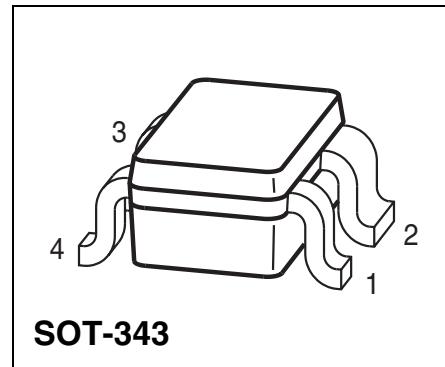


## The BGA622 Silicon-Germanium Universal Low Noise Amplifier MMIC in 1800 - 2500 MHz Receiver Applications

**Application Note No. 069**

### Features

- Versatile, easy-to-use LNA MMIC in 70 GHz  $f_T$  SiGe technology
- 50  $\Omega$  matched output, pre-matched input
- Integrated output DC blocking capacitor, integrated RF choke on internal bias network
- Low current consumption of 6 mA
- “Shutdown” or “Sleep” mode
- Unconditionally stable
- Low external component count
- Exceptional noise figure: 1.1 dB in a PC board at 2 GHz



### Applications

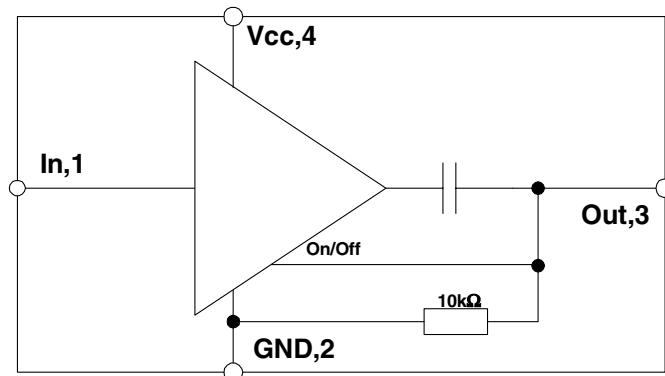
- Low Noise Amplifier for 800/900 MHz, GSM900, 900 MHz ISM, DCS1800, GPS, 1900 MHz PCS, 2.1 GHz UMTS and 2.4 GHz Wireless LAN
- Long-Range Bluetooth applications requiring improved system sensitivity via use of an external LNA

### Introduction

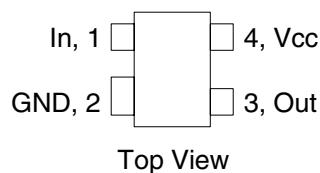
The BGA622 is an easy-to-use, versatile and flexible low-cost **Low Noise Amplifier (LNA) MMIC** designed for the high linearity and sensitivity requirements of existing and next - generation wireless applications including GSM, 900 MHz ISM, GPS, UMTS and Wireless LANs. Based on Infineon's cost-effective 70 GHz  $f_T$  Silicon-Germanium (SiGe) B7HF bipolar process technology, the BGA622 offers a 1.1 dB noise figure and 15 dB of gain at 2.1 GHz for high performance, cost-effective mobile communications applications. BGA622 offers impressive noise figure performance, particularly for a low-cost, integrated MMIC. In the past, in-circuit noise figures approaching 1.0 dB at 2 GHz were possible only for more expensive GaAs-based, fully discrete solutions utilizing narrowband impedance matching and higher external parts count. The BGA622 combines the excellent noise figure advantages of a high-performance discrete solution with the ease-of-use, low parts count, and diminished risk and reduced system development time made possible by a MMIC approach.

## Introduction

The new LNA incorporates a  $50\ \Omega$  matched output with an integrated output DC blocking capacitor. The broadband output match simplifies integration issues with external image-stripping filters. The input is pre-matched, requiring an external DC blocking capacitor. An integrated, on-chip inductor eliminates the need for an external RF choke on the voltage supply pin. The noise figure of BGA622 is relatively insensitive to the input impedance matching approach taken by the end user, reducing development time and risk. A low supply current of 6 mA at 2.75 V and an integrated on/off feature provides for low power consumption and increased stand by time for 3G cellular handsets or other portable, battery-operated wireless applications.



**Figure 1** BGA622's Equivalent Circuit



**Figure 2** Pin Connections

### Overview

The BGA622 is shown in three different configurations for the frequency band between 1700 MHz and 2500 MHz which covers the PCN/PCS, UMTS and BlueTooth frequencies at 1800 / 1900 MHz, 2.14 GHz and 2.4 GHz:

- Configuration A: minimum parts count, power down option is not used
- Configuration B: BGA622 with power down option
- Configuration C: BGA622 with power down option and increased  $IIP_3$

The following table shows the measured performance of these three circuits. All measurement values presented in this application note include losses of both PCB and connectors - in other words, the reference planes used for measurements are the PCB's RF SMA connectors. Noise figure and gain results shown do not have any PCB loss extracted from them.

### Performance Overview

Parameter	Configuration A	Configuration B	Configuration C
Supply voltage	2.75 V	2.75 V	2.75 V
Supply current	5.5 mA	5.4 mA	5.4 mA
Gain	14.8 dB @ 1.85 GHz 13.8 dB @ 2.14 GHz 12.6 dB @ 2.4 GHz	14.5 dB @ 1.85 GHz 13.5 dB @ 2.14 GHz 12.5 dB @ 2.4 GHz	14.6 dB @ 1.85 GHz 13.5 dB @ 2.14 GHz 12.5 dB @ 2.4 GHz
Noise Figure	1.2 dB @ 1.85 GHz 1.25 dB @ 2.14 GHz 1.3 dB @ 2.4 GHz	1.2 dB @ 1.85 GHz 1.2 dB @ 2.14 GHz 1.35 dB @ 2.4 GHz	1.2 dB @ 1.85 GHz 1.25 dB @ 2.14 GHz 1.3 dB @ 2.4 GHz
Input return loss	11.1 dB @ 1.85 GHz 12.5 dB @ 2.14 GHz 11.6 dB @ 2.4 GHz	11.9 dB @ 1.85 GHz 12.3 dB @ 2.14 GHz 11.2 dB @ 2.4 GHz	14.1 dB @ 1.85 GHz 13.1 dB @ 2.14 GHz 11.1 dB @ 2.4 GHz
Output return loss	12.4 dB @ 1.85 GHz 12.5 dB @ 2.14 GHz 12.8 dB @ 2.4 GHz	12.2 dB @ 1.85 GHz 11.4 dB @ 2.14 GHz 11.0 dB @ 2.4 GHz	11.7 dB @ 1.85 GHz 11.3 dB @ 2.14 GHz 11.0 dB @ 2.4 GHz
Reverse Isolation	26.1 dB @ 1.85 GHz 24.8 dB @ 2.14 GHz 23.8 dB @ 2.4 GHz	26.3 dB @ 1.85 GHz 25.0 dB @ 2.14 GHz 24.0 dB @ 2.4 GHz	26.2 dB @ 1.85 GHz 25.0 dB @ 2.14 GHz 24.1 dB @ 2.4 GHz
Input compression point <sup>1)</sup>	-15 dBm	-16 dBm	-15 dBm
Input 3 <sup>rd</sup> order intercept point <sup>2)</sup>	-7.1 dBm @ 1.8 GHz -5.5 dBm @ 2.14 GHz -3.9 dBm @ 2.4 GHz	-6.6 dBm @ 1.8 GHz -4.0 dBm @ 2.14 GHz -3.9 dBm @ 2.4 GHz	4.7 dBm @ 1.8 GHz 4.4 dBm @ 2.14 GHz 4.3 dBm @ 2.4 GHz

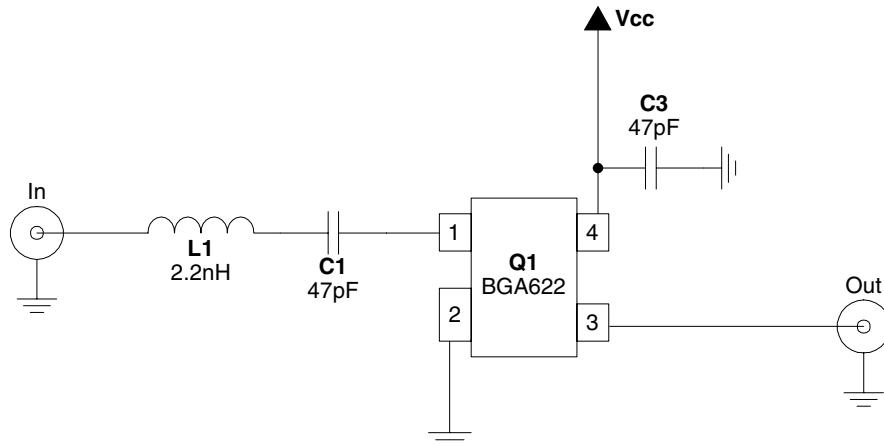
<sup>1)</sup> Measured at 2.14 GHz

<sup>2)</sup> -30 dBm per tone,  $\Delta f = 1$  MHz

## Configuration A

### Configuration A

The circuit in **Figure 3** shows the minimum parts count version of a BGA622 LNA. There are only three external elements necessary. A DC blocking capacitor at the output and a coil at the power supply are already integrated on chip



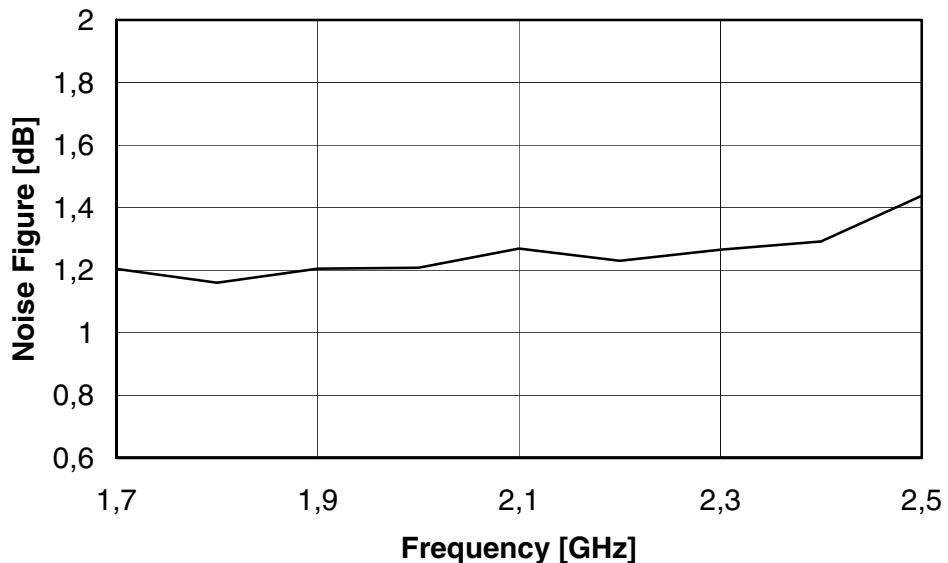
**Figure 3** Circuit Diagram of Configuration A

