BGA925L6

Improving Immunity of BGA925L6 against Out-Of-Band Jammers (LTE Band-13, GSM850/900/1800, UMTS, WLAN)

Application Note AN274

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Page	Subjects (major changes since last revision)
10-19	Markers and corresponding values updated

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1 BGA925L6 GPS Front-End LNA for High Performance Integrated Solution

1.1 Features

- High gain: 15.8 dB
- High out-of-band input 3rd-order intercept point: +7 dBm
- High input 1dB compression point: -5 dBm
- Low noise figure: 0.65 dB
- Low current consumption: 4.8 mA
- Operating frequency: 1550-1615 MHz
- Supply voltage: 1.5 V to 3.6 V
- Digital on/off switch (1V logic high level)
- Ultra small TSLP-6-2 leadless package
- Package dimensions: 0.70mm x 1.1mm x 0.40mm
- B7HF Silicon Germanium technology
- RF output internally matched to 50 Ω
- Only two external SMD components necessary
- 2 kV HBM ESD protection (including AI-pin)
- Pb-free (RoHS compliant) package

Figure 1 BGA925L6 in TSLP-6-2 Package (0.70mm x 1.1mm x 0.40mm)

1.2 Applications

- GPS (Global Positioning System) working in the L1 band at 1575.42 MHz

- GLONASS (Russian GNSS) working in the L1 band from 1598.06 MHz to 1605.38 MHz

- Galileo[1] (European GNSS) working in the E2-L1-E1 band from 1559 MHz to 1592 MHz

- COMPASS[1] (Chinese Beidou Navigation System) working in E2 band at 1561.10 MHz and E1 band at 1589.74 MHz

[1] The application circuit (Figure 3) proposed in this Application Note is suitable for GPS and GLONASS bands

2 Introduction

The BGA925L6 is a front-end Low Noise Amplifier (LNA) for Global Navigation Satellite Systems (GNSS) application. It is based on Infineon Technologies' B7HF Silicon-Germanium (SiGe:C) technology, enabling a cost-effective solution in a ultra small TSLP-6-2 package with ultra 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 BGA925L6 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 BGA925L6 against these jammers. 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 ever growing demand to integrate more and more functionality into one device leads to many challenges when transmitter/receiver has to work simultaneously without degrading the performance of each other. In today's smart-phones a GNSS receiver simultaneously co-exists with transceivers in the GSM/EDGE/UMTS/LTE bands. These 3G/4G transceivers transmit high power in the range of +24 dBm which due to insufficient isolation couple to the GNSS receiver. The cellular signals can mix to produce Intermodulation products exactly in the GNSS receiver frequency band. For example, GSM 1712.7 MHz mixes with UMTS 1850 MHz to produce third-order-product exactly at GPS, LTE Band-13 2nd harmonic falls into GPS band, GSM 827/897 MHz mixes with WLAN 2402/2472 MHz to produce second-order-product at GPS.

The jamming resistance of BGA925L6 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 BGA925L6. 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 L2-C1/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 BGA925L6 is presented in Figure 2. Table 1 shows the pin assignment of BGA925L6. Table 2 shows the truth table to turn on/off BGA925L6 by applying different voltage to the PON pin.

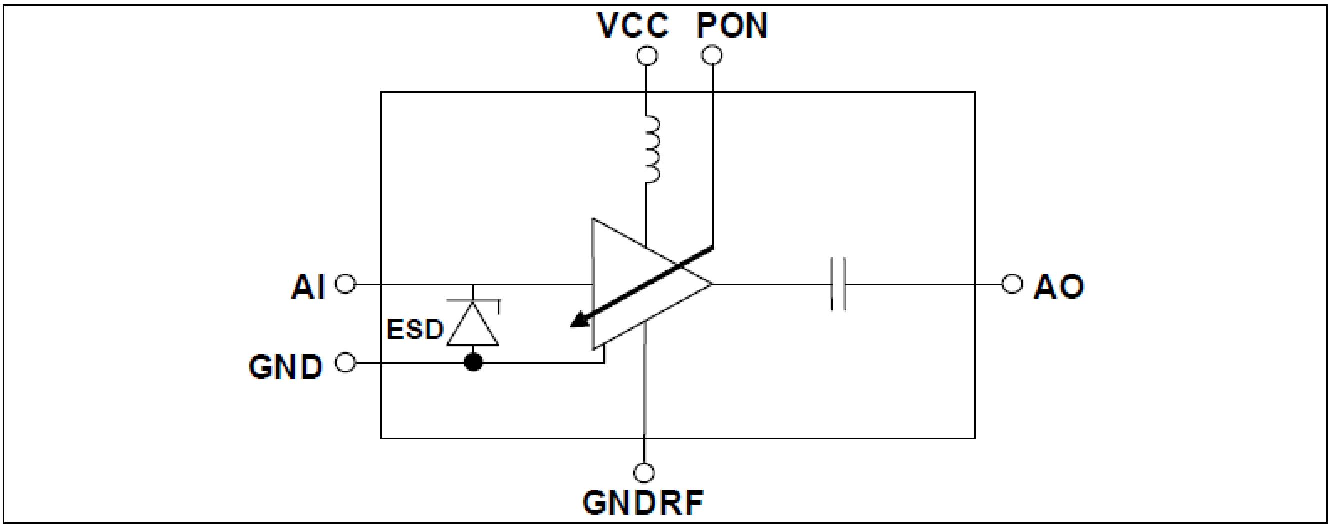

Figure 2 Block diagram of the BGA925L6 for GNSS band 1559-1615MHz applications

Table 1 Pin Definition

Pin	Symbol	Comment
1	GND	General ground
2	VCC	DC supply
3	AO	LNA output
4	GNDRF	LNA RF ground
5	AI	LNA input
6	PON	Power on control

