BGA231L7

Improving Immunity of BGA231L7 against Out-Of-Band Jammers (LTE Band-13, GSM850/900/1800, UMTS, WLAN) Using Series Notches

Application Note AN276

Revision: Rev. 1.0
2011-09-08

RF and Protection Devices

Edition 2011-09-16

Published by
Infineon Technologies AG
81726 Munich, Germany

Application Note AN276	
Revision History: 2011-09-08	
Previous Revision: None	
Page	**Subjects (major changes since last revision)**

Table of Content

List of Figures

List of Tables

1 BGA231L7 GPS Front-End LNA

1.1 Features

- High gain: 16.0 dB
- High out-of-band input 3rd-order intercept point: +5 dBm
- High input 1dB compression point: -5 dBm
- Low noise figure: 0.75 dB
- Low current consumption: 4.4 mA
- Operating frequency: 1550-1615 MHz
- Supply voltage: 1.5 V to 3.6 V
- Digital on/off switch (1V logic high level)
- Tiny TSLP-7-1 leadless package
- B7HF Silicon Germanium technology
- RF output internally matched to 50 Ω
- Only three external SMD components necessary
- 2 kV HBM ESD protection (including AI-pin)
- Pb-free (RoHS compliant) package

Figure 1 BGA231L7 in TSLP-7-1 Package (2 mm x 1.3 mm x 0.4 mm)

1.2 Applications

- Global Positioning System (GPS)
- GLONASS (Russian GNSS)
- Galileo (European GNSS)
- COMPASS (Chinese Beidou Navigation System)

2 Introduction

The BGA231L7 is a front-end Low Noise Amplifier (LNA) for Global Navigation Satellite Systems (GNSS) application. It is based on Infineon Technologies' B7HF Silicon-Germanium technology, enabling a cost-effective solution in a small TSLP-7-1 package with low noise figure, high gain, high linearity and low current consumption over a wide range of supply voltages from 3.6 V down to 1.5 V. All these features make BGA231L7 an excellent choice for GNSS LNA as it improves sensitivity, provide greater immunity against out-of-band jammer signals, reduces filtering requirement and hence the overall cost of the GNSS receiver.

This application note addresses the issue of out-of-band jammers and improving the immunity of BGA231L7 against these jammers. There is always a tradeoff between noise figure and out-of-band supression. The circuit designed here is inclined toward the applications where low noise figure is desired at the cost of out-of-band intermodulation products. The out-of-band signals considered are LTE Band-13, GSM850/900/1800, UMTS and WLAN as their intermodulation products fall into GPS band.

The jamming resistance of BGA231L7 against these jammers is improved by increasing the attenuation of the circuit at these specific out-of-band frequencies (787MHz, 827MHz, 897MHz, 1712MHz, 1850MHz, 2402MHz, 2472MHz). This is achieved by using external SMDs and a SAW filter before BGA231L7. In some applications where more rejection is required at special frequencies and SAW filter alone cannot provide sufficient attenuation, some external notches can be designed for those frequencies. Figure 3 shows such an application circuit where notches have been designed to attenuate 787MHz, 827MHz, 897MHz, 2402 MHz and 2472MHz. The notches L3-C3/L4-C4 and L5-C5 are designed for 750-950MHz range and 2.45GHz respectively. The component values are fine tuned so as to have optimal noise figure, jammer rejection, gain and input matching.

The Internal circuit diagram of the BGA231L7 is presented in Figure 2. Table 1 shows the pin assignment of BGA231L7. Table 2 shows the truth table to turn on/off BGA231L7 by applying different voltage to the PON pin.

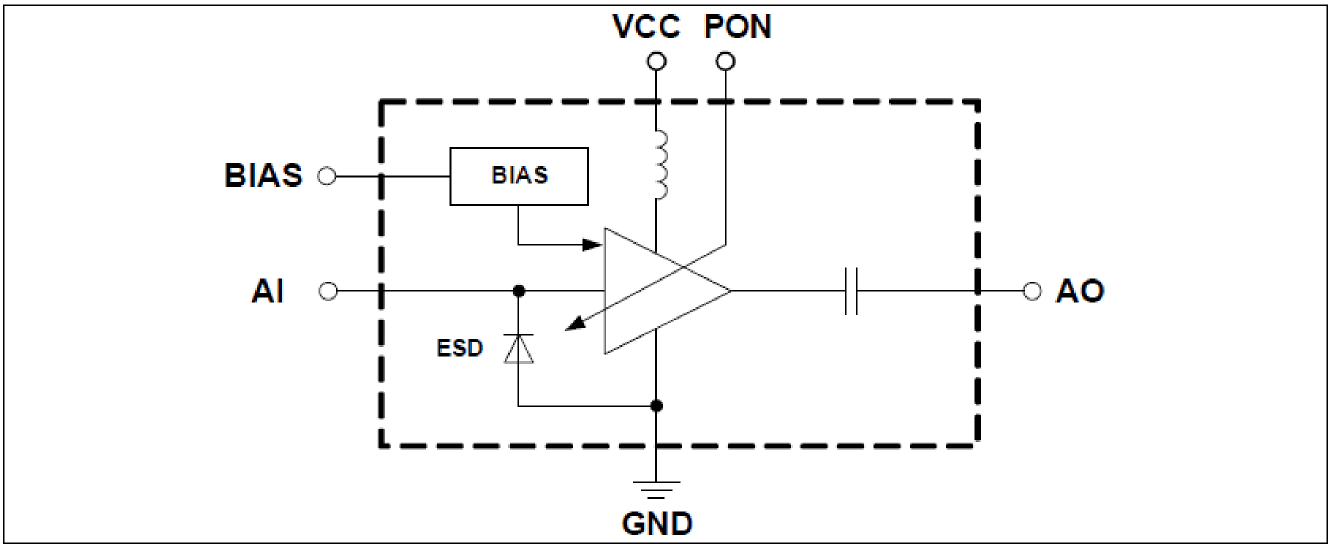

Figure 2 Block diagram of the BGA231L7 for GNSS band 1559-1615MHz applications

Table 1 Pin Definition

Pin	Symbol	Comment
1	PON	Power on control
2	AI	LNA input
3	BIAS	DC Bias
4	n.c.	Not connected
5	AO	LNA output
6	VCC	DC Supply
7	GND	RF and DC ground

Table 2 Switching Mode

Mode	Symbol	ON/OFF Control Voltage	
		Min	Max
On	PON, on	1.0V	VCC
Off	PON, off	0	0.4