### Bill of Materials of Configuration A

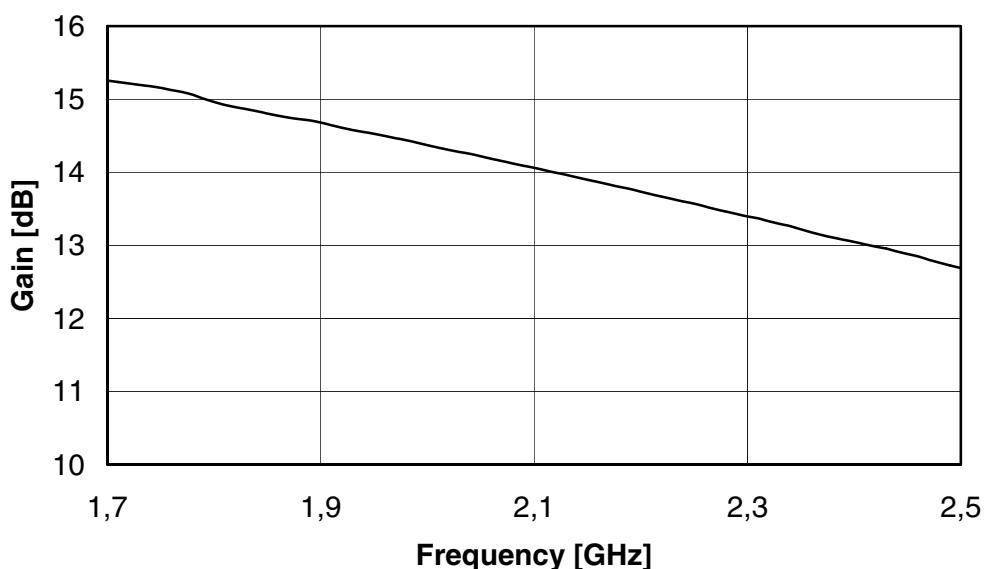
Name	Value	Package	Manufacturer	Function
$C_1$	47 pF	0402	various	DC block
$C_3$	47 pF	0402	various	RF bypass
$L_1$	2.2 nH	0402	Toko LL1005-FH	Input matching
Q1	BGA622	SOT-343	Infineon Technologies	SiGe MMIC

For measurement graphs of configuration A please refer to the next pages.