Table 2 Switching Mode

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

3 Application Circuit

3.1 Schematic Diagram

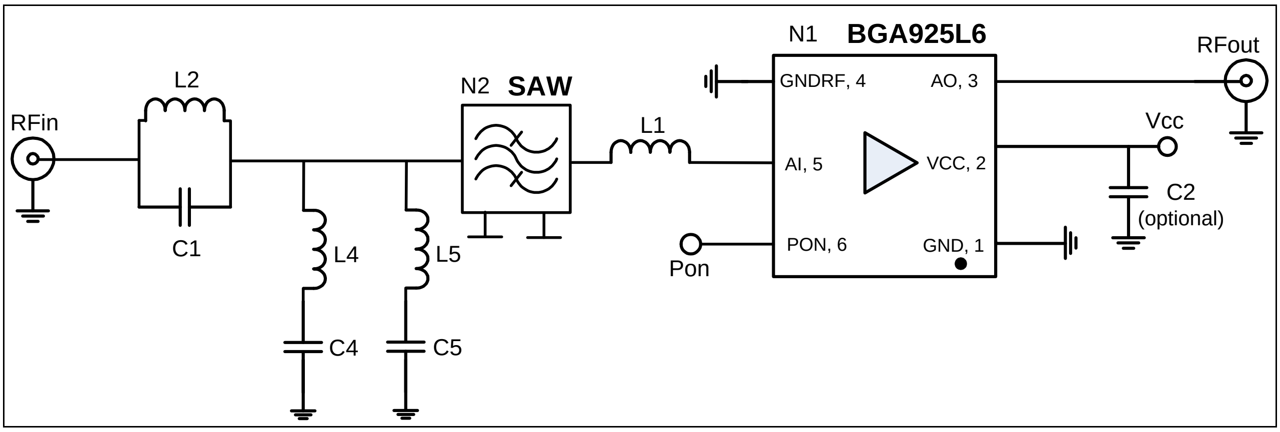

Figure 3 BGA925L6 application circuit for improved rejection of out-of-band jammers

Table 3 Bill-of-Materials

Symbol	Value	Unit	Package	Manufacturer	Comment
C2 (optional)	10	nF	0201	Various	RF bypass
L1	6.8	nH	0201	Murata LQP series	Matching between SAW and LNA
L2	4.3	nH	0201	Murata LQP series	750-950 MHz Notch
C1	9.0	pF	0201	Various	750-950 MHz Notch
L4	4.7	nH	0201	Murata LQP series	750-950 MHz Notch
C4	7.0	pF	0201	Various	750-950 MHz Notch
L5	3.3	nH	0201	Murata LQP series	2.45 GHz Notch
C5	1.0	pF	0201	Various	2.45 GHz Notch
N1	BGA925L6		TSLP-6-2	Infineon	SiGe:C LNA
N2[1]	SAW		TSNP-7-10		SAW filter of BGM1033N7 used in this application circuit
PCB substrate	FR4				

[1] Please contact Infineon regarding the external SAW filter used in this application circuit

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	5.0		mA	
Navigation System	Sys	GPS	GLONASS		
Frequency Range	Freq	1575.42	1598-1606	MHz	
Gain	G	14.7	14.4	dB	
Noise Figure	NF	1.95	2.37	dB	PCB and SMA connector losses of 0.06 dB substracted
Input Return Loss	RLin	17.6	18.4	dB	
Output Return Loss	RLout	29.7	20.6	dB	
Reverse Isolation	IRev	22.8	22.9	dB	
Input P1dB	IP1dB	-6.5	-6.2	dBm	f_{gps} = 1575.42 MHz $f_{GLONASS}$ = 1605 MHz
Output P1dB	OP1dB	7.2	7.2	dBm	
Input IP3 In-band	IIP3	-2.5	-2.0	dBm	
Output IP3 In-band	OIP3	12.2	12.4	dBm	f_{1gps} = 1575.5 MHz, f_{2gps} = 1576.5 MHz $f_{1GLONASS}$ = 1602 MHz, $f_{2GLONASS}$ = 1603 MHz Input power = -30 dBm
LTE band-13 2nd Harmonic	H2	-92.3		dBm	f_{IN} = 787.76 MHz, P_{IN} = +15 dBm; f_{H2} = 1575.52 MHz
Output IM2 Out-of-band	IM2	-114.1		dBm	f_1 = 827 MHz, P_{1IN} = +12 dBm; f_2 = 2402 MHz, P_{2IN} = +8 dBm f_{IM2} = 1575 MHz
Output IM2 Out-of-band	IM2	-111.6		dBm	f_1 = 897 MHz, P_{1IN} = +12 dBm; f_2 = 2472 MHz, P_{2IN} = +8 dBm f_{IM2} = 1575 MHz
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 f_{IIP3} = 1575.4 MHz
Stability	k	>1		--	Unconditionally 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	5.2		mA	
Navigation System	Sys	GPS	GLONASS		
Frequency Range	Freq	1575.42	1598-1606	MHz	
Gain	G	14.8	14.5	dB	
Noise Figure	NF	1.96	2.39	dB	PCB and SMA connector losses of 0.06 dB substracted
Input Return Loss	RLin	18.5	19.1	dB	
Output Return Loss	RLout	24.6	22.8	dB	
Reverse Isolation	IRev	23.2	23.3	dB	
Input P1dB	IP1dB	-5.3	-4.9	dBm	f_{gps} = 1575.42 MHz $f_{GLONASS}$ = 1605 MHz
Output P1dB	OP1dB	8.5	8.6	dBm	
Input IP3 In-band	IIP3	-2.4	-1.9	dBm	
Output IP3 In-band	OIP3	12.4	12.6	dBm	f_{1gps} = 1575.5 MHz, f_{2gps} = 1576.5 MHz $f_{1GLONASS}$ = 1602 MHz, $f_{2GLONASS}$ = 1603 MHz Input power = -30 dBm
LTE band-13 2nd Harmonic	H2	-92.8		dBm	f_{IN} = 787.76 MHz, P_{IN} = +15 dBm; f_{H2} = 1575.52 MHz
Output IM2 Out-of-band	IM2	-114.3		dBm	f_1 = 827 MHz, P_{1IN} = +12 dBm; f_2 = 2402 MHz, P_{2IN} = +8 dBm f_{IM2} = 1575 MHz
Output IM2 Out-of-band	IM2	-111.9		dBm	f_1 = 897 MHz, P_{1IN} = +12 dBm; f_2 = 2472 MHz, P_{2IN} = +8 dBm f_{IM2} = 1575 MHz
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 f_{IIP3} = 1575.4 MHz
Stability	k	>1		--	Unconditionally Stable from 0 to 10GHz

