHz WLAN LNA with BFP760 (Smith Chart)

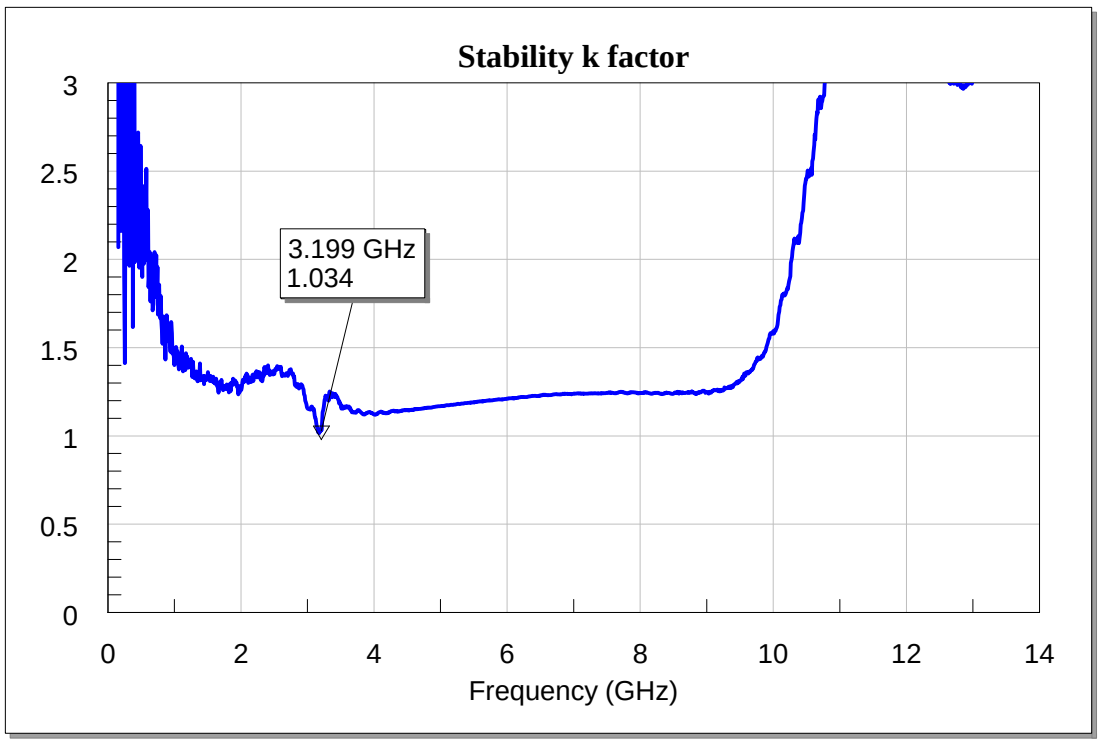

Figure 13 Wideband Stability k Factor of the 5-6 GHz WLAN LNA with BFP760

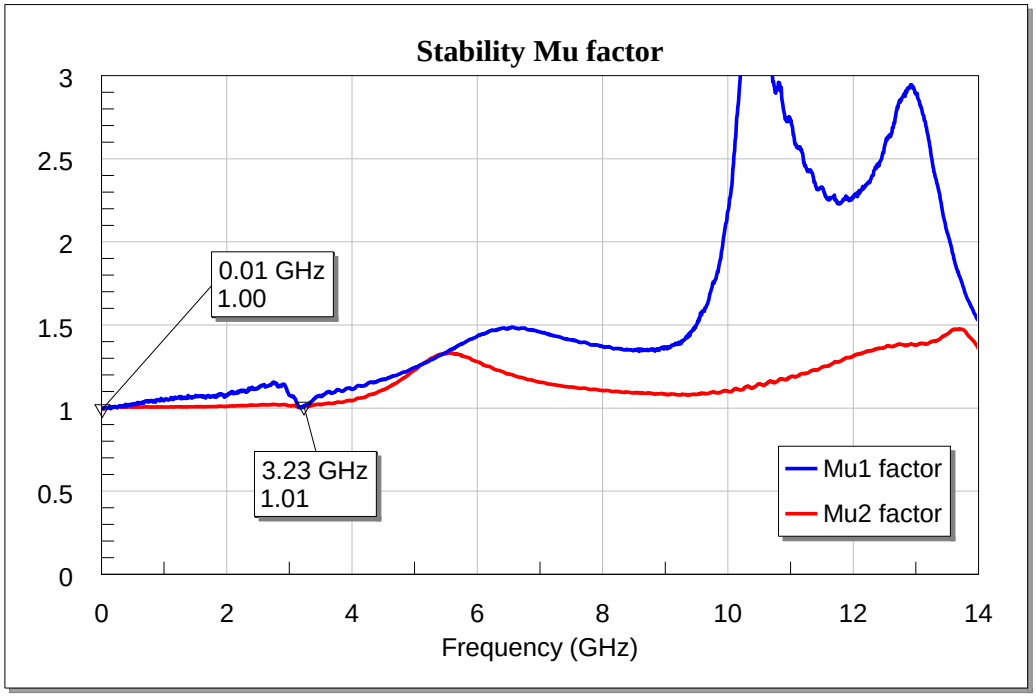