## Configuration A

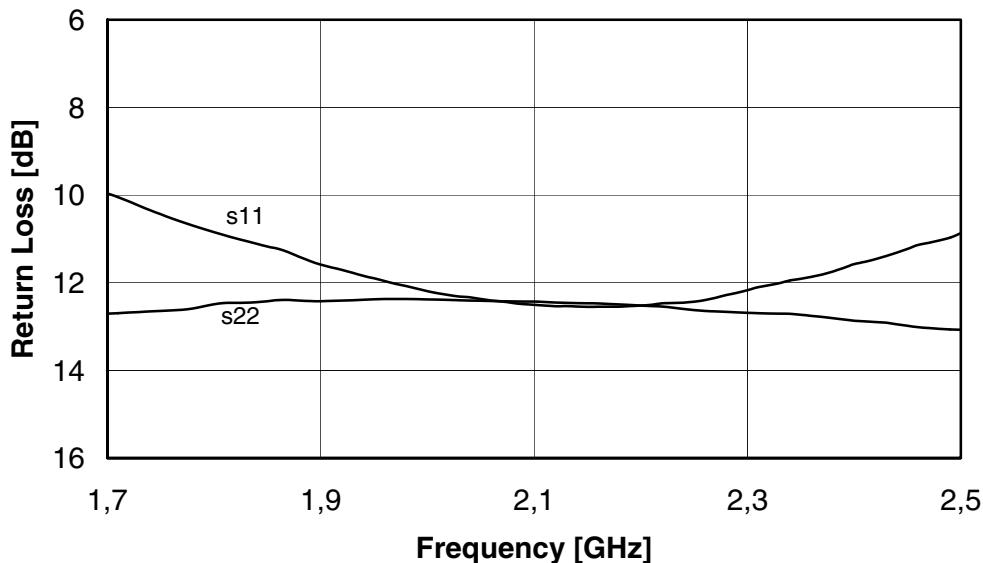


**Figure 4** Noise Figure Configuration A

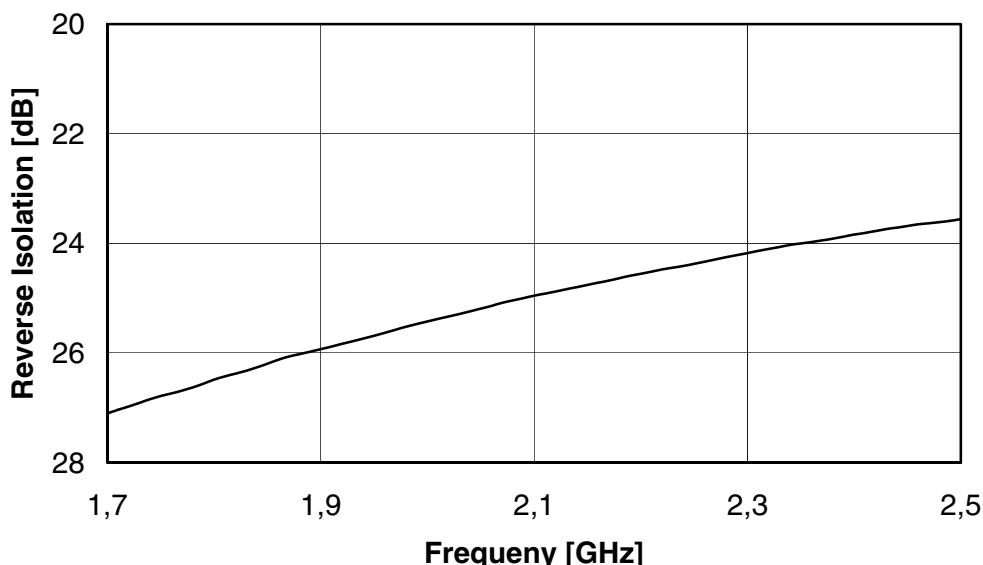


**Figure 5** Gain Configuration A

## Configuration A

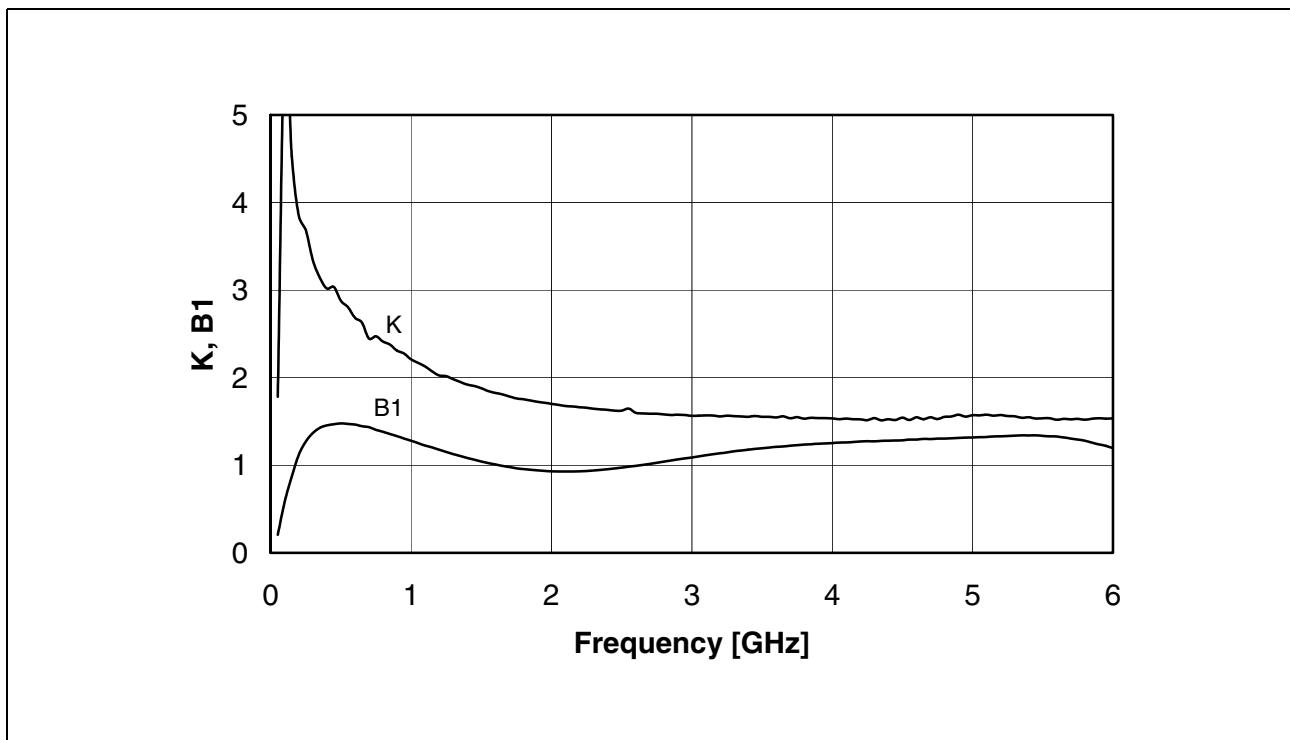


**Figure 6**      **Return Loss Configuration A**

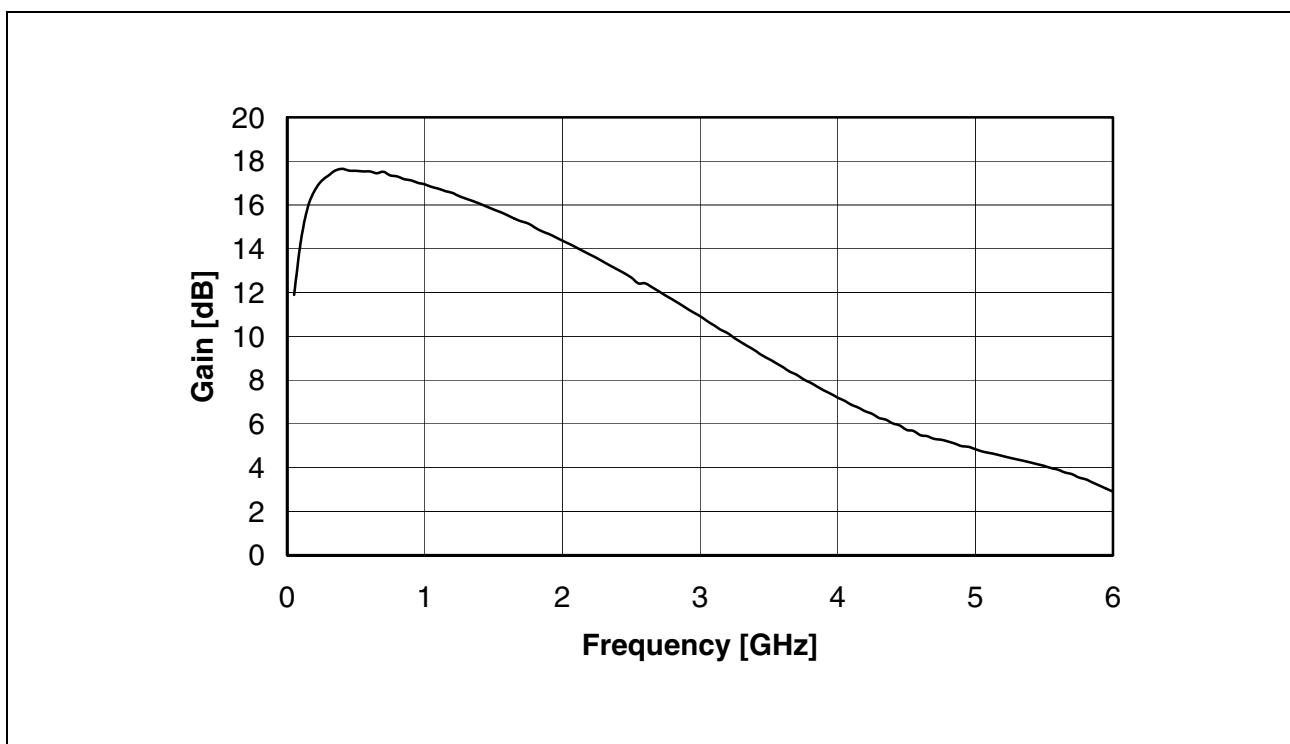


**Figure 7**      **Reverse Isolation Configuration A**

## Configuration A

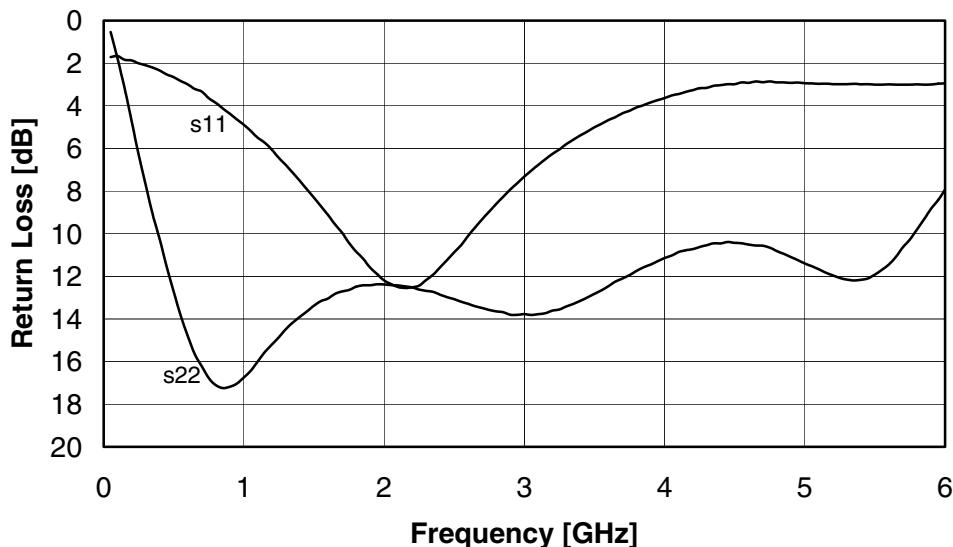


**Figure 8 Stability Factor K and Stability Measure B1 of Configuration A**

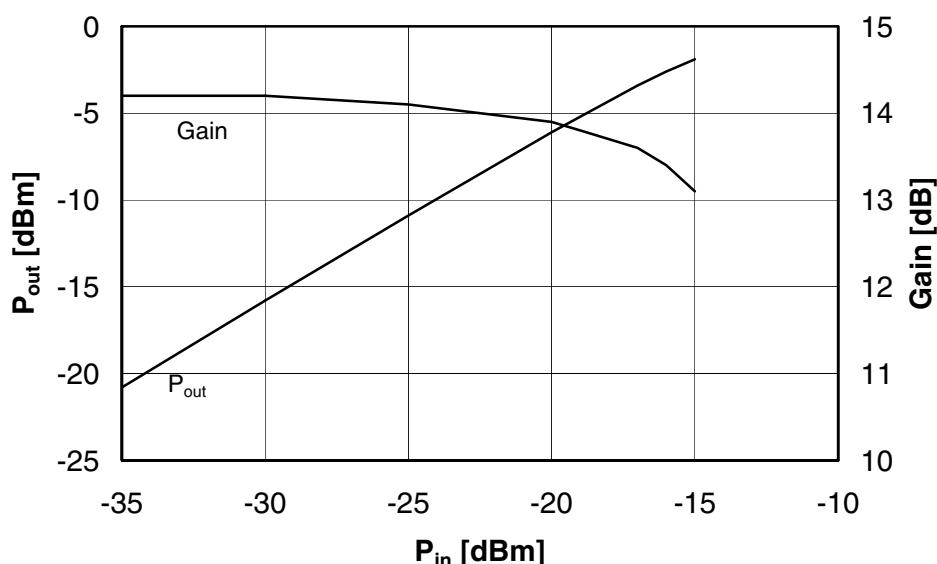


**Figure 9 Wide Span Gain Configuration A**

**Configuration A**



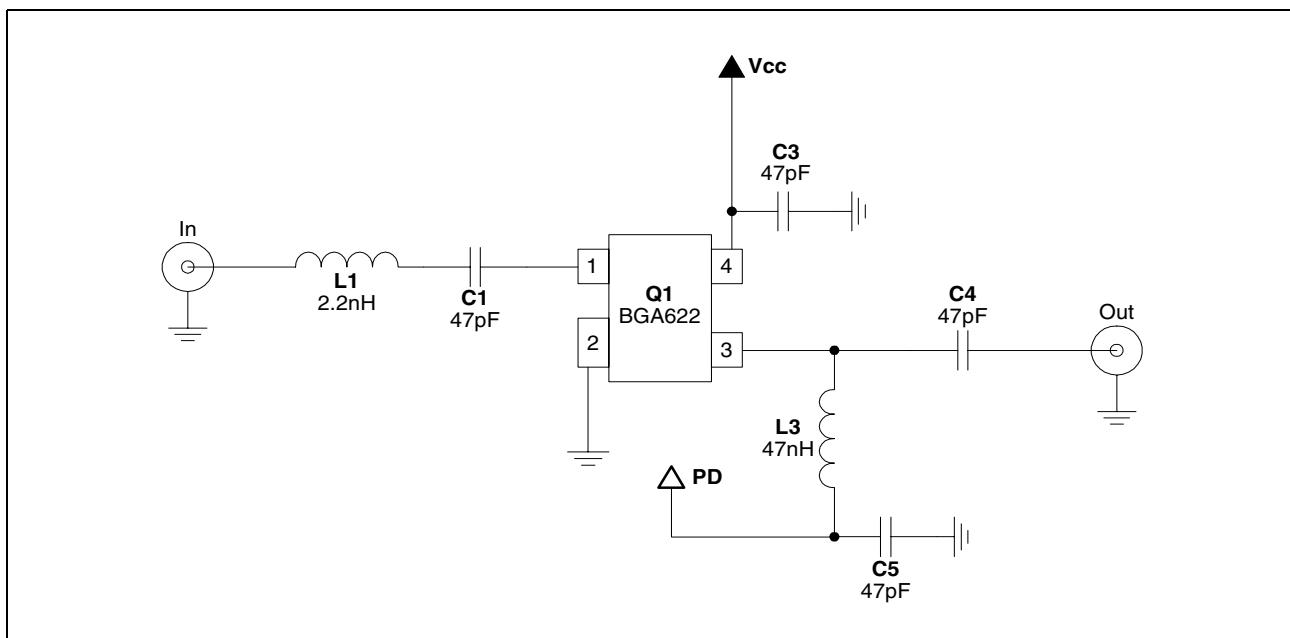
**Figure 10**    **Wide Span Return Loss Configuration A**



**Figure 11**    **Gain Compression @ 2.14 GHz Configuration A**

### Configuration B

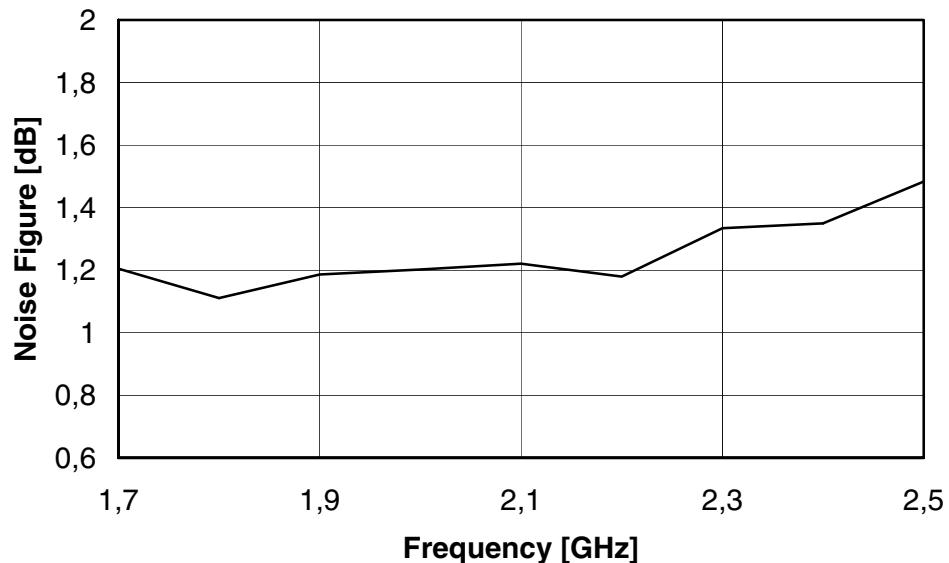
**Figure 12** shows a BGA622 LNA with available power down mode. In the BGA622, an internal high-impedance path exists around the device's internal output DC blocking capacitor, between the output pin and the device's internal shutdown circuitry. Applying  $V_{cc}$  at the Output pin (pin 3) will switch off the BGA622 and only a small supply current of about 0.26 mA flows into the device in shutdown mode. The schematic shows the "PD" (Power Down) connection where the shutdown signal may be applied. Ground or an open circuit at the PD pin will turn on the device. Note that if the Power Down feature is employed, the internal DC blocking capacitor of the BGA622 is bypassed by external circuitry, and therefore some sort of external DC blocking at the output must be employed. This can be either an external output DC blocking capacitor, or the usual image-stripping filter, provided the input of the filter presents a DC open circuit.