5 Measured Graphs for GPS and GLONASS bands

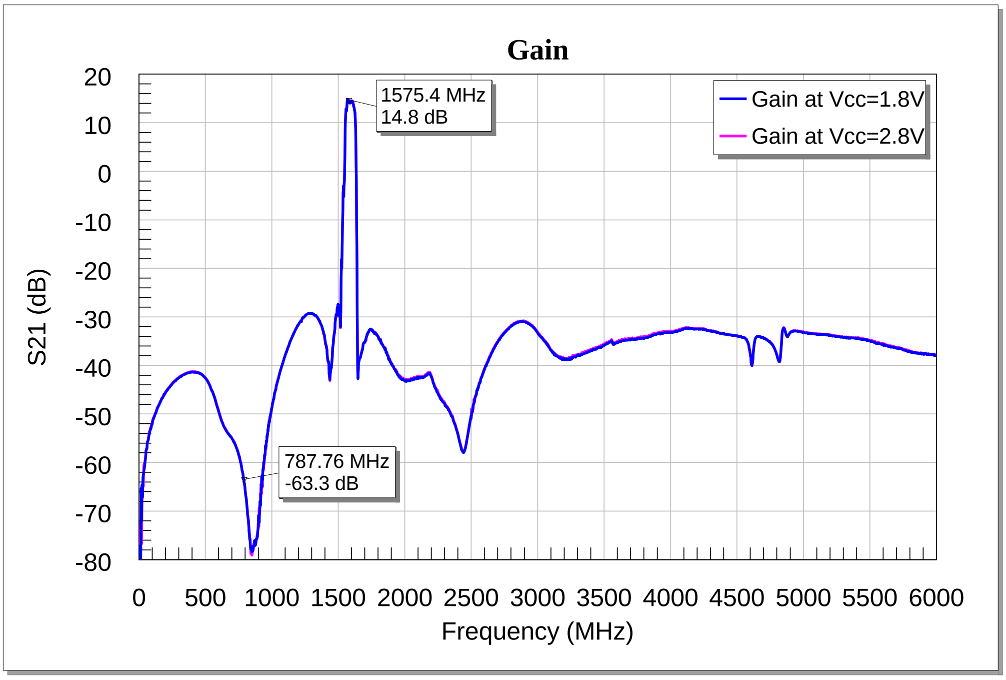

Figure 4 Wideband Power gain of BGA925L6

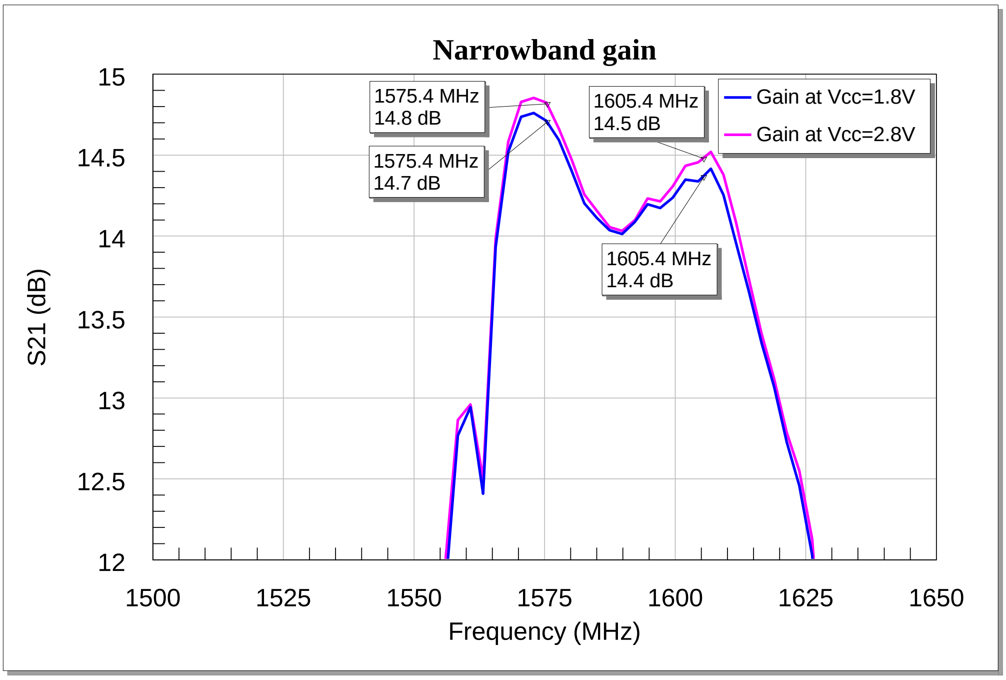

Figure 5 Narrowband power gain of BGA925L6 for GPS and GLONASS bands

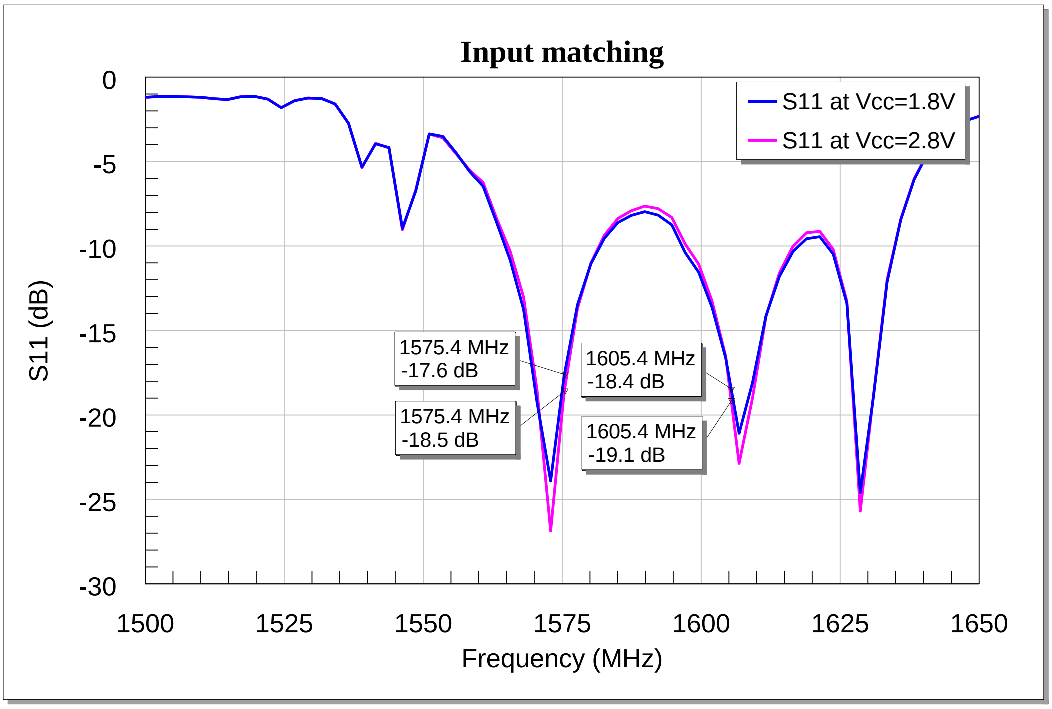

Figure 6 Input matching of BGA925L6 for GPS and GLONASS bands