Figure 14 Wideband Stability Mu Factor of the 5-6 GHz WLAN LNA with BFP760

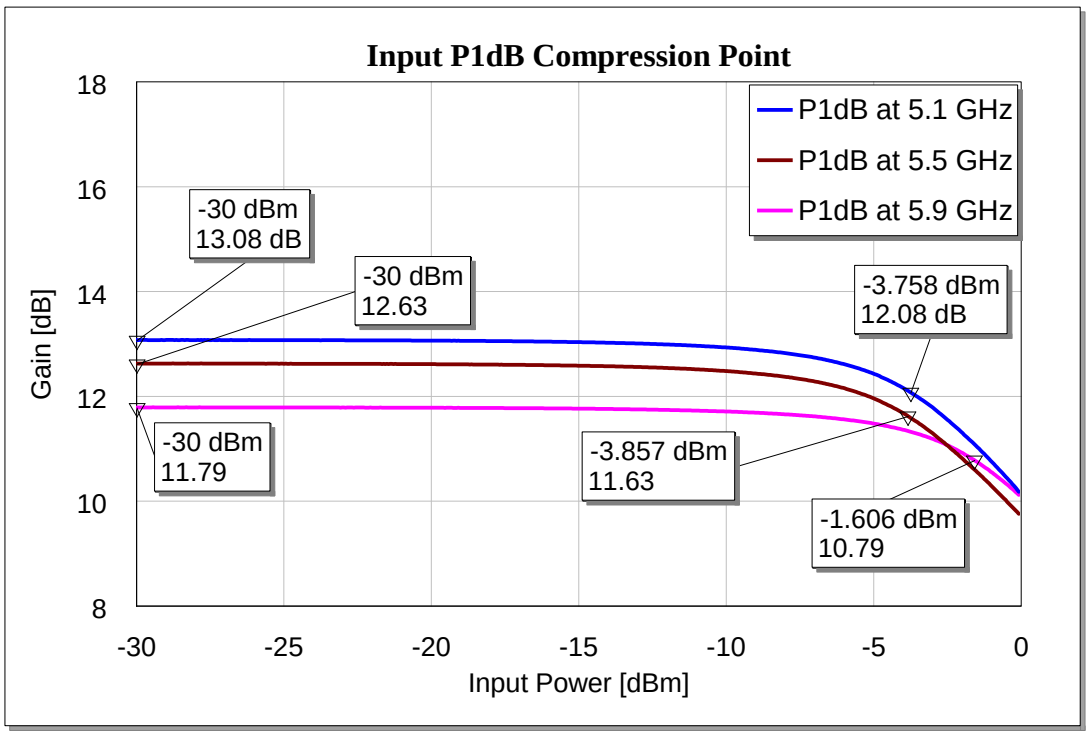

Figure 15 Input 1dB Compression Point of the BFP760 Circuit

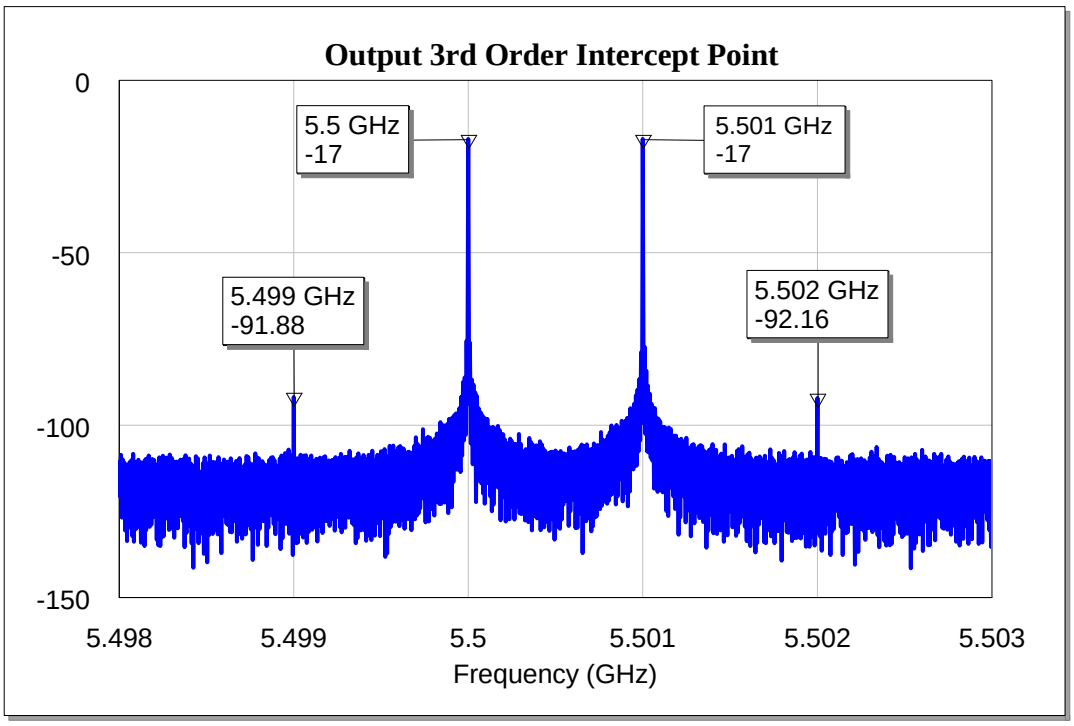