3 Application Circuit

3.1 Schematic Diagram

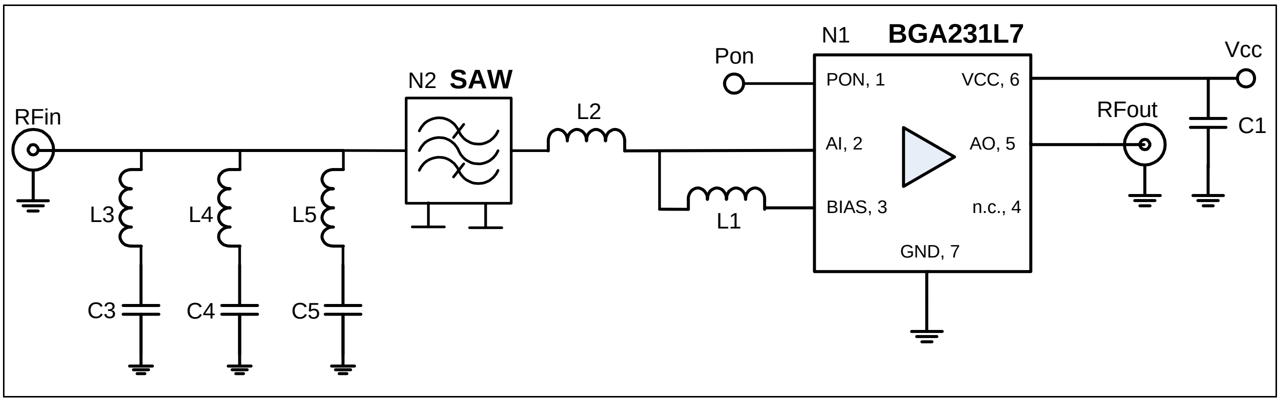

Figure 3 BGA231L7 application circuit for improved rejection of out-of-band jammers

Table 3 Bill-of-Materials

Symbol	Value	Unit	Package	Manufacturer	Comment
C1 (optional)	10.0	nF	0201	Various	RF bypass
L1	39.0	nH	0201	Murata LQP series	Biasing inductor
L2	7.5	nH	0201	Murata LQP series	Matching between SAW and LNA
L3	10.0	nH	0201	Murata LQP series	750-950 MHz Notch
C3	3.0	pF	0201	Various	750-950 MHz Notch
L4	8.2	nH	0201	Murata LQP series	750-950 MHz Notch
C4	4.3	pF	0201	Various	750-950 MHz Notch
L5	2.8	nH	0201	Murata LQP series	2.45 GHz Notch
C5	1.1	pF	0201	Various	2.45 GHz Notch
N1	BGA231L7		TSLP-7-1	Infineon	SiGe LNA
N2	SAW		TSNP-7-10		SAW filter of BGM1033N7
PCB substrate	FR4				

4 Typical Measurement Results

Table 4 and Table 5 show typical measurement results of the application circuit shown in Figure 3. The values given in this table include losses of the board and the SMA connectors if not otherwise stated.

Table 4 Electrical Characteristics (at room temperature), Vcc = Vpon = 1.8V

Parameter	Symbol	Value		Unit	Comment/Test Condition
DC Voltage	Vcc	1.8		V	
DC Current	Icc	4.3		mA	
Frequency System	Sys	GPS	GLONASS		
Frequency Range	Freq	1575	1602-1615	MHz	
Gain	G	14.9	14.4	dB	
Noise Figure	NF	2.1	2.45	dB	PCB and SMA connector losses of 0.07 dB substracted
Input Return Loss	RLin	10.7	11.0	dB	
Output Return Loss	RLout	19.0	28.8	dB	
Reverse Isolation	IRev	23.7	23.9	dB	
Input P1dB	IP1dB	-6.2	-5.9	dBm	f_{gps} = 1575 MHz $f_{GLONASS}$ = 1605 MHz
Output P1dB	OP1dB	7.7	7.5	dBm	
LTE band-13 2nd Harmonic	H2	-75.0		dBm	f_{IN} = 787.76 MHz P_{IN} = +15 dBm
Output IM2 Out-of-band	IM2	-94.8		dBm	f_1 = 827 MHz, P_{1IN} = +12 dBm; f_2 = 2402 MHz, P_{2IN} = +8 dBm
Output IM2 Out-of-band	IM2	-99.1		dBm	f_1 = 897 MHz, P_{1IN} = +12 dBm; f_2 = 2472 MHz, P_{2IN} = +8 dBm
Input IP3 In-band	IIP3	0.7		dBm	
Output IP3 In-band	OIP3	15.6		dBm	f_1 = 1575.5 MHz f_2 = 1576.5 MHz Input power= -30dBm
Input IP3 Out-of-band	$IIP3_{OOB}$	67.1		dBm	f_1 = 1712.7 MHz, P_{1IN} = +10 dBm; f_2 = 1850 MHz, P_{2IN} = +10 dBm
Stability	k	>1		--	Unconditionnally Stable from 0 to 10GHz

Table 5 Electrical Characteristics (at room temperature), Vcc = Vpon = 2.8V

Parameter	Symbol	Value		Unit	Comment/Test Condition
DC Voltage	Vcc	2.8		V	
DC Current	Icc	4.5		mA	
Frequency System	Sys	GPS	GLONASS		
Frequency Range	Freq	1575	1602-1615	MHz	
Gain	G	15.0	14.6	dB	
Noise Figure	NF	2.1	2.45	dB	PCB and SMA connector losses of 0.07 dB substracted
Input Return Loss	RLin	11.3	11.4	dB	
Output Return Loss	RLout	17.2	34.9	dB	
Reverse Isolation	IRev	24.3	24.4	dB	
Input P1dB	IP1dB	-3.5	-3.1	dBm	f_{gps} = 1575 MHz $f_{GLONASS}$ = 1605 MHz
Output P1dB	OP1dB	10.5	10.5	dBm	
LTE band-13 2nd Harmonic	H2	-75.2		dBm	f_{IN} = 787.76 MHz P_{IN} = +15 dBm
Output IM2 Out-of-band	IM2	-95.0		dBm	f_1 = 827 MHz, P_{1IN} = +12 dBm; f_2 = 2402 MHz, P_{2IN} = +8 dBm
Output IM2 Out-of-band	IM2	-99.4		dBm	f_1 = 897 MHz, P_{1IN} = +12 dBm; f_2 = 2472 MHz, P_{2IN} = +8 dBm
Input IP3 In-band	IIP3	0.9		dBm	
Output IP3 In-band	OIP3	15.9		dBm	f_1 = 1575.5 MHz f_2 = 1576.5 MHz Input power= -30dBm
Input IP3 Out-of-band	$IIP3_{OOB}$	67.1		dBm	f_1 = 1712.7 MHz, P_{1IN} = +10 dBm; f_2 = 1850 MHz, P_{2IN} = +10 dBm
Stability	k	>1		--	Unconditionnally Stable from 0 to 10GHz