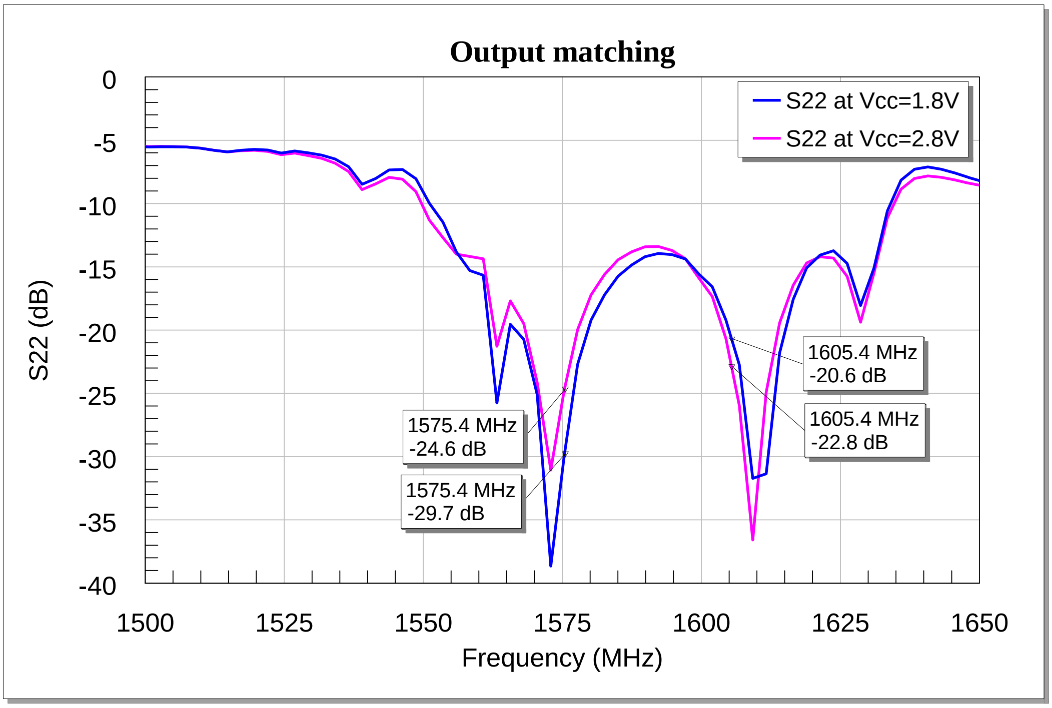

Figure 7 Output matching of BGA925L6 for GPS and GLONASS bands

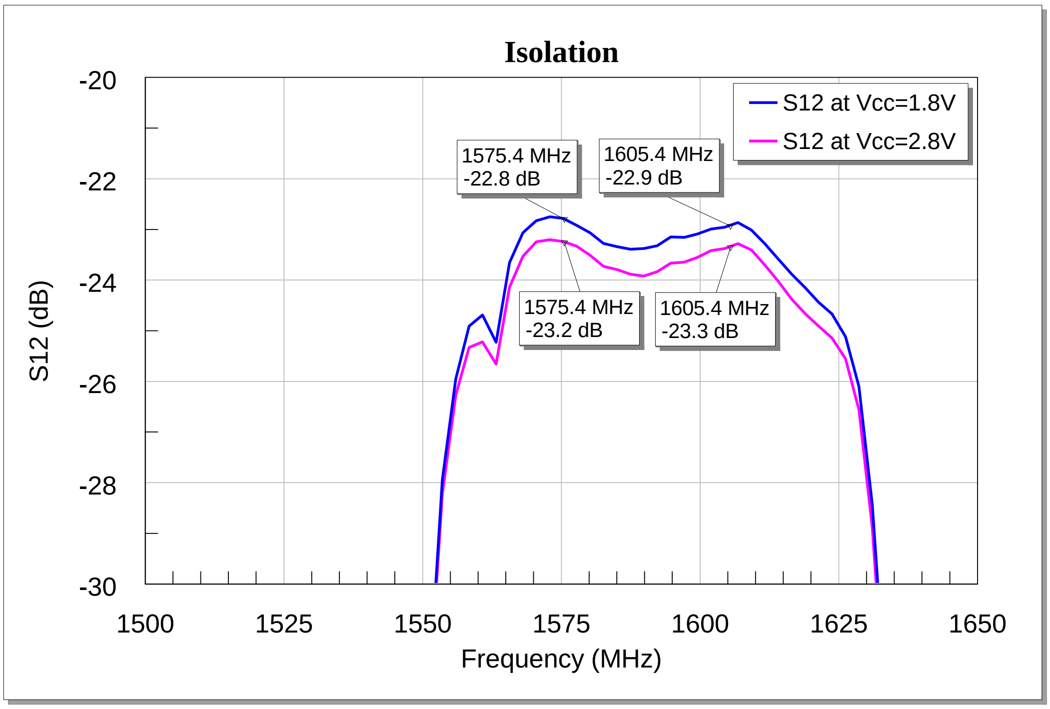

Figure 8 Reverse isolation of BGA925L6 for GPS and GLONASS bands

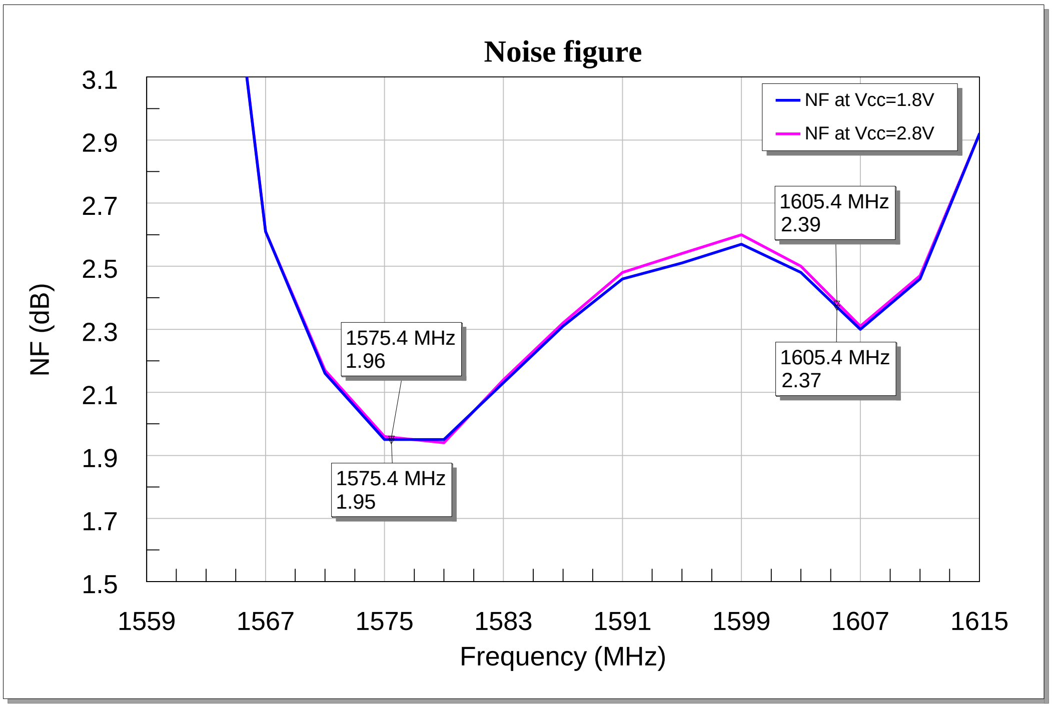

Figure 9 Noise figure of BGA925L6 for GPS and GLONASS bands