Figure 16 Output 3rd Order Intercept Point of BFP760 at 5500 MHz

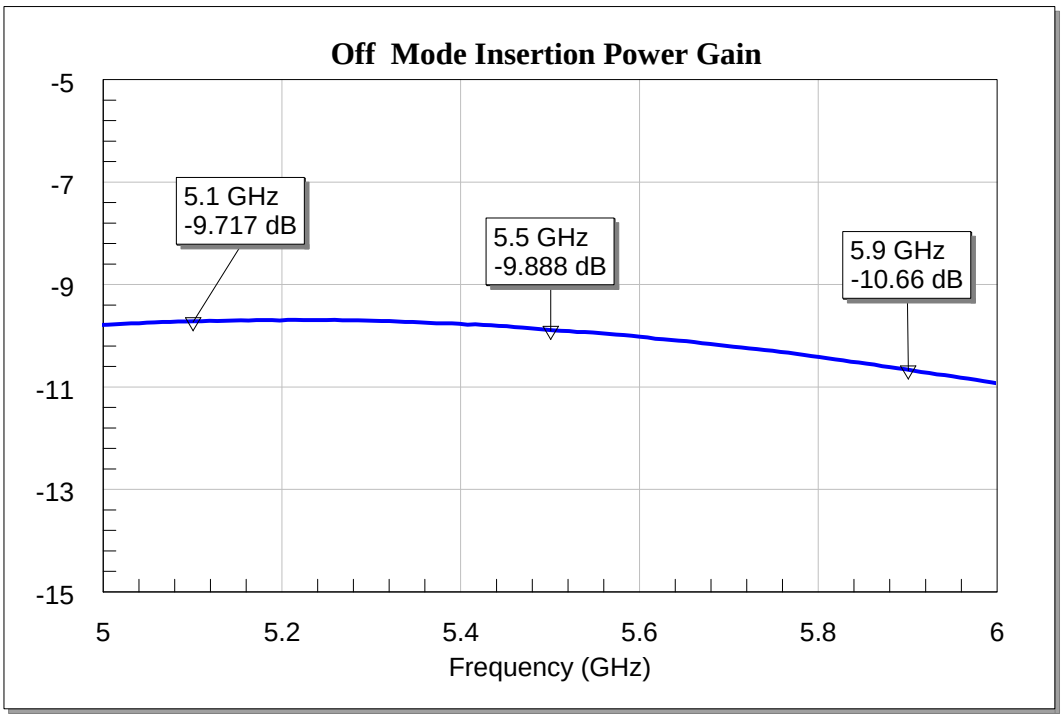

Figure 17 Off mode Insertion Power Gain of the 5-6 GHz WLAN LNA with BFP760

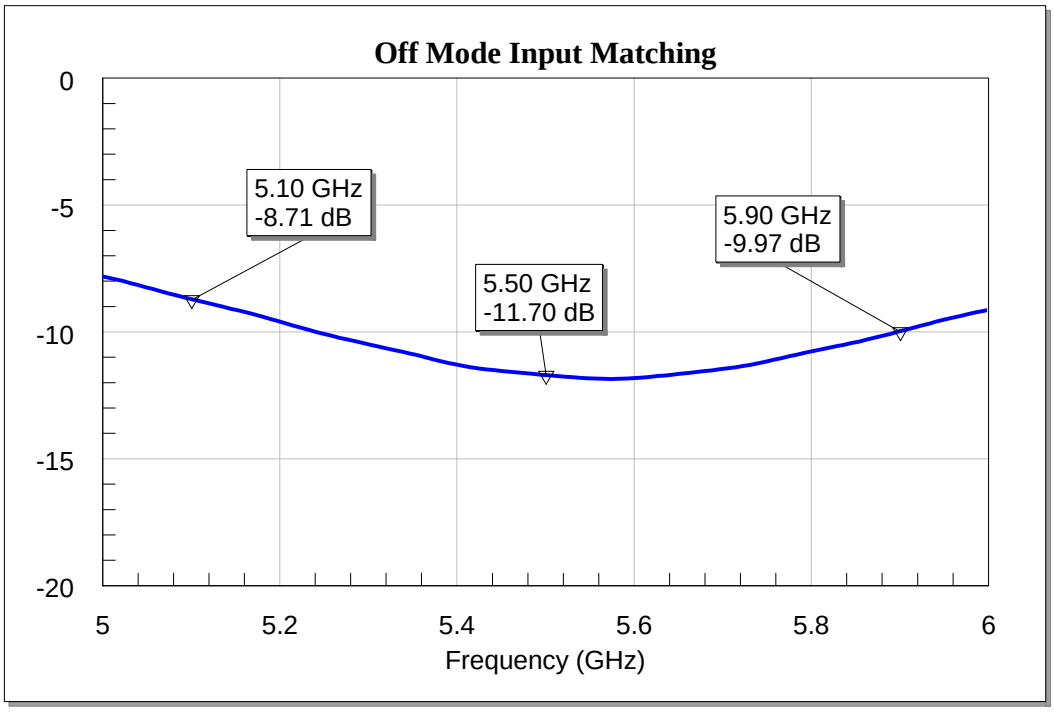