5 Measured Graphs for GPS and GLONASS bands

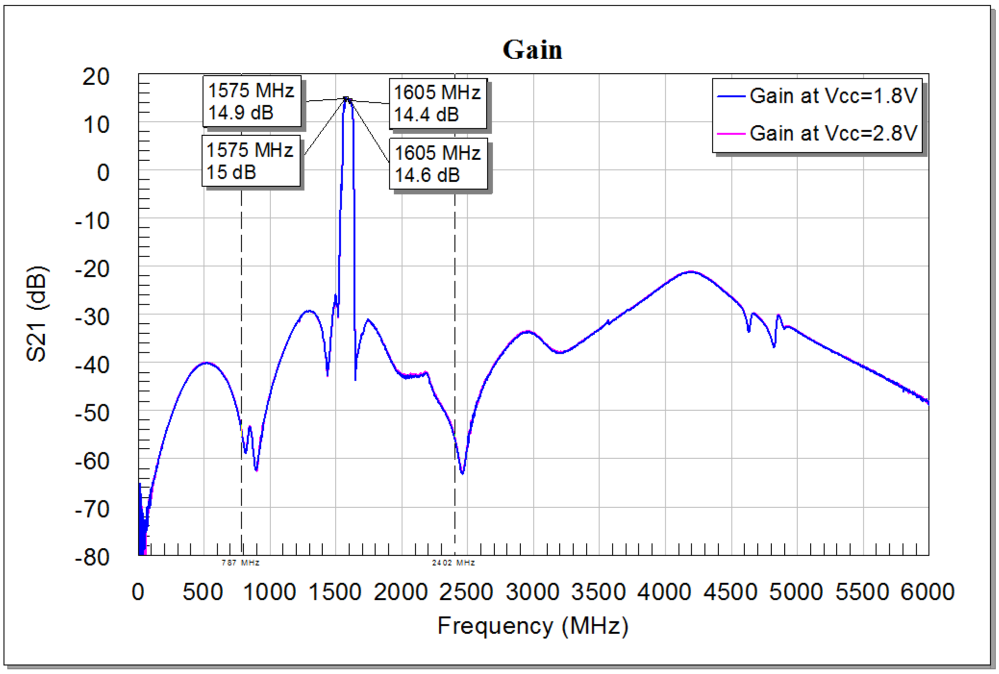

Figure 4 Power gain of BGA231L7 for GPS and GLONASS bands

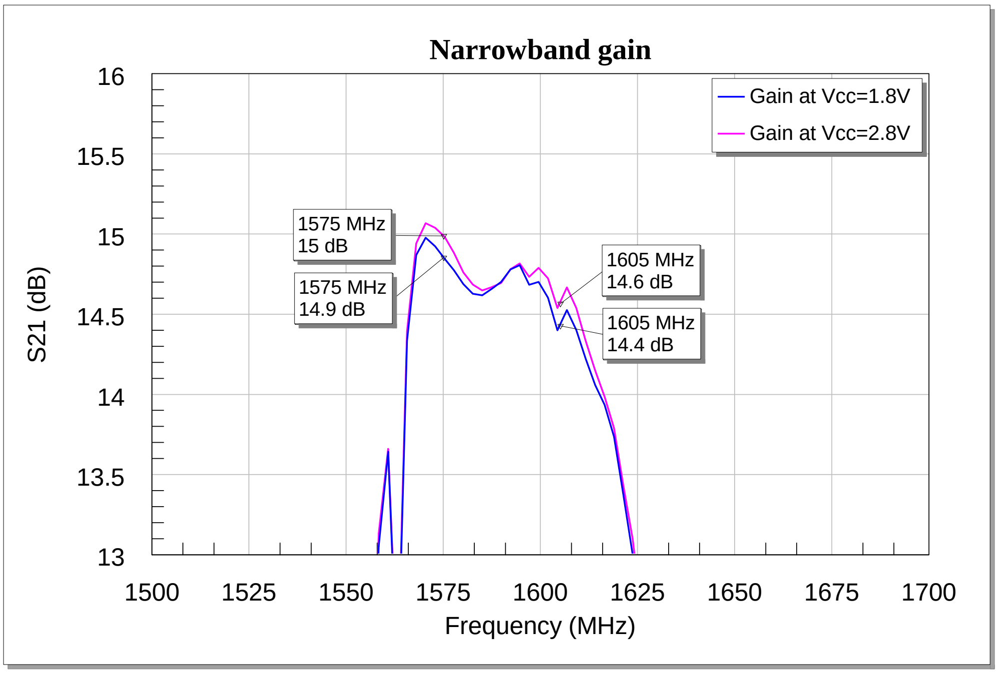

Figure 5 Narrowband power gain of BGA231L7 for GPS and GLONASS bands

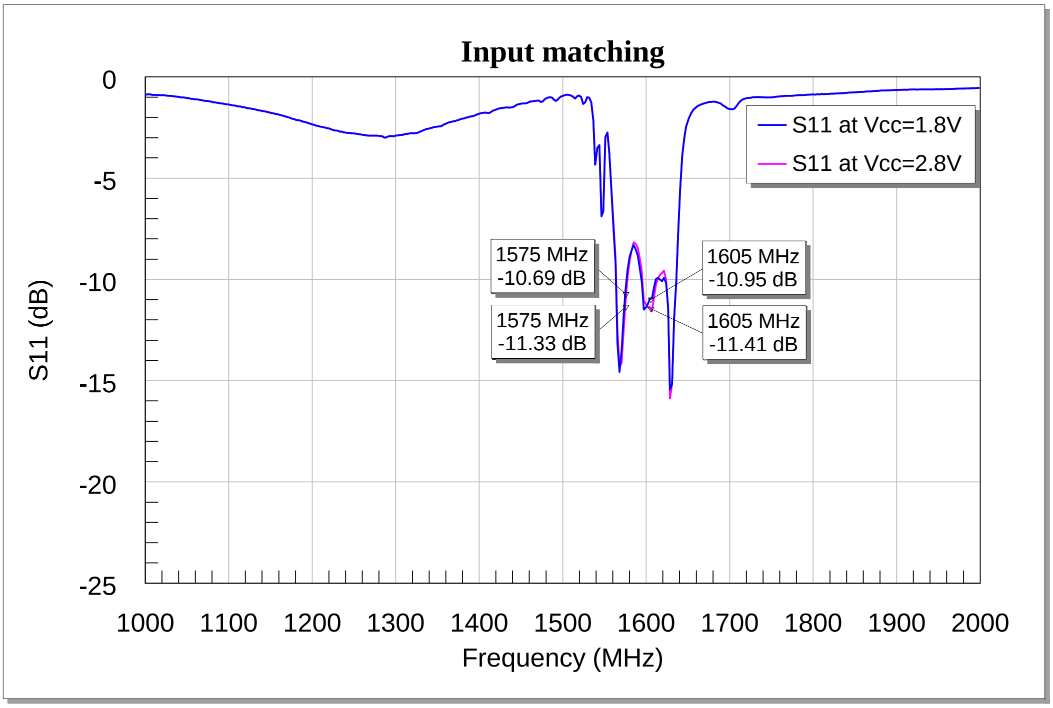