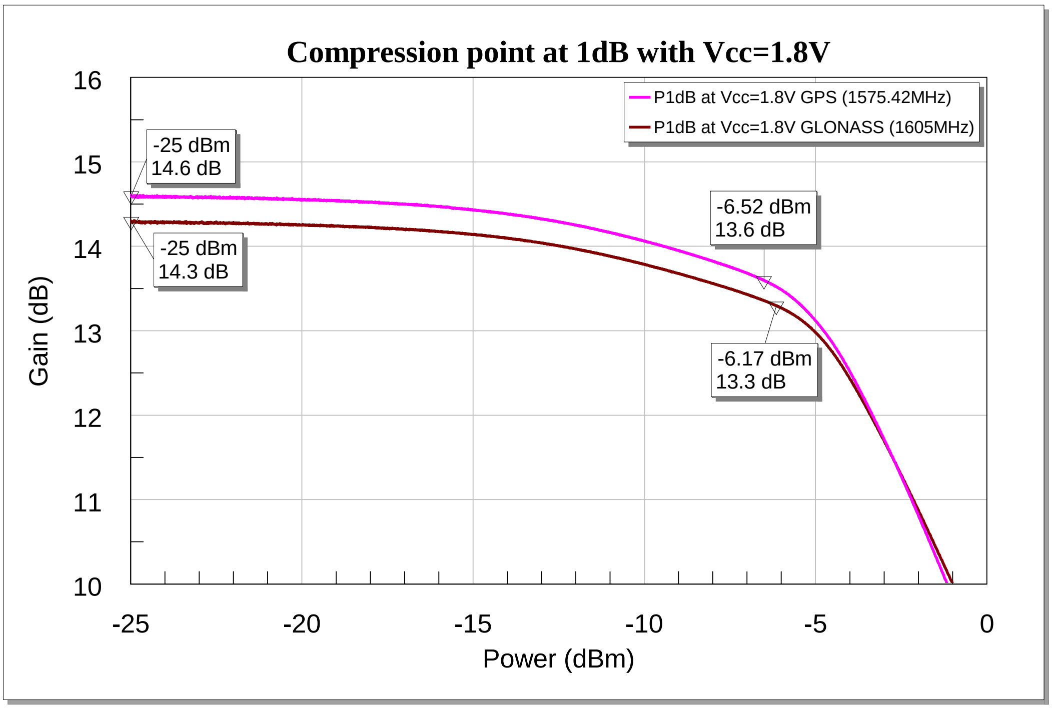

Figure 10 Input 1 dB compression point of BGA925L6 at supply voltage of 1.8V for GPS and GLONASS bands

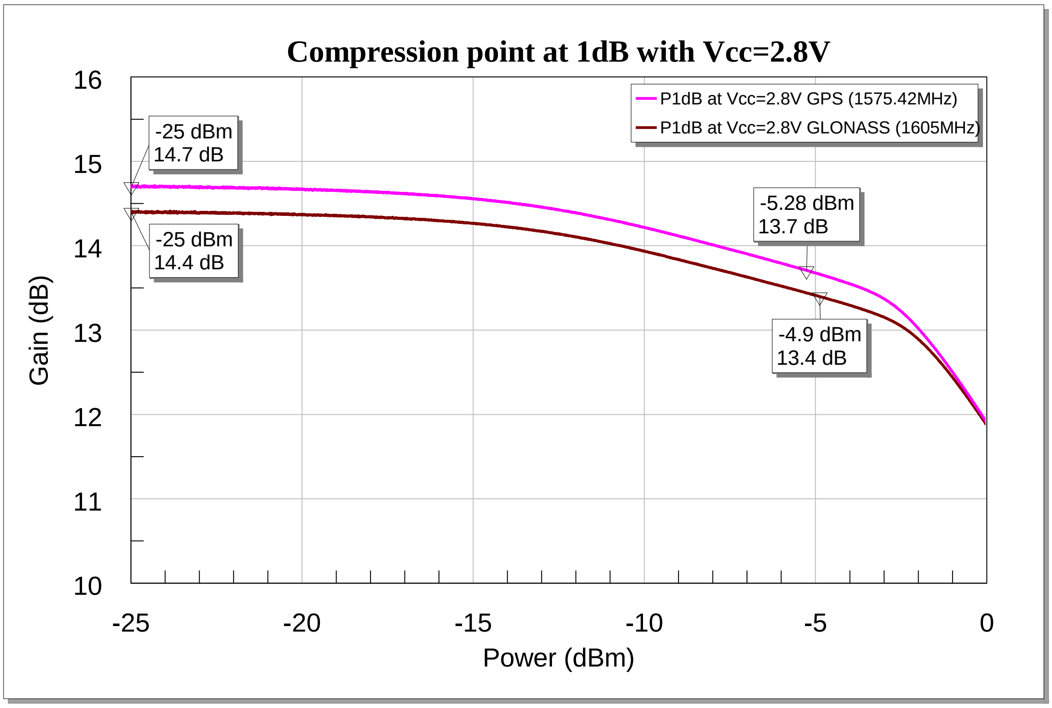

Figure 11 Input 1 dB compression point of BGA925L6 at supply voltage of 2.8V for GPS and GLONASS bands