Figure 18 Off mode Input Matching of the 5-6 GHz WLAN LNA with BFP760

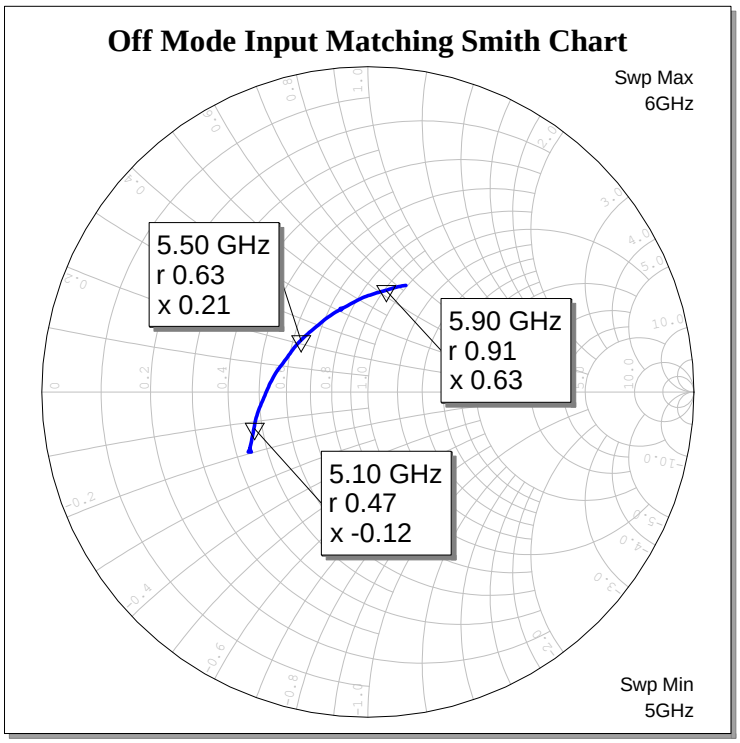

Figure 19 Off mode input matching of 5-6 GHz WLAN LNA with BFP760 (Smith Chart)