Figure 6 Input matching of BGA231L7 for GPS and GLONASS bands

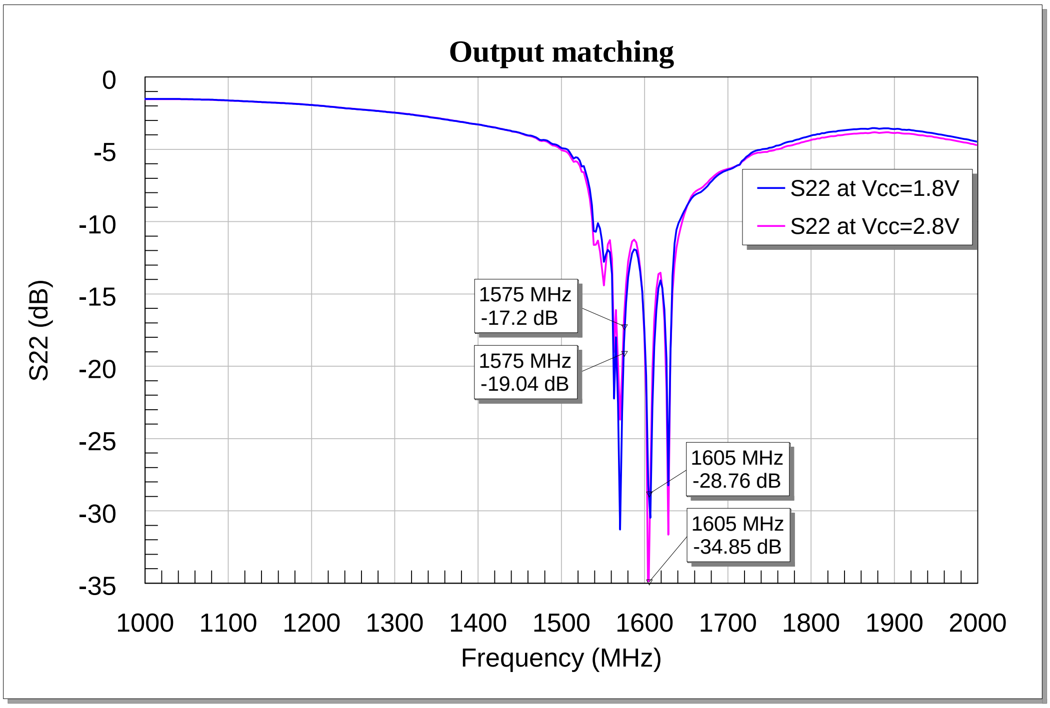

Figure 7 Output matching of BGA231L7 for GPS and GLONASS bands

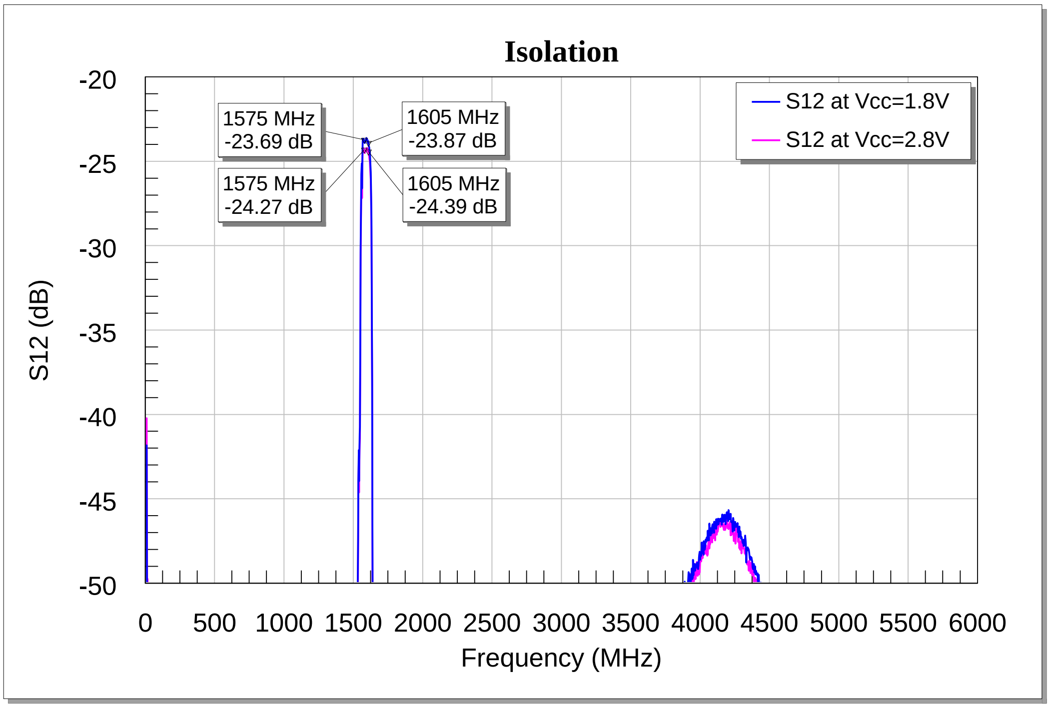

Figure 8 Reverse isolation of BGA231L7 for GPS and GLONASS bands

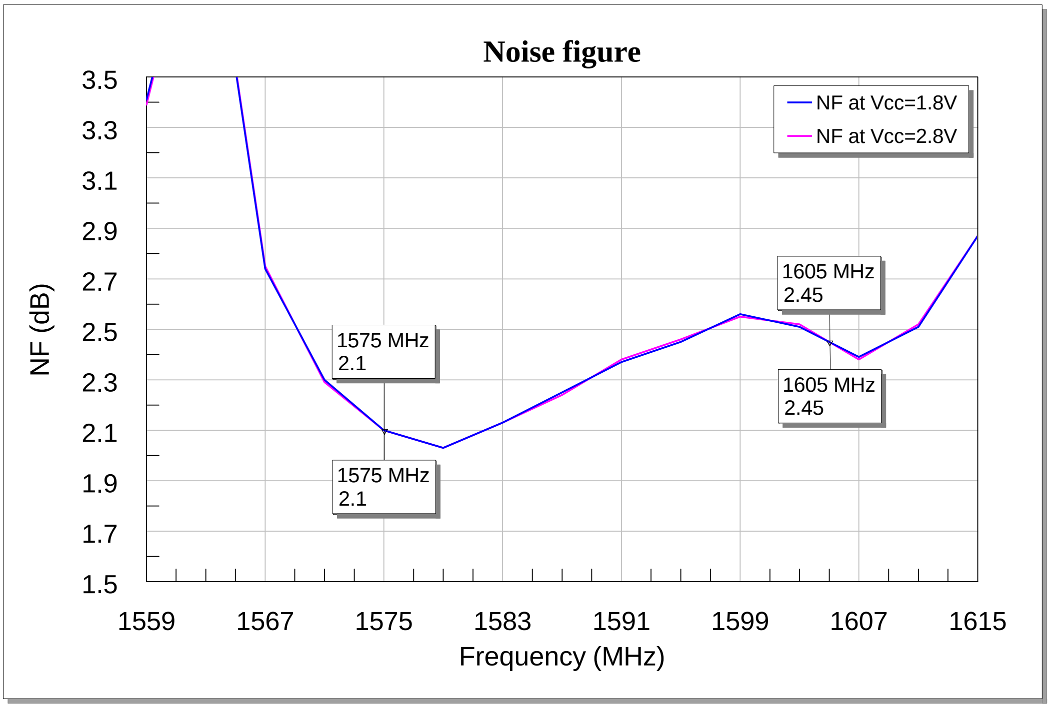