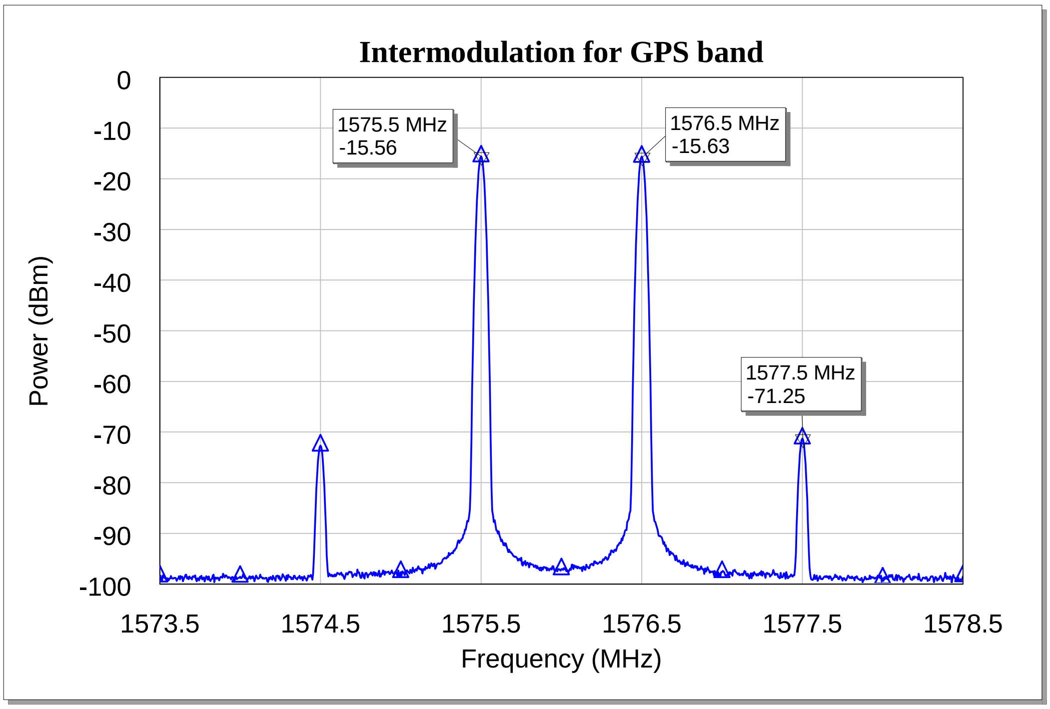

Figure 12 Carrier and intermodulation products of BGA925L6 for GPS band at Vcc=1.8V

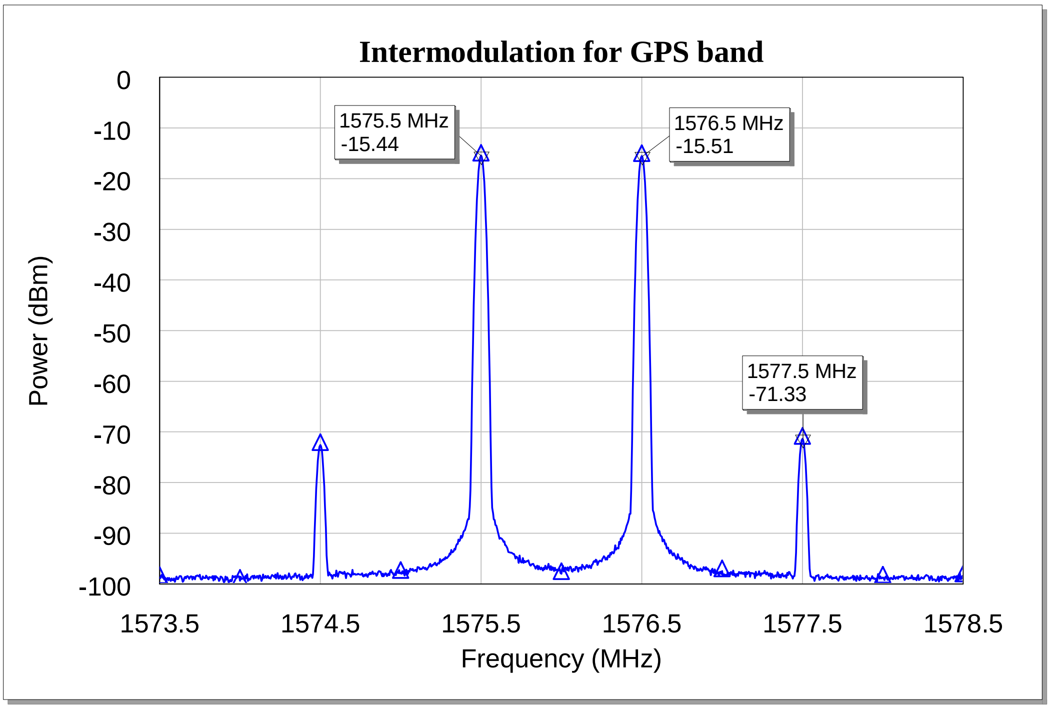

Figure 13 Carrier and intermodulation products of BGA925L6 for GPS band at Vcc=2.8V