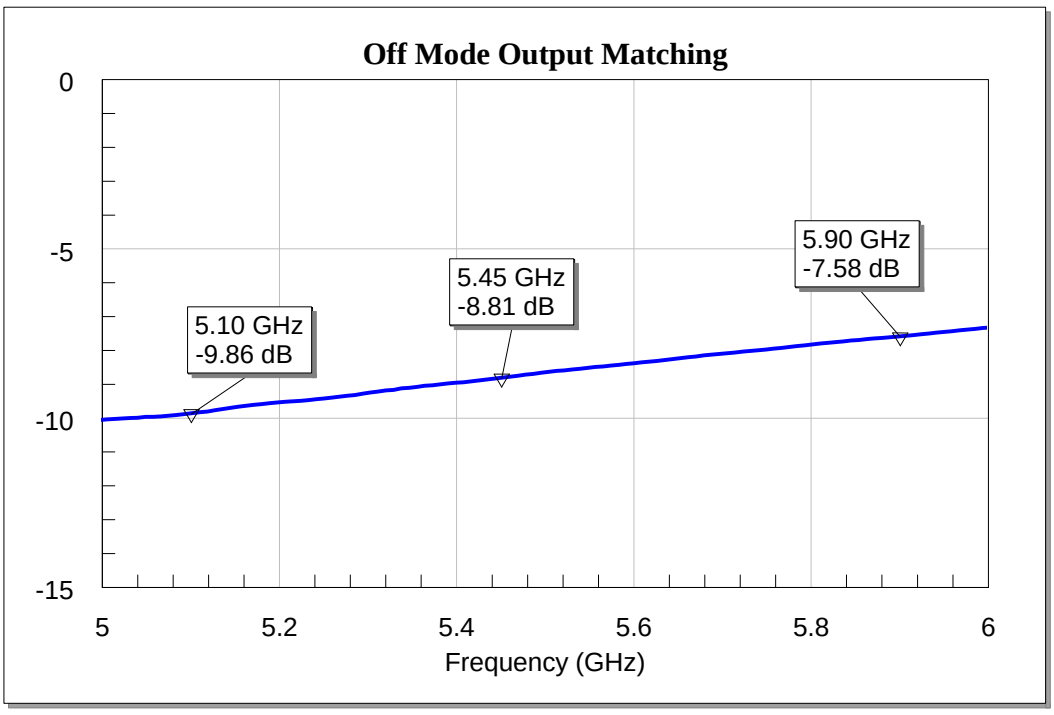

Figure 20 Off mode Output Matching of the 5-6 GHz WLAN LNA with BFP760

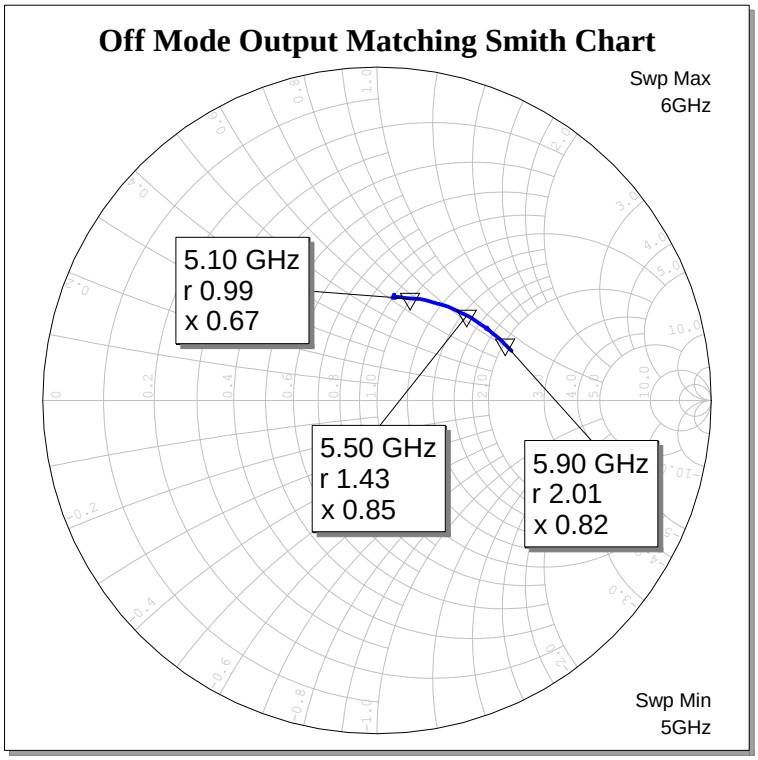

Figure 21 Off mode output Matching of 5-6 GHz WLAN LNA with BFP760 (Smith Chart)