Figure 9 Noise figure of BGA231L7 for GPS and GLONASS bands

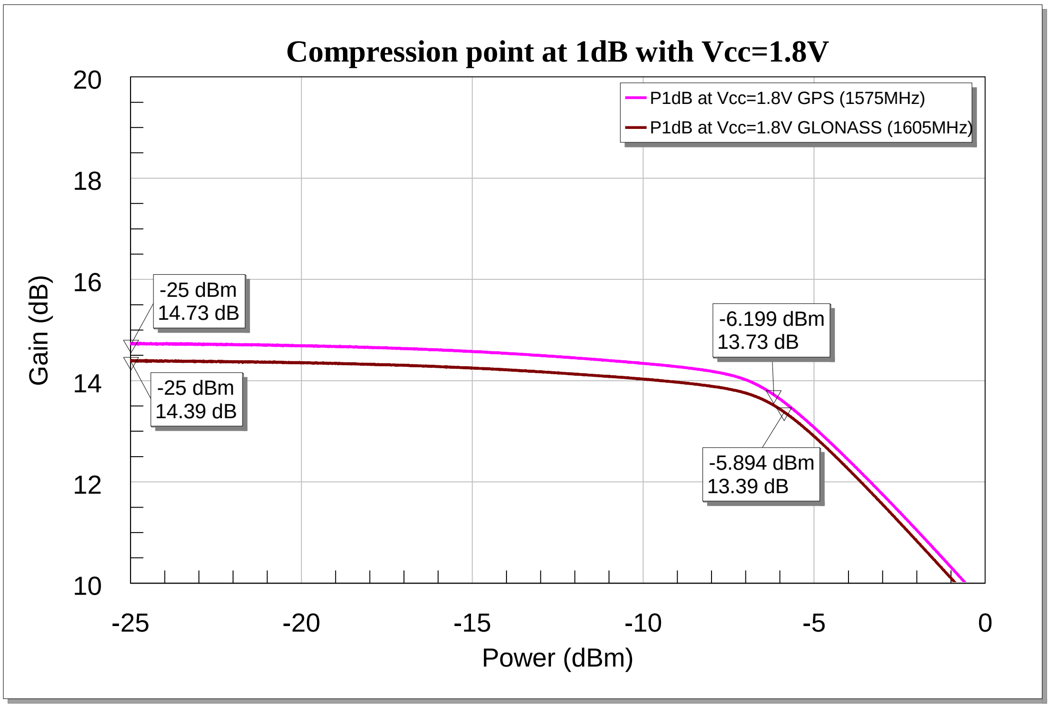

Figure 10 Input 1 dB compression point of BGA231L7 at supply voltage of 1.8V for GPS and GLONASS bands

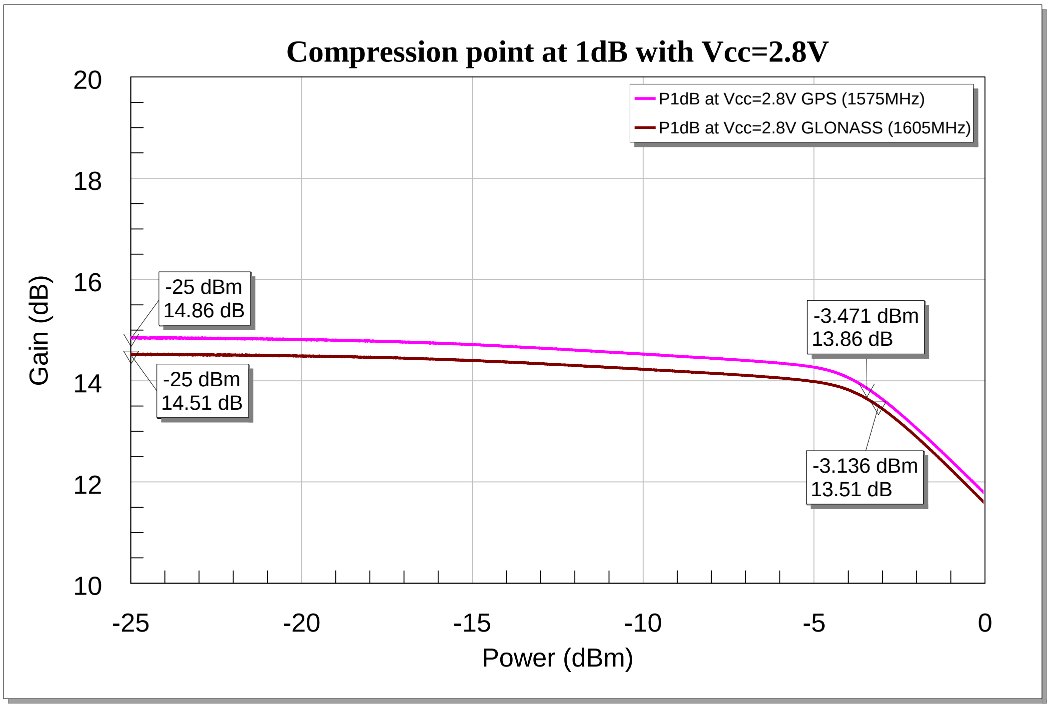

Figure 11 Input 1 dB compression point of BGA231L7 at supply voltage of 2.8V for GPS and GLONASS bands