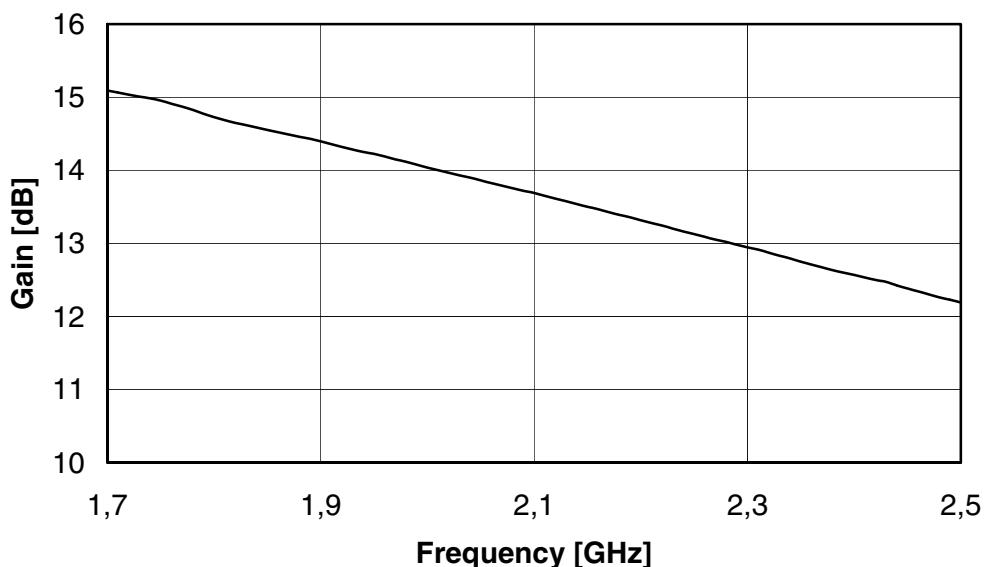
**Figure 12** Circuit Diagram Configuration B

### Bill of Materials of Configuration B

Name	Value	Package	Manufacturer	Function
$C_1$	47 pF	0402	various	DC block
$C_3$	47 pF	0402	various	RF bypass
$C_4$	47 pF	0402	various	DC block
$C_5$	47 pF	0402	various	RF bypass
$L_1$	2.2 nH	0402	Toko LL 1005-FH	Input matching
$L_3$	47 nH	0402	Toko LL 1005-FH	RF block
Q1	BGA622	SOT-343	Infineon Technologies	SiGe MMIC