6 Miscellaneous Measured Graphs

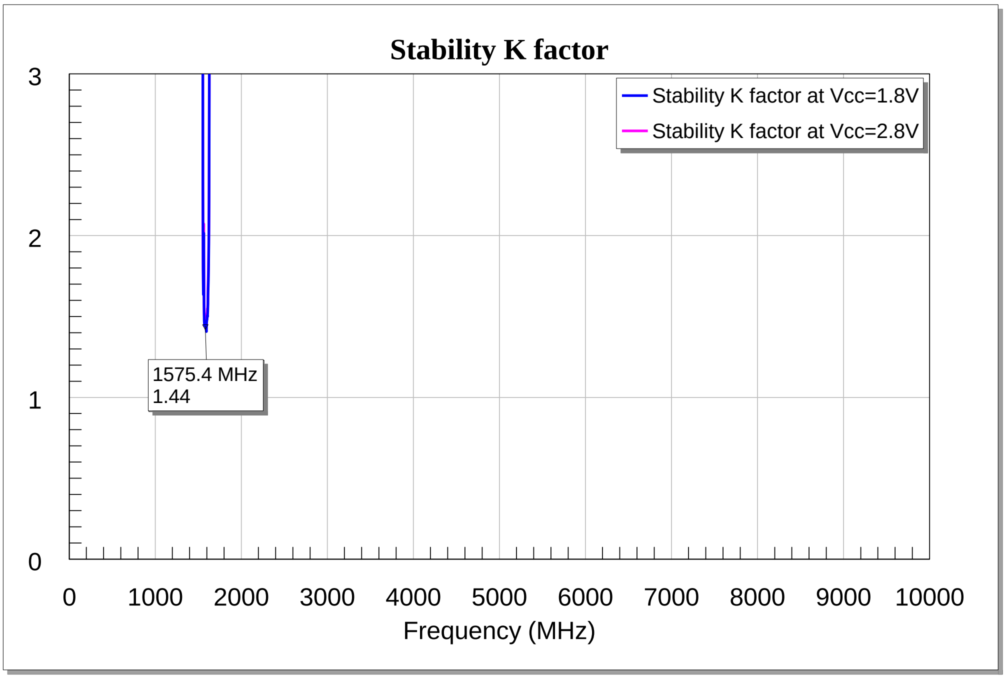

Figure 14 Stability factor k of BGA925L6 upto 10GHz

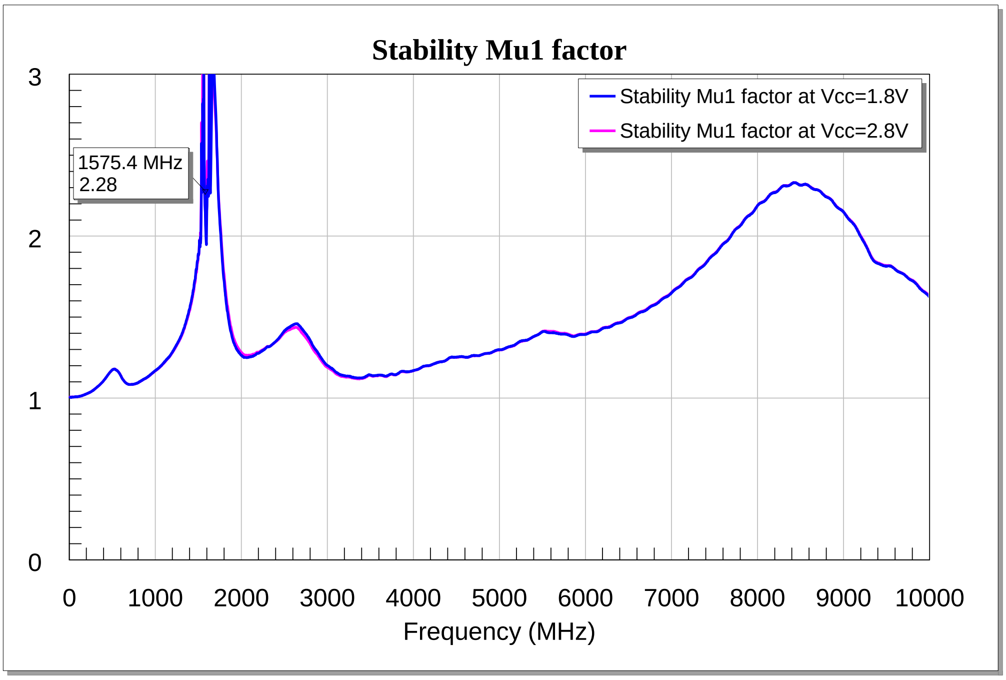

Figure 15 Stability factor μ1 of BGA925L6 upto 10GHz

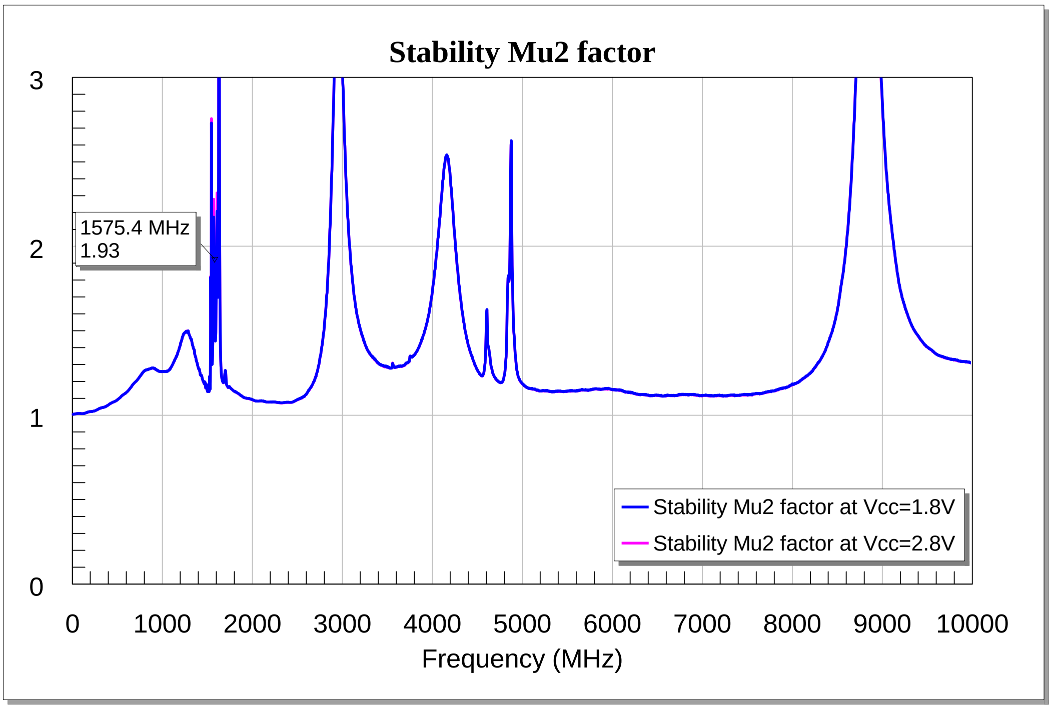

Figure 16 Stability factor μ2 of BGA925L6 upto 10GHz

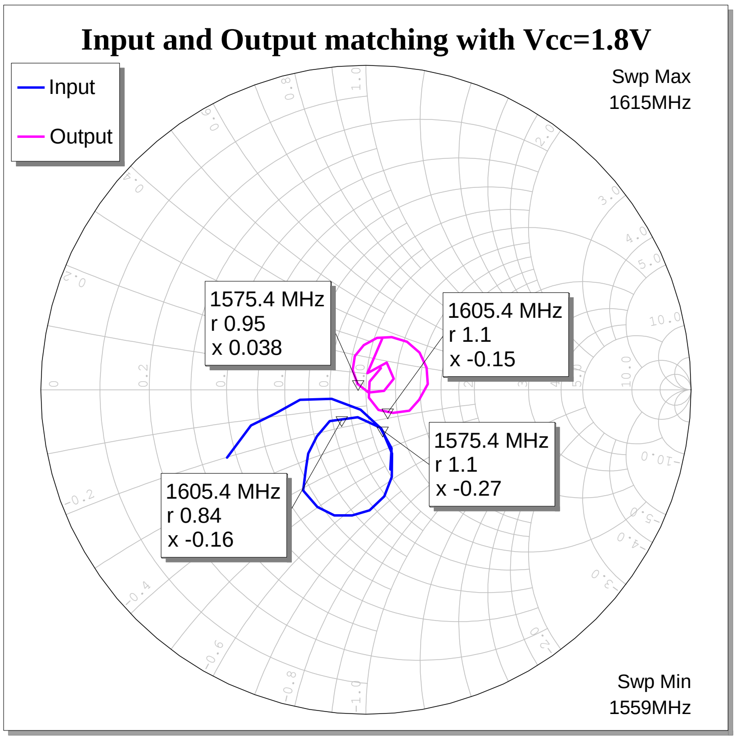