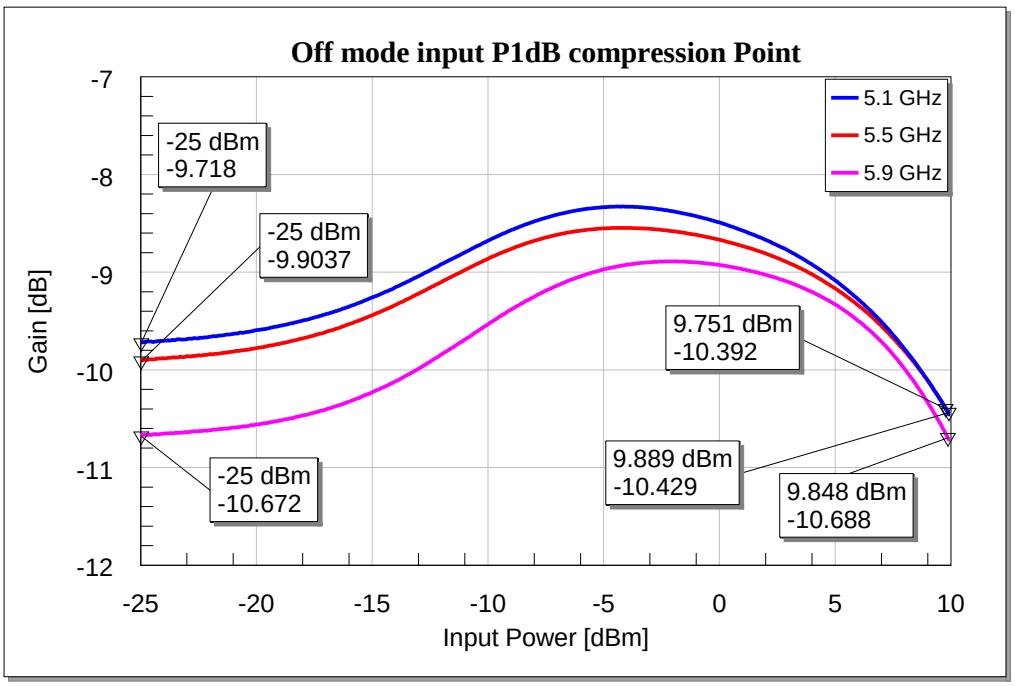

Figure 22 Off mode input 1dB compression point of the 5-6 GHz WLAN LNA with BFP760

4 Evaluation Board and Layout Information

In this application note, the following PCB is used:

PCB Marking: M130225

PCB material: FR4

ε_r of PCB material:4.3 (FR4)

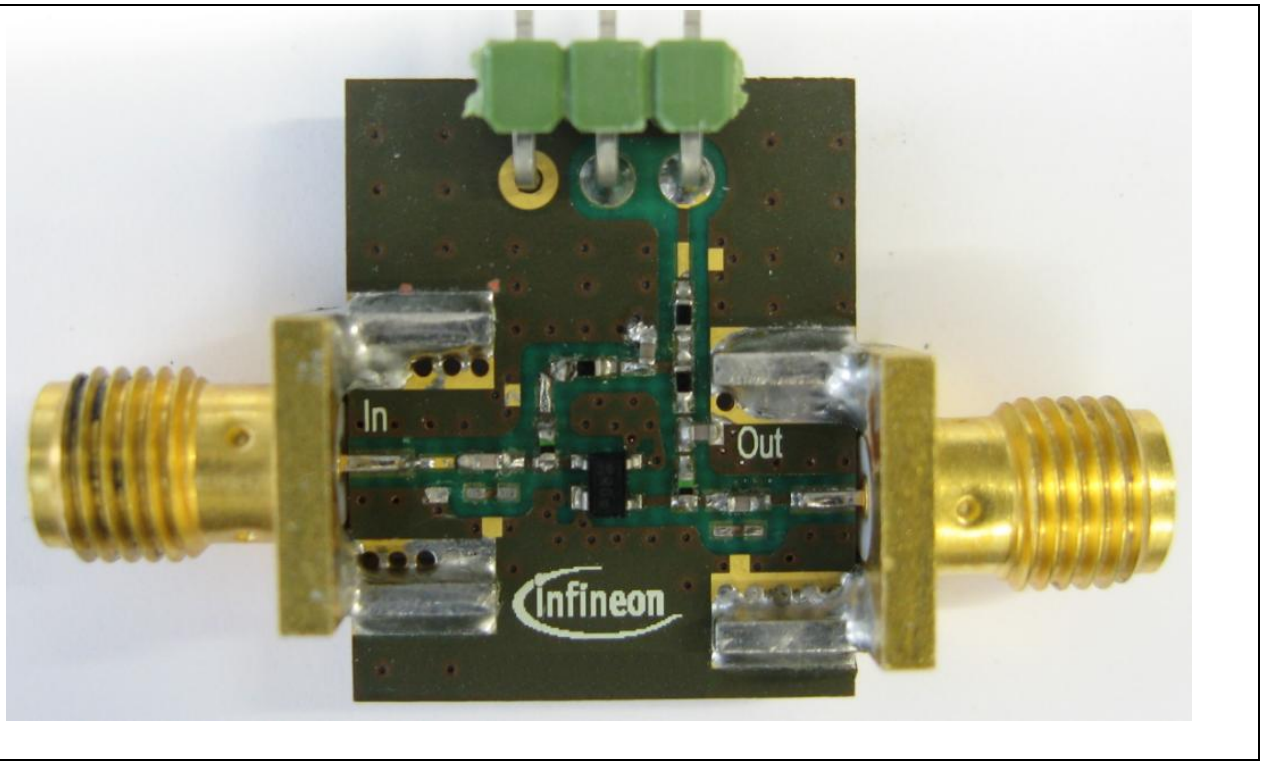

Figure 23 Photo Picture of Evaluation Board (overview) <PCB Marking Myymmdd Rev. x.x>