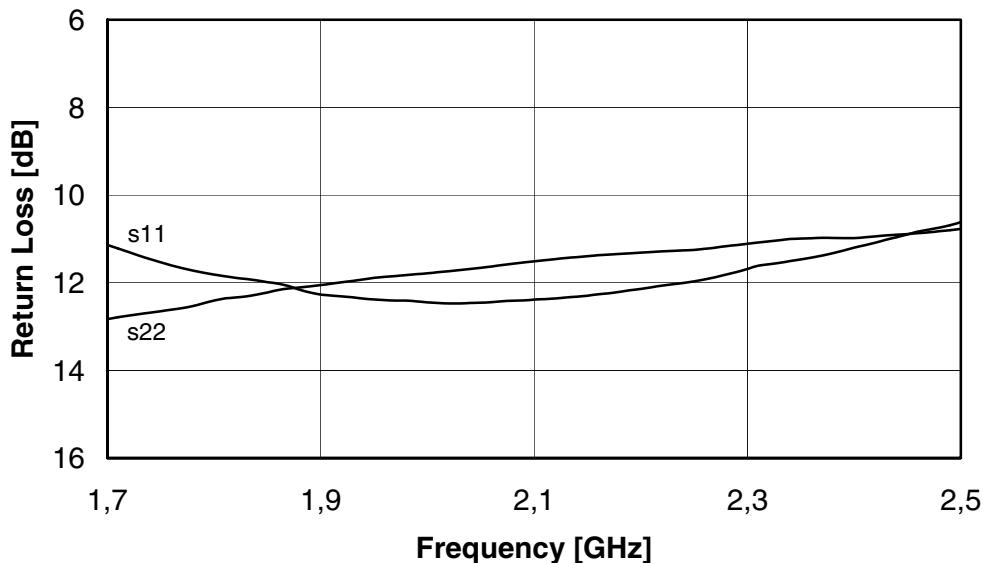


**Figure 13** Noise Figure Configuration B

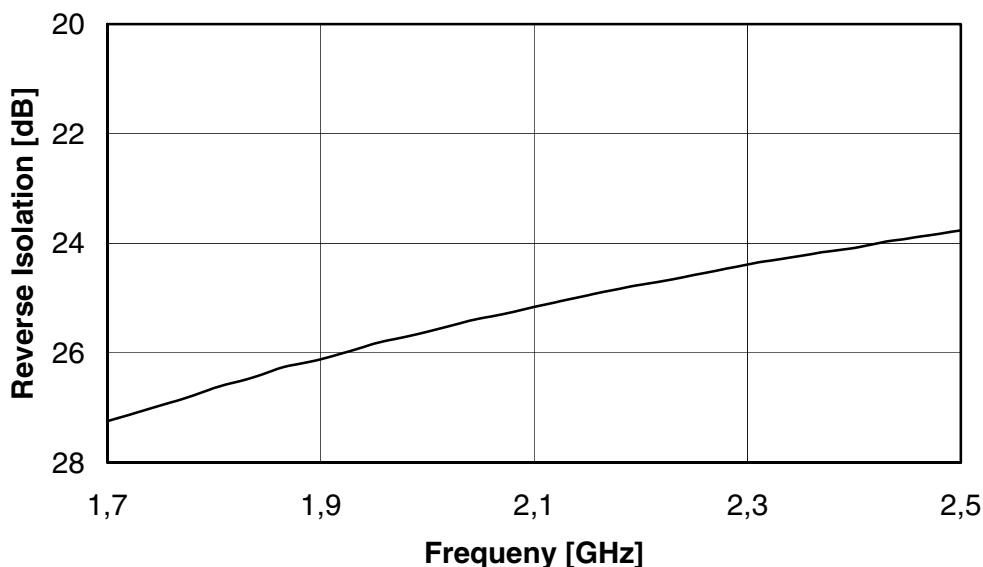


**Figure 14** Gain Configuration B

## Configuration B

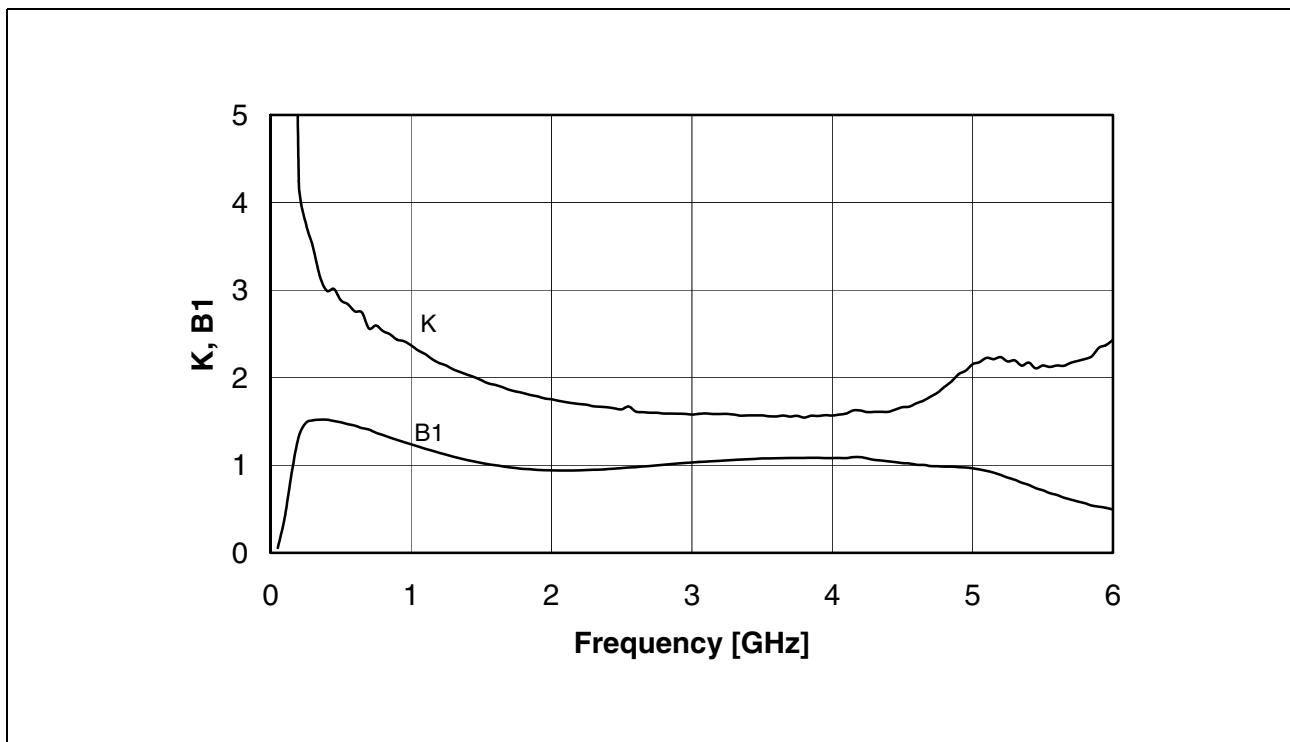


**Figure 15** Return Loss Configuration B

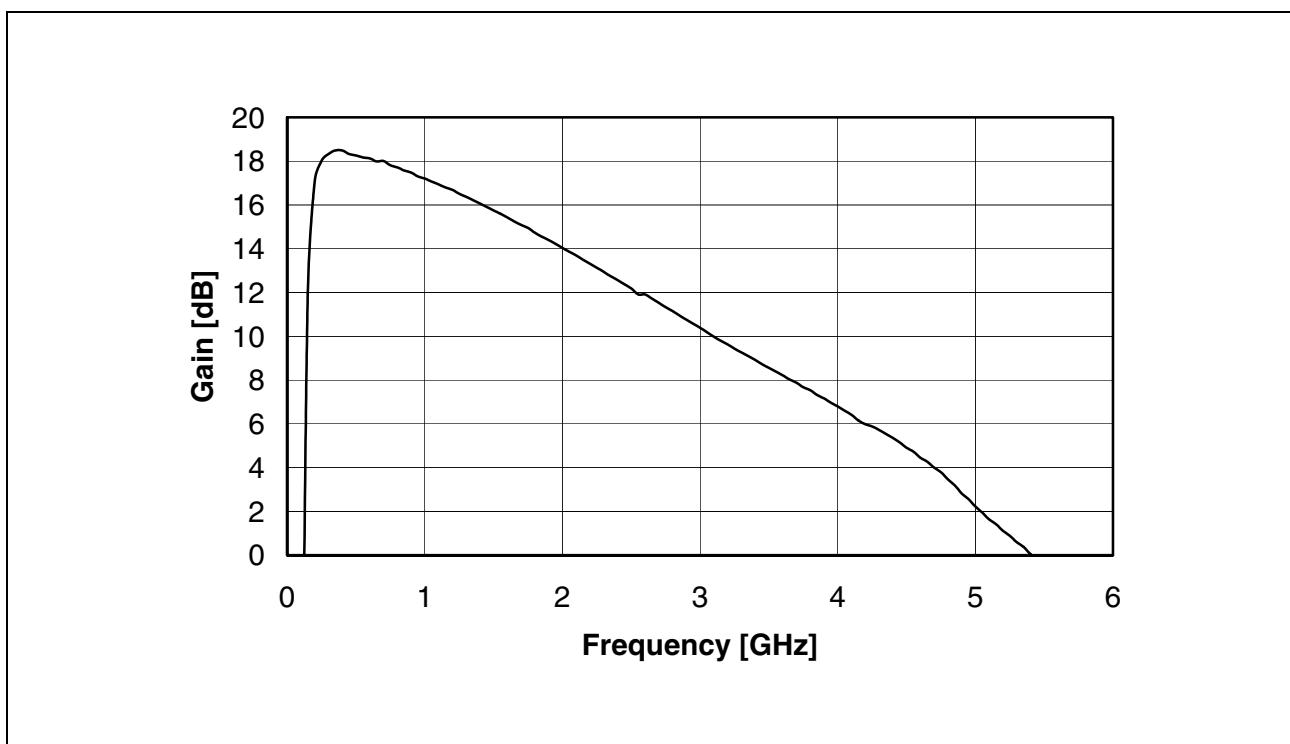


**Figure 16** Reverse Isolation Configuration B

**Configuration B**

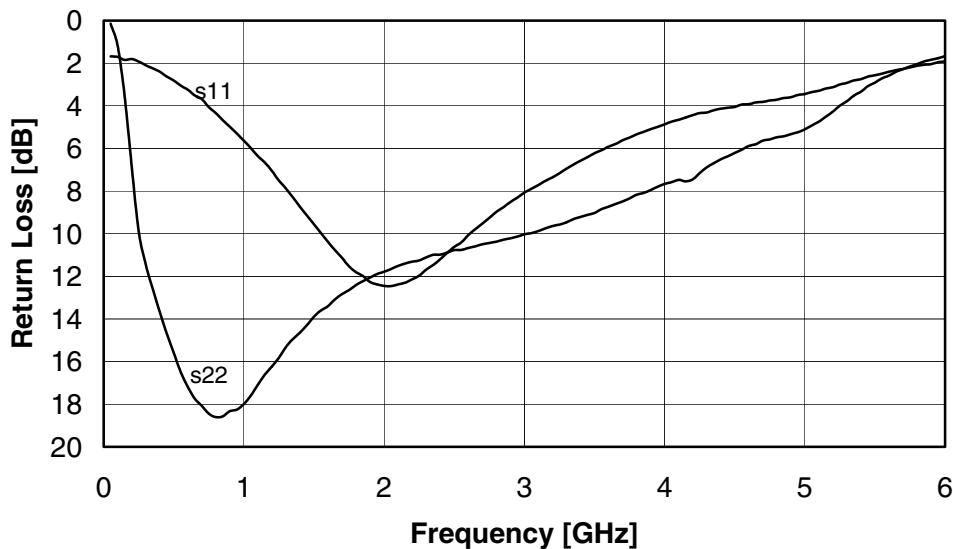


**Figure 17 Stability Factor K and Stability Measure B1 of Configuration B**

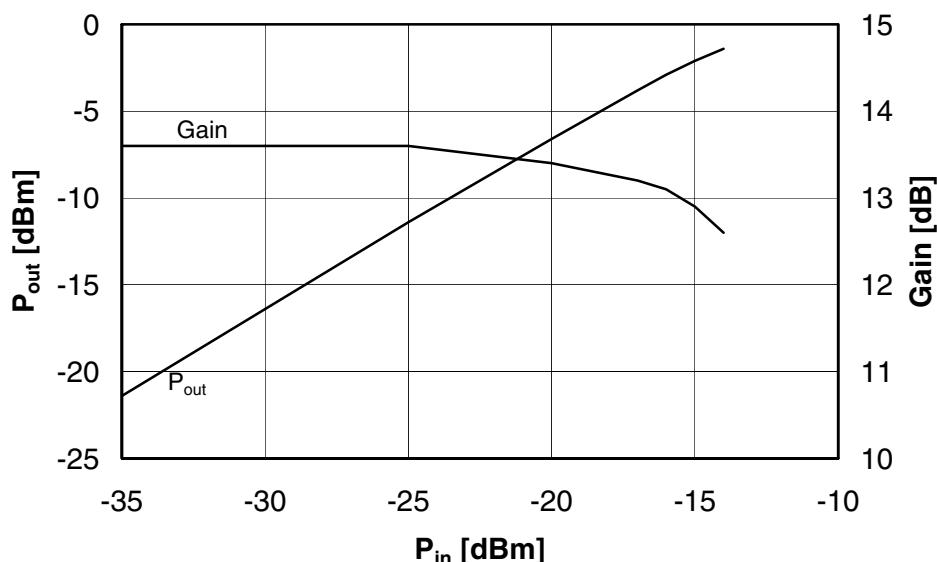


**Figure 18 Wide Span Gain Configuration B**

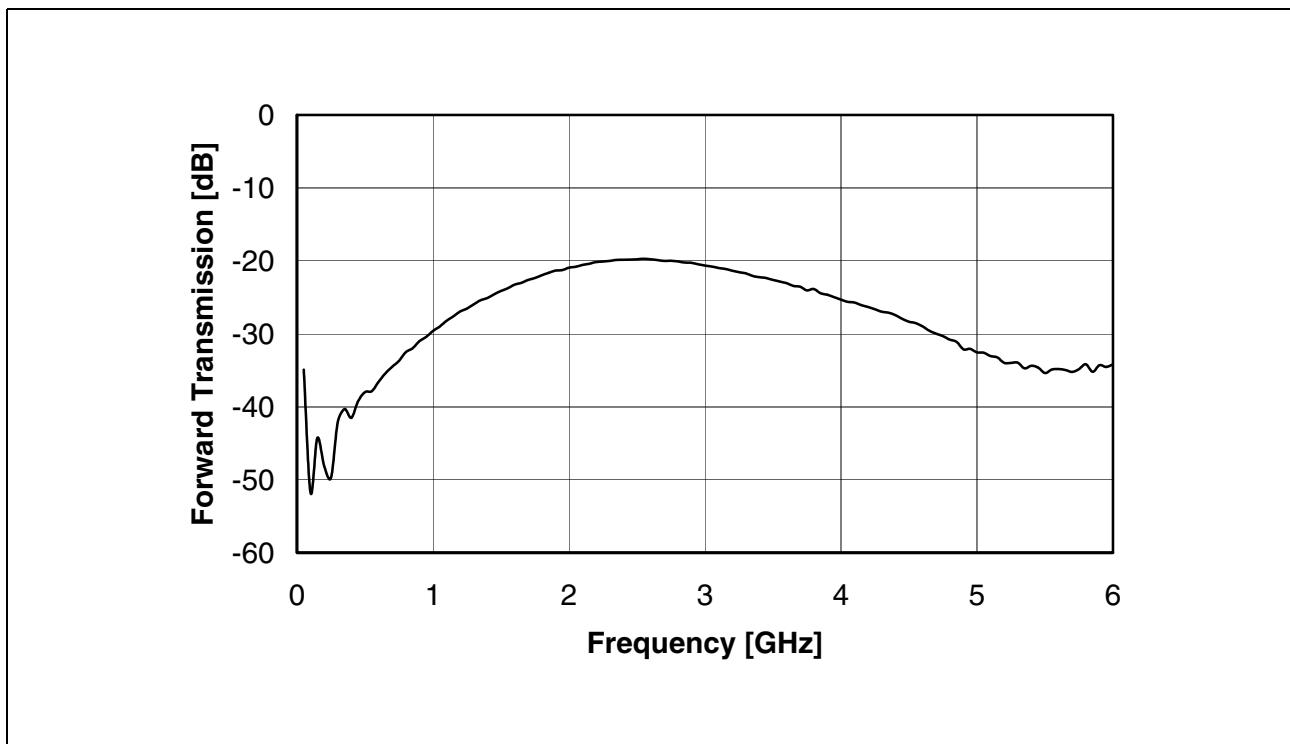
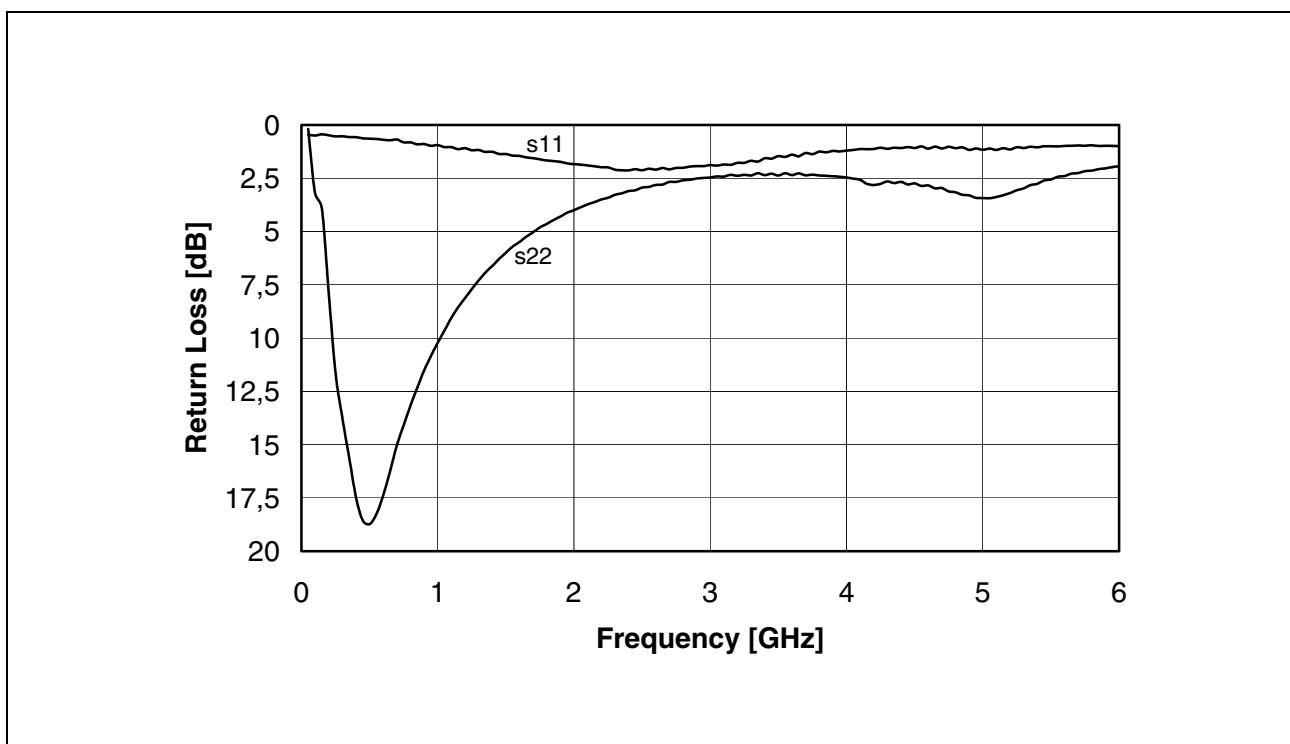
**Configuration B**