Figure 17 Input and output matching for GPS and GLONASS bands with Vcc=1.8V

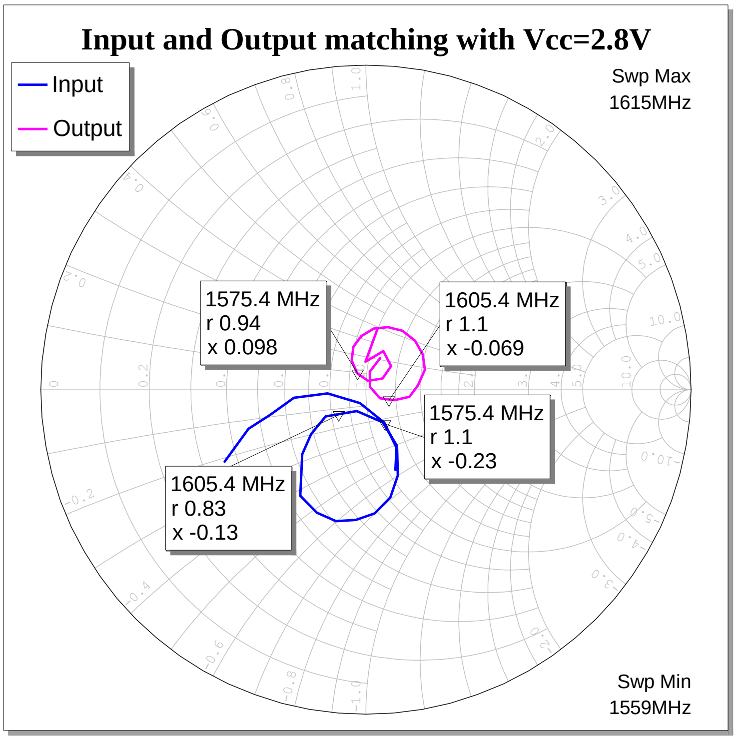

Figure 18 Input and output matching for GPS and GLONASS bands with Vcc=2.8V

7 Evaluation Board

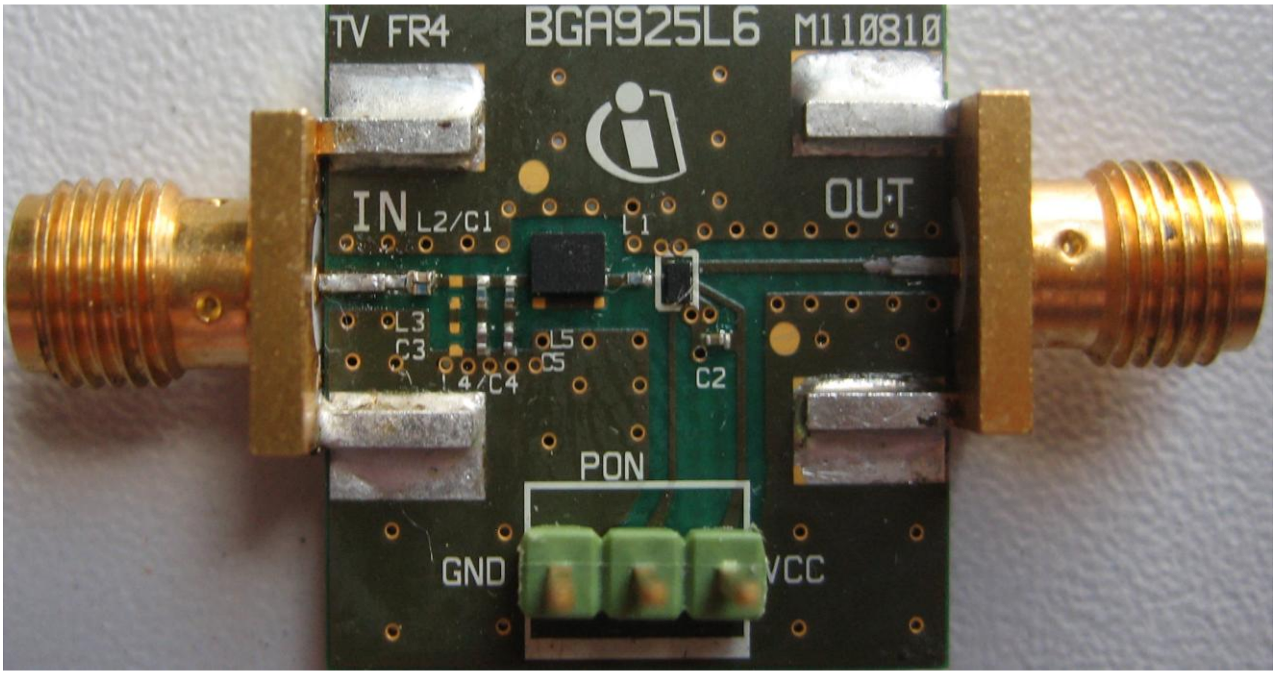

Figure 19 Populated PCB picture of BGA925L6

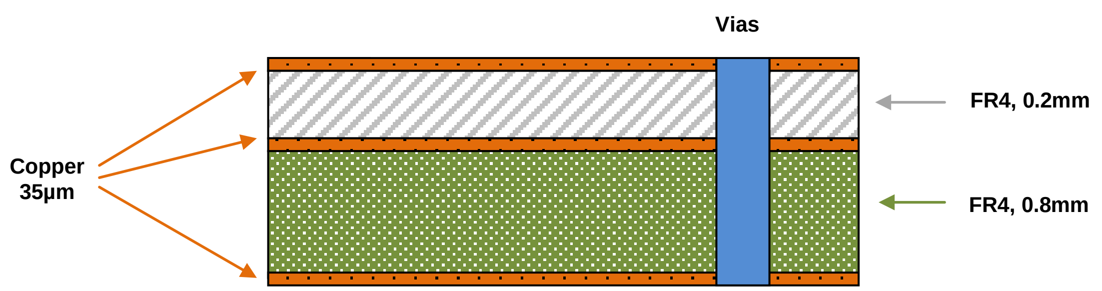

Figure 20 PCB layer stack

8 Authors

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