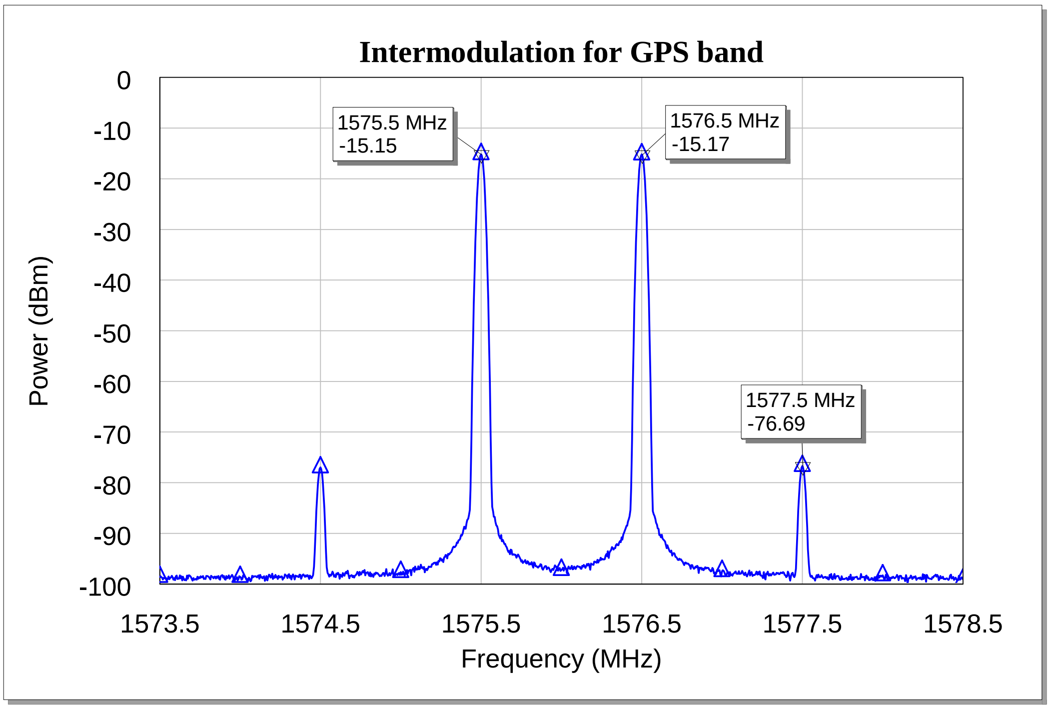

Figure 12 Carrier and intermodulation products of BGA231L7 for GPS band at Vcc=1.8V

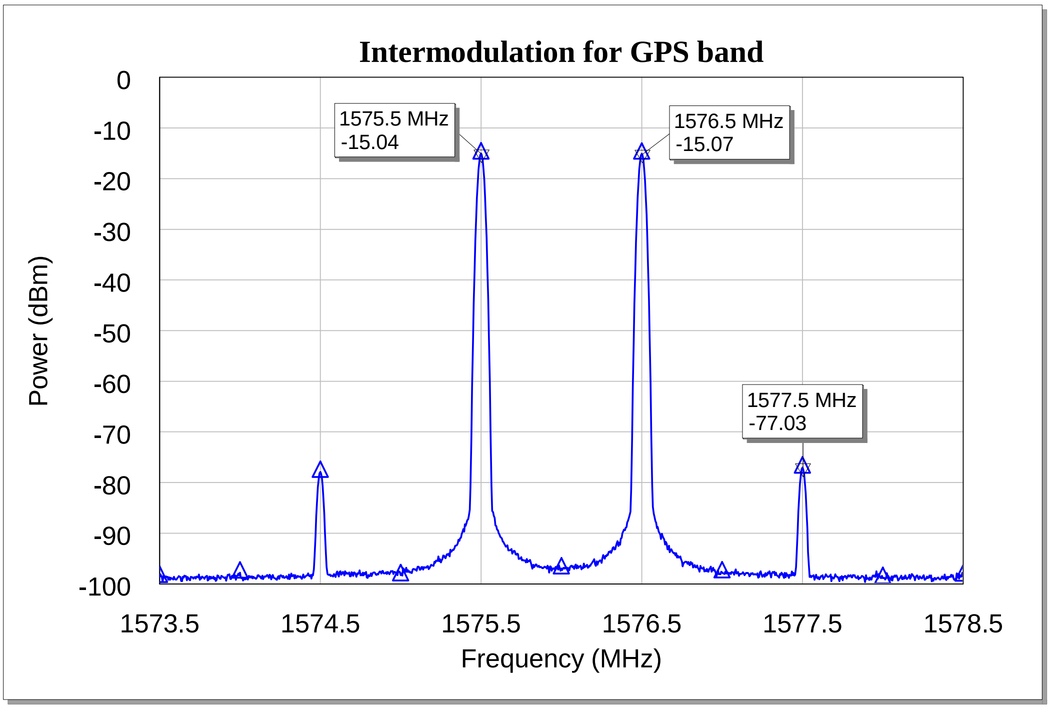

Figure 13 Carrier and intermodulation products of BGA231L7 for GPS band at Vcc=2.8V