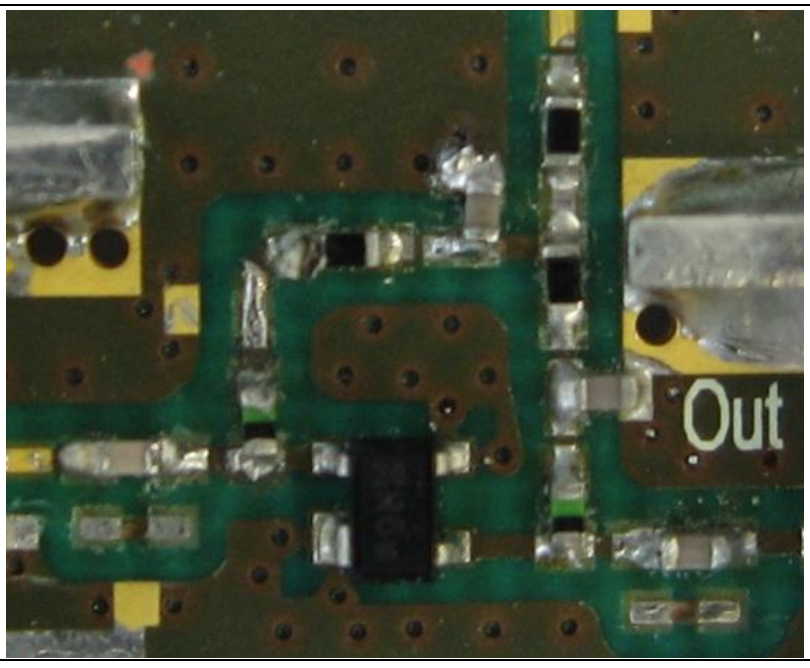

Figure 24 Photo Picture of Evaluation Board (detailed view)

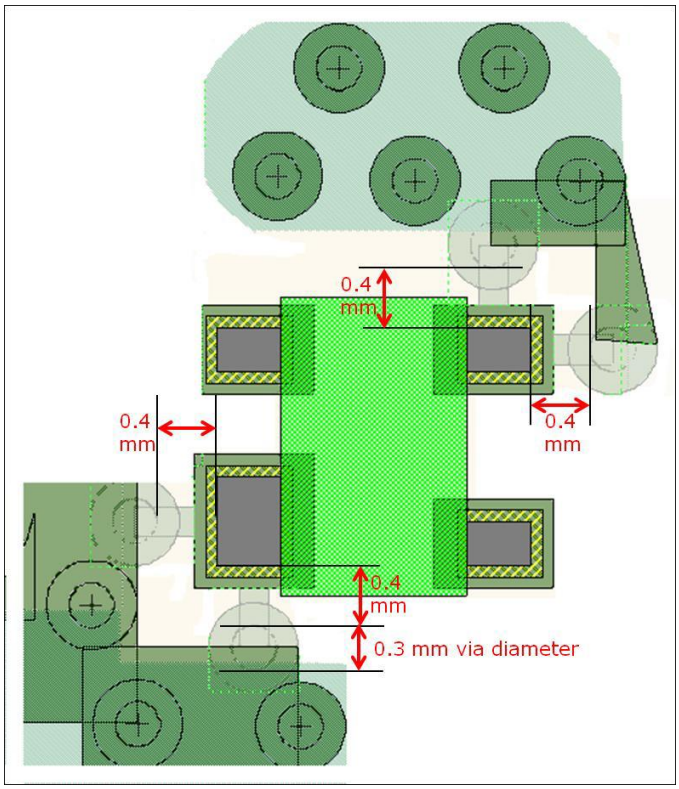

Figure 25 Layout Proposal for RF Grounding of the 5-6 GHz WLAN LNA with BFP760

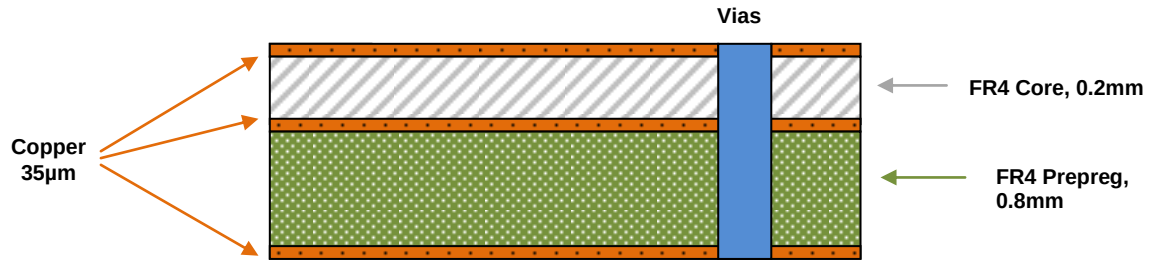

Figure 26 PCB Layer Information

5 Authors

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

6 Remark

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

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