**Figure 19**    **Wide Span Return Loss Configuration B**

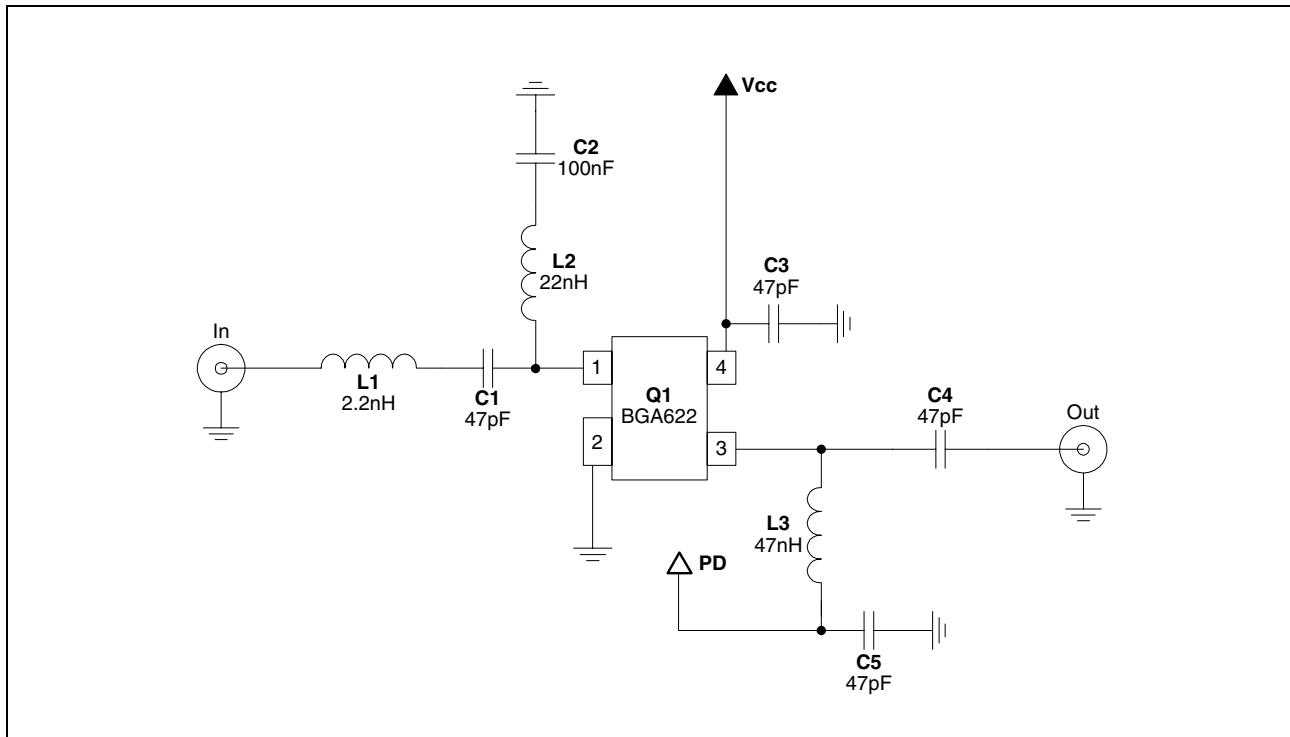


**Figure 20**    **Gain Compression @ 2.14 GHz Configuration B**

**Figure 21** Forward Transmission in Power Down Mode**Figure 22** Input and Output Return Loss in Power Down Mode

### Configuration C

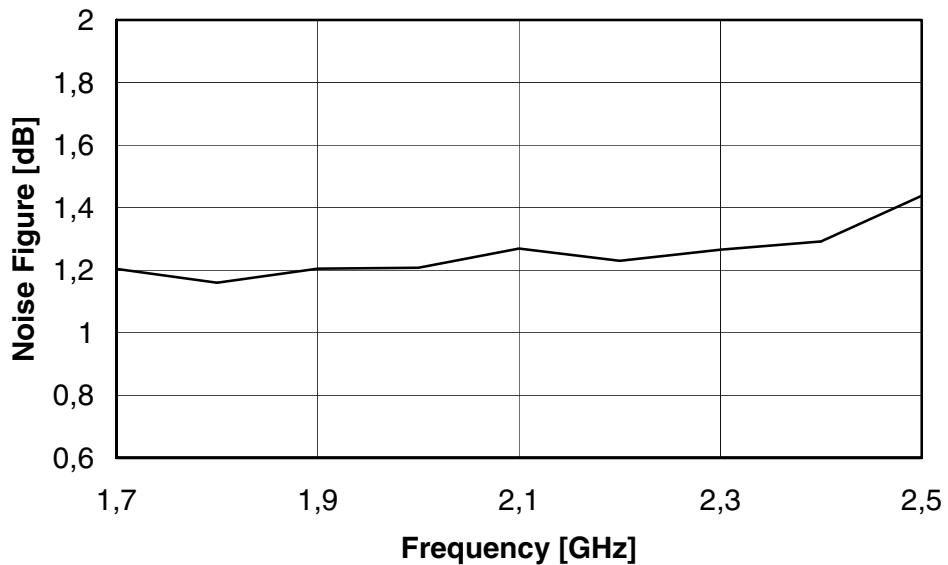
The circuit in **Figure 23** shows a way to increase the input 3<sup>rd</sup> order intercept point of BGA622.  $L_2$  and  $C_2$  offer low-frequency intermodulation products a low impedance path to ground. This prevents them from modulating the base voltage of the BGA622's internal RF transistor and thus linearity is improved. Typically the input 3<sup>rd</sup>-order intercept point of BGA622 can be improved by 6 to 10 dB in this manner.



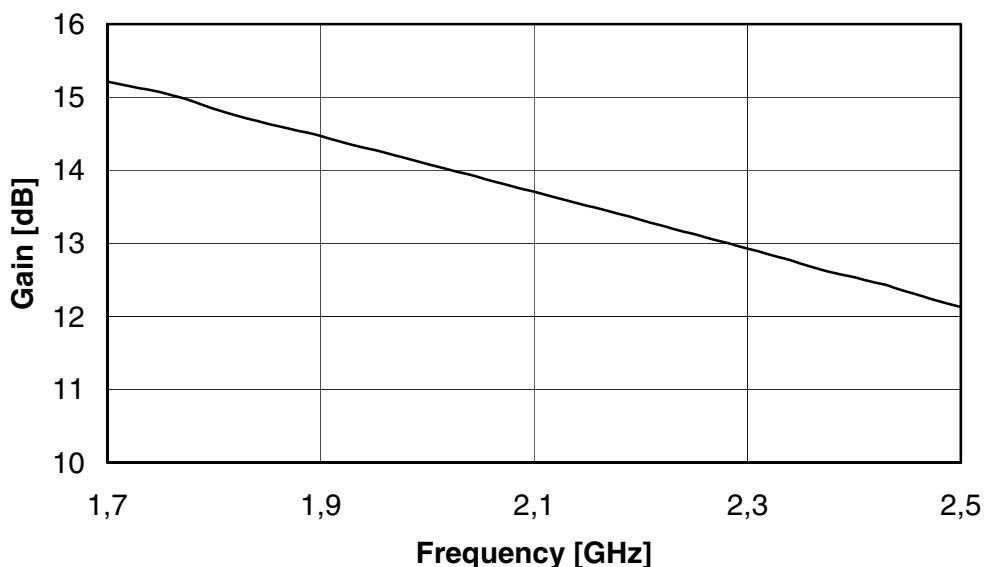
**Figure 23** Circuit Diagram Configuration C