6 Miscellaneous Measured Graphs

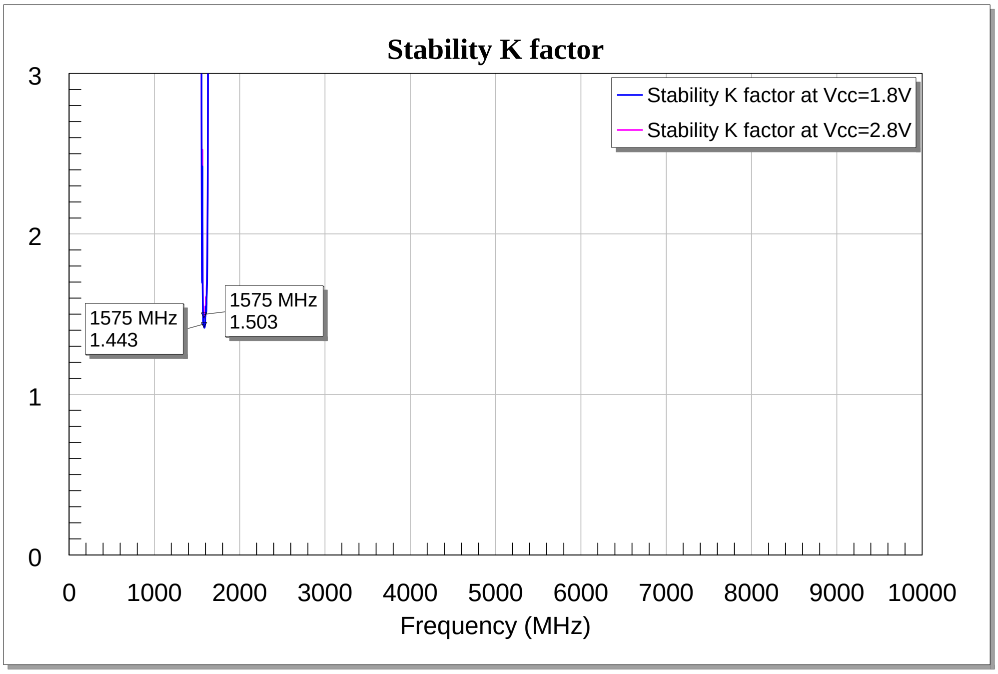

Figure 14 Stability factor k of BGA231L7 upto 10GHz

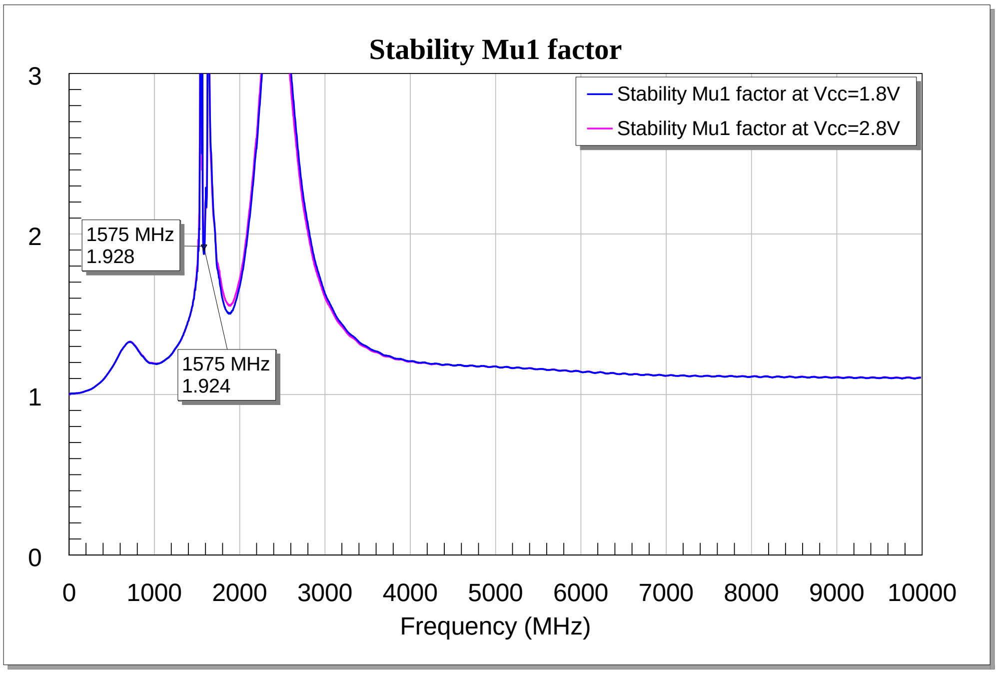

Figure 15 Stability factor μ1 of BGA231L7 upto 10GHz

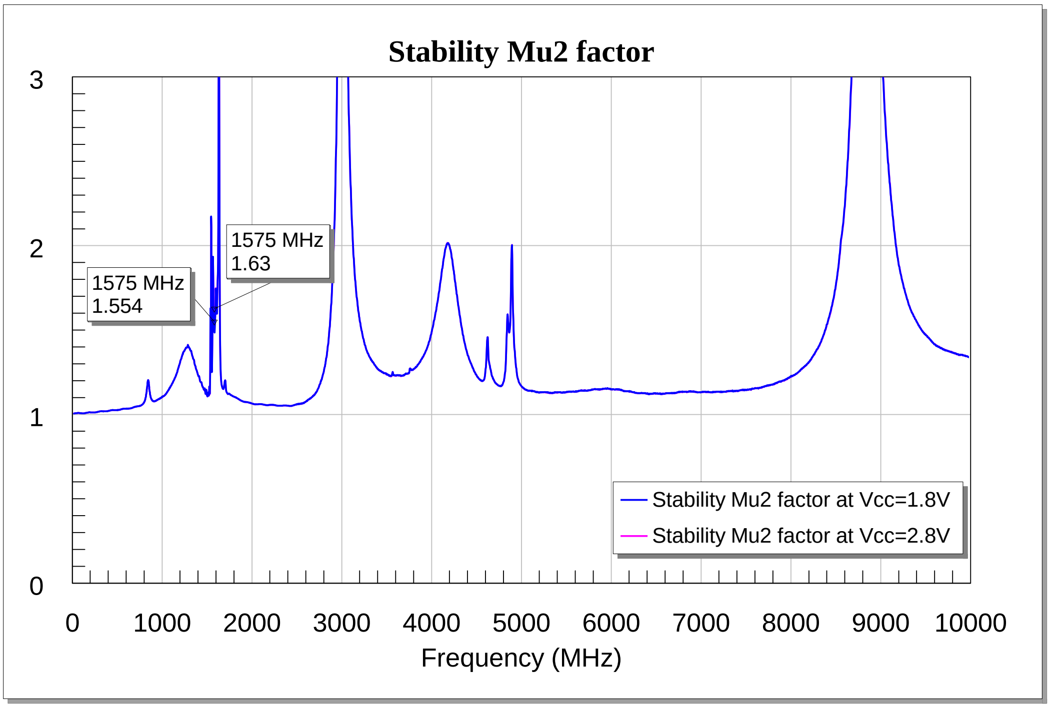

Figure 16 Stability factor μ2 of BGA231L7 upto 10GHz

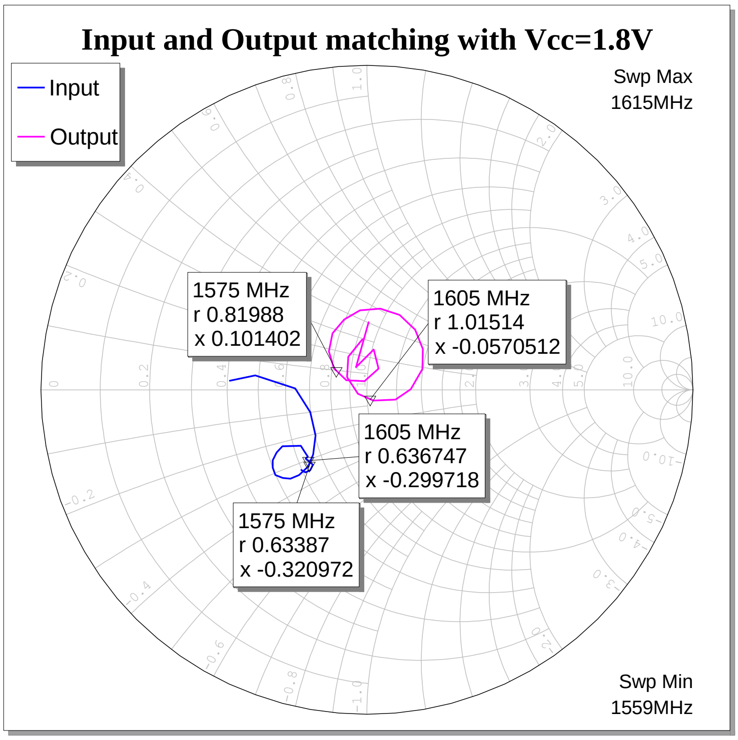

Figure 17 Input and output matching for GPS and GLONASS bands with Vcc=1.8V

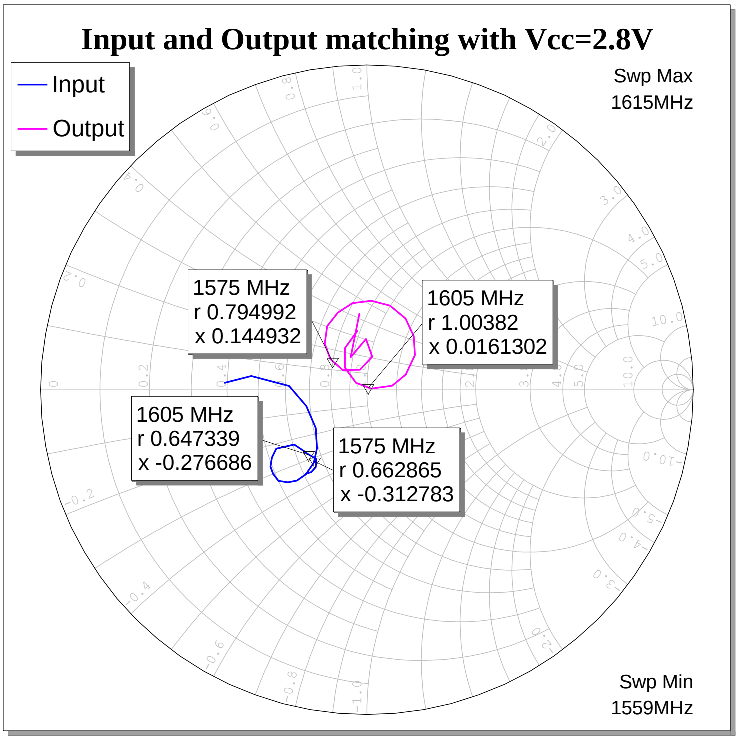