### Bill of Materials of Configuration C

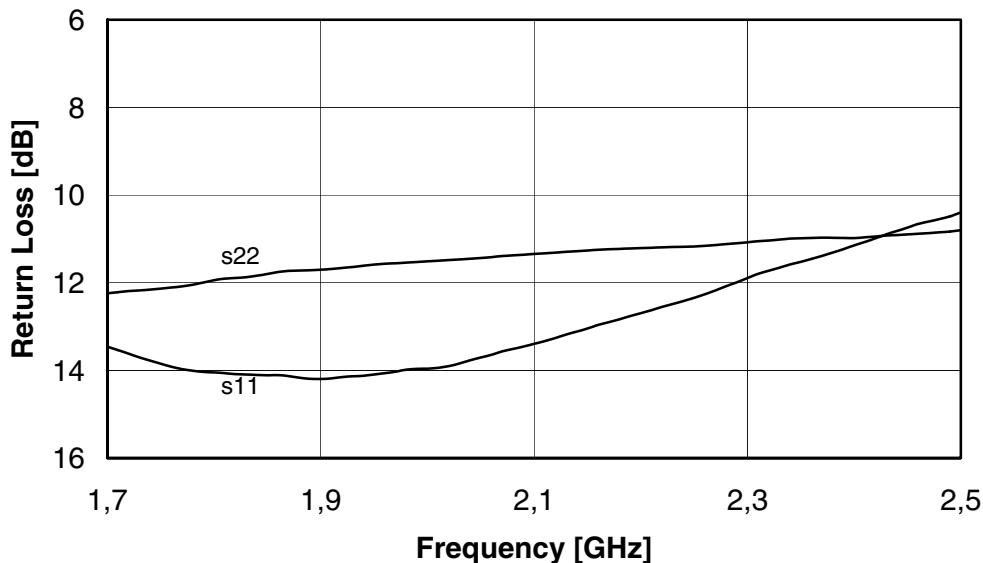
Name	Value	Package	Manufacturer	Function
$C_1$	47 pF	0402	various	DC block
$C_2$	100 nF	0603	various	IIP <sub>3</sub> improvement
$C_3$	47 pF	0402	various	RF bypass
$C_4$	47 pF	0402	various	DC block
$C_5$	47 pF	0402	various	RF bypass
$L_1$	2.2 nH	0402	Toko LL 1005-FH	Input matching
$L_2$	22 nH	0402	Toko LL 1005-FH	RF block
$L_3$	47 nH	0402	Toko LL 1005-FH	RF block
Q1	BGA622	SOT-343	Infineon Technologies	SiGe MMIC



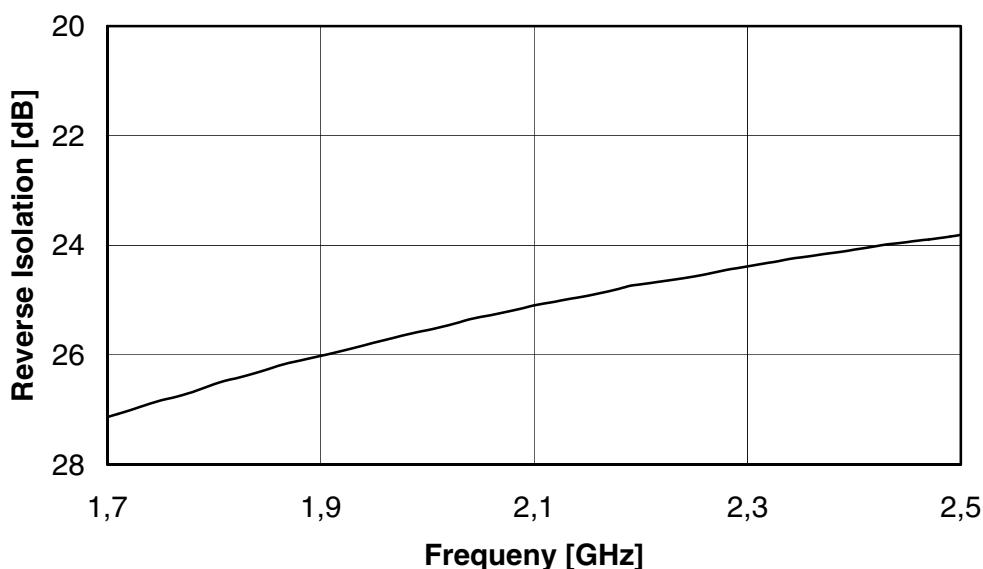
**Figure 24** Noise Figure Configuration C



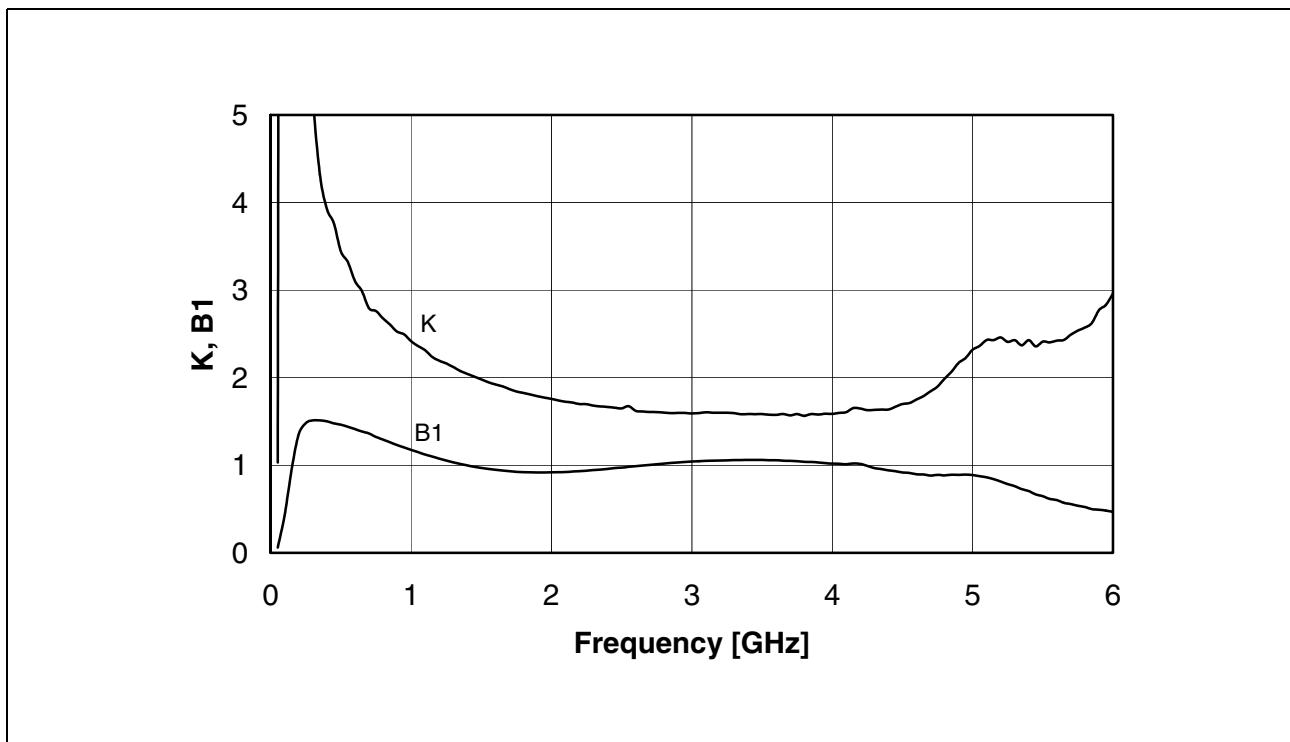
**Figure 25** Gain Configuration C



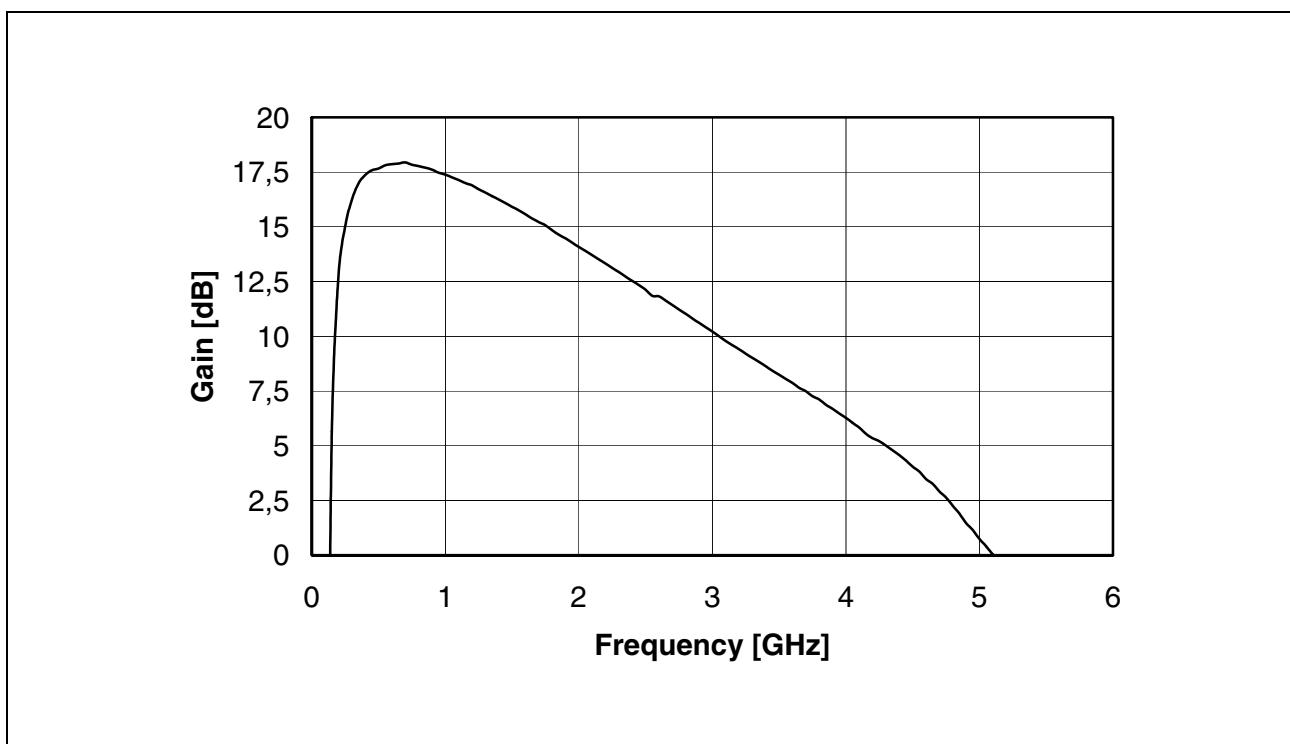
**Figure 26** Return Loss Configuration C



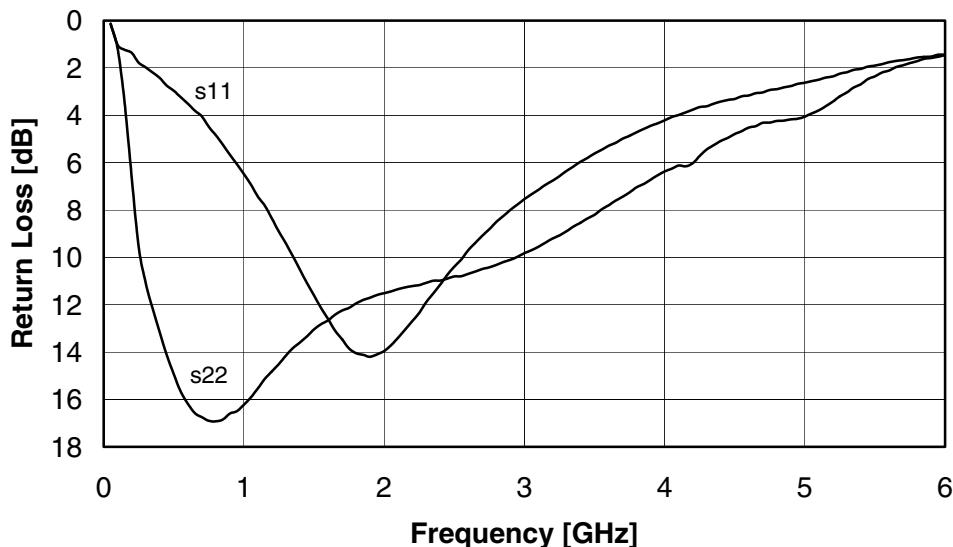
**Figure 27** Reverse Isolation Configuration C



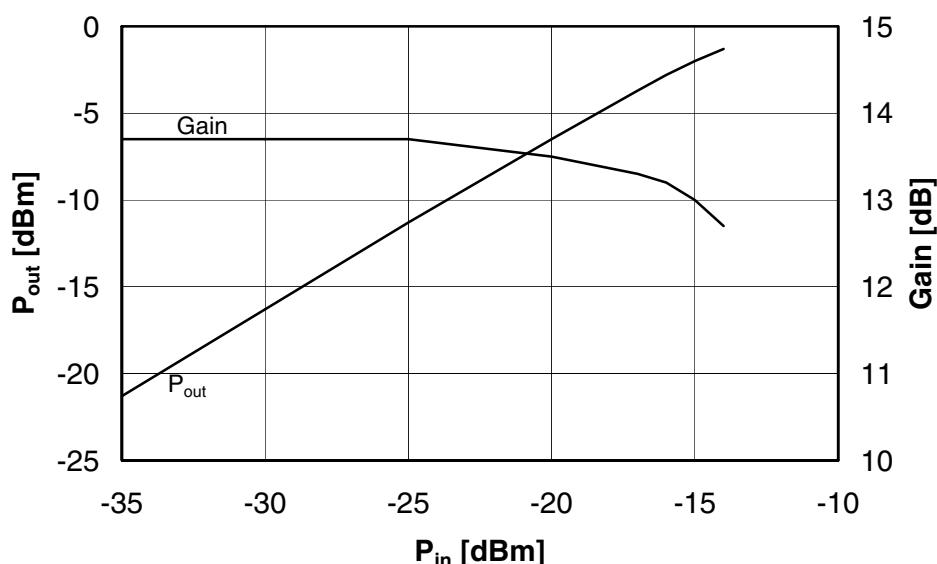
**Figure 28 Stability Factor K and Stability Measure B1 of Configuration C**



**Figure 29 Wide Span Gain Configuration C**



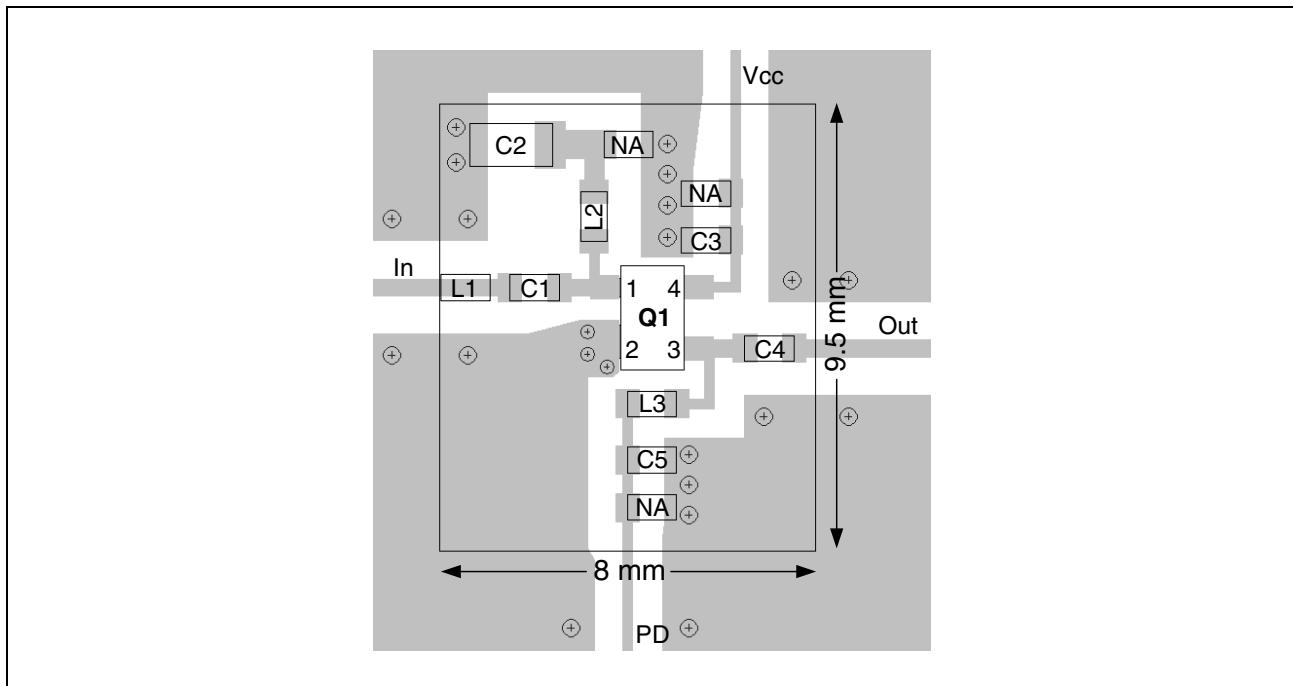
**Figure 30    Wide Span Return Loss Configuration C**



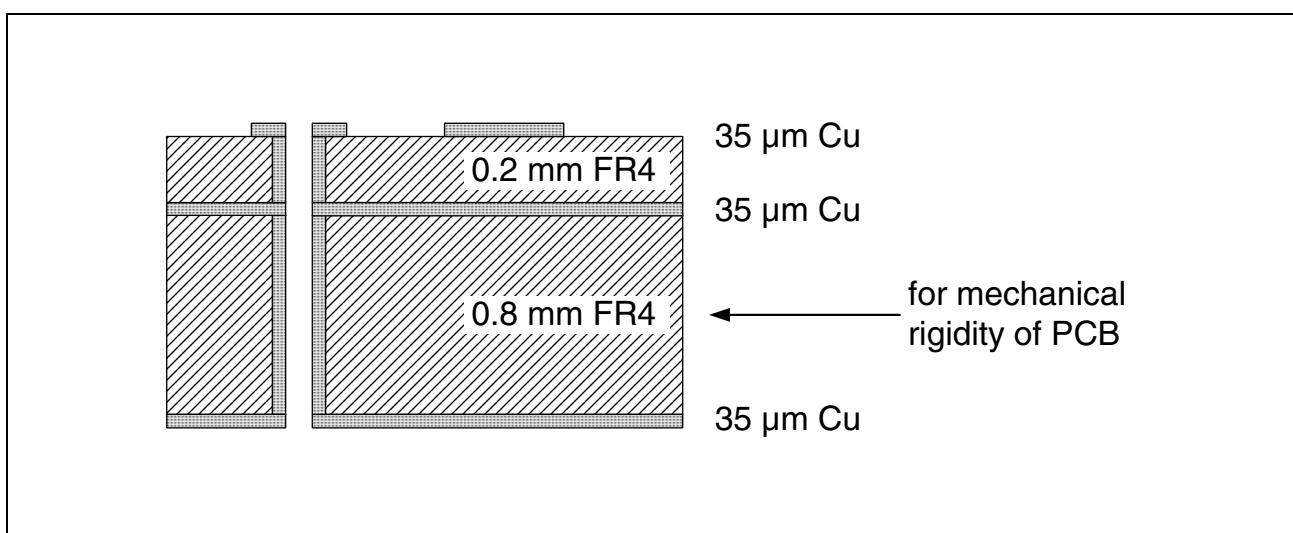
**Figure 31    Gain Compression @ 2.14 GHz Configuration C**

### Application PCB

**Figure 32** shows the placement of the specific components on the PCB. To place  $L_1$  on the board the input 50  $\Omega$  transmission line has to have a gap cut in it to allow for the insertion of  $L_1$ . For this purpose a relief is provided in the solder mask to ease the soldering of the component.



**Figure 32 Component Placement on Application PCB**



**Figure 33 PCB Cross Section**

Evaluation boards for the LNA applications described in this application note are available from Infineon Technologies.

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# **The BGA622 Silicon-Germanium Universal Low Noise Amplifier MMIC in 1800 - 2500 MHz Receiver Applications**

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**Revision History:** 2001-10 V3.0

Previous Version:

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<b>Page</b>	<b>Subjects (major changes since last revision)</b>
	Document's layout has been changed: 2002-Sep.

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