Figure 18 Input and output matching for GPS and GLONASS bands with Vcc=2.8V

7 Evaluation Board

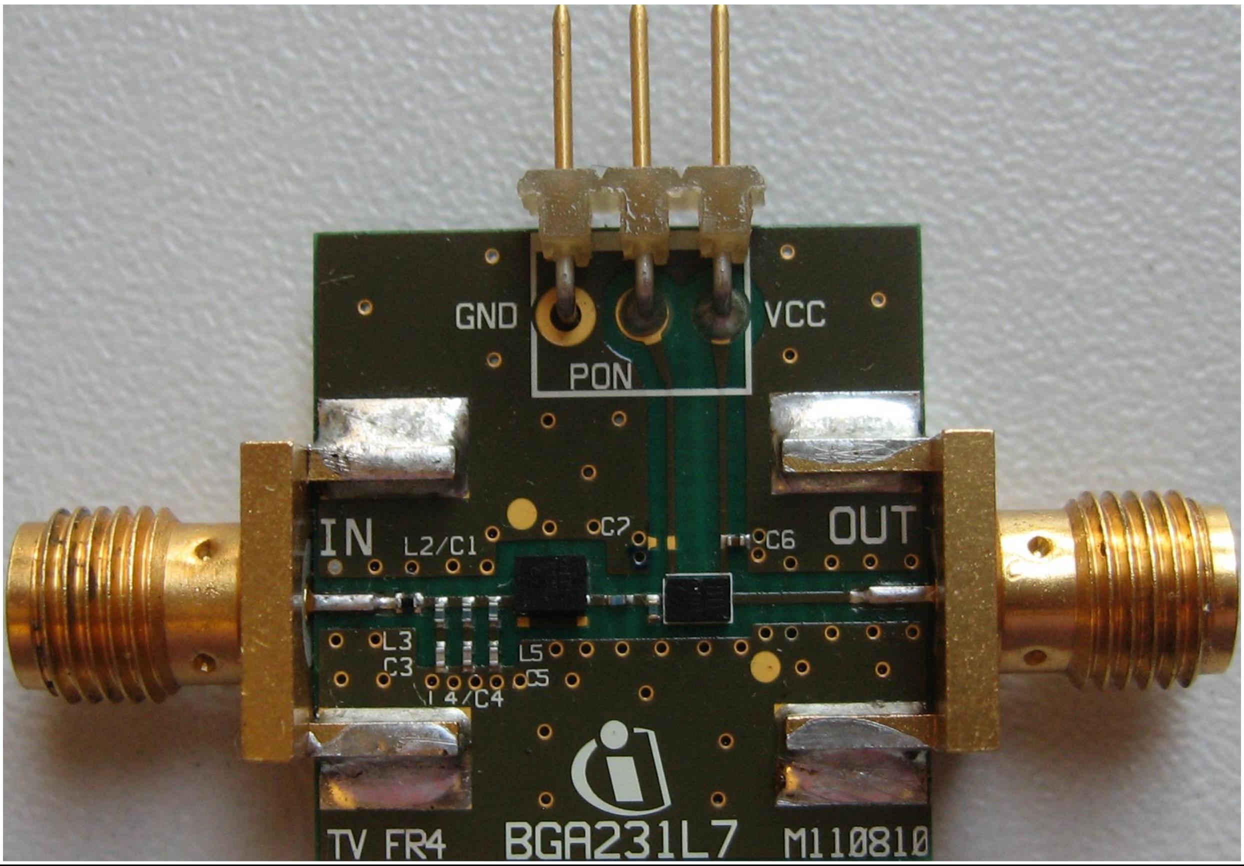

Figure 19 Populated PCB picture of BGA231L7

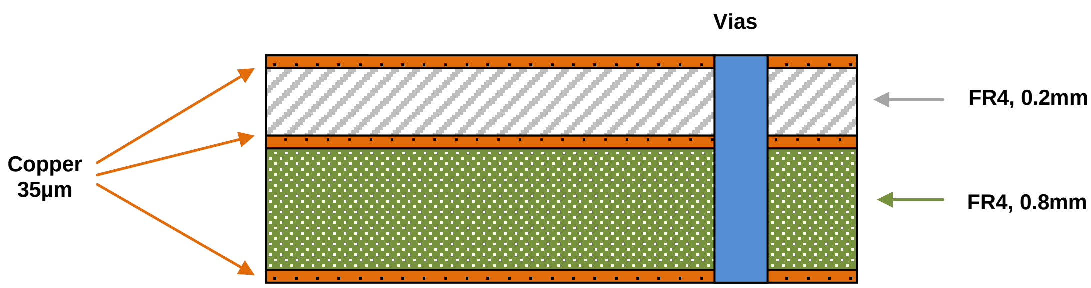

Figure 20 PCB layer stack

8 Authors

Jagjit Singh Bal, Application Engineer of Business Unit “RF and Protection Devices”.
Dr. Chih-I Lin, Senior Staff Engineer of Business Unit “RF and Protection Devices”.

w w w . i n f i n e o n . c o m

Published by Infineon Technologies AG

AN276