BGM1034N7

High Gain Front-End Module for Global Navigation Satellite Systems (GNSS) Application Using High-Q Inductors

Application Note AN269

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RF and Protection Devices

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Application Note AN269
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Previous Revision: Rev. 1.1, 2011-09-16

Page	Subjects (major changes since last revision)
11-12	GLONASS measurement results added

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1 BGM1034N7 GPS and GLONASS Front-End Module

1.1 Features

- Operating frequency: 1575.42 MHz and 1598.06-1605.38 MHz
- High Gain: 17.0 dB
- Low Noise Figure (GPS): 1.7 dB
- Low current consumption: 3.9 mA
- Out-of-band rejection in cellular bands: > 43dBc
- Input compression point in cellular bands: 22dBm
- Supply voltage: 1.5 V to 3.6 V
- Tiny TSNP-7-10 leadless package (2.3 x 1.7 x 0.73 mm^3)
- RF output internally matched to 50 Ω
- IEC ESD contact discharge of RF input pin: 6 kV
- Only 3 external SMD parts
- RoHS compliant package (Pb-free)

Figure 1 BGM1034N7 in TSNP-7-10 Package

1.2 Applications

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

- GLONASS (Globalnaya Navigatsionnaya Sputnikovaya Sistema) working in the L1 band from 1598.06 MHz to 1605.38 MHz

2 Introduction

Global Navigation Satellite System or GNSS receiver, as we know, works on the reception of location based information from satellite signals. There are several standards worldwide like GPS, GLONASS, Galileo and COMPASS Bei Du. However, the power levels of the satellite signals received, can be lower than -130 dBm. This poses a challenge on the sensitivity of the GNSS receiver. Along with this, the ever growing disturbing or jamming signals in the adjacent cellular bands makes the design of the receiver front-end even more difficult. The rapidly growing market for GNSS systems is driving the design of advanced and high-performance GNSS receivers. A simple overview of the GNSS RF system in a mobile phone or other handheld devices is shown in **Figure 2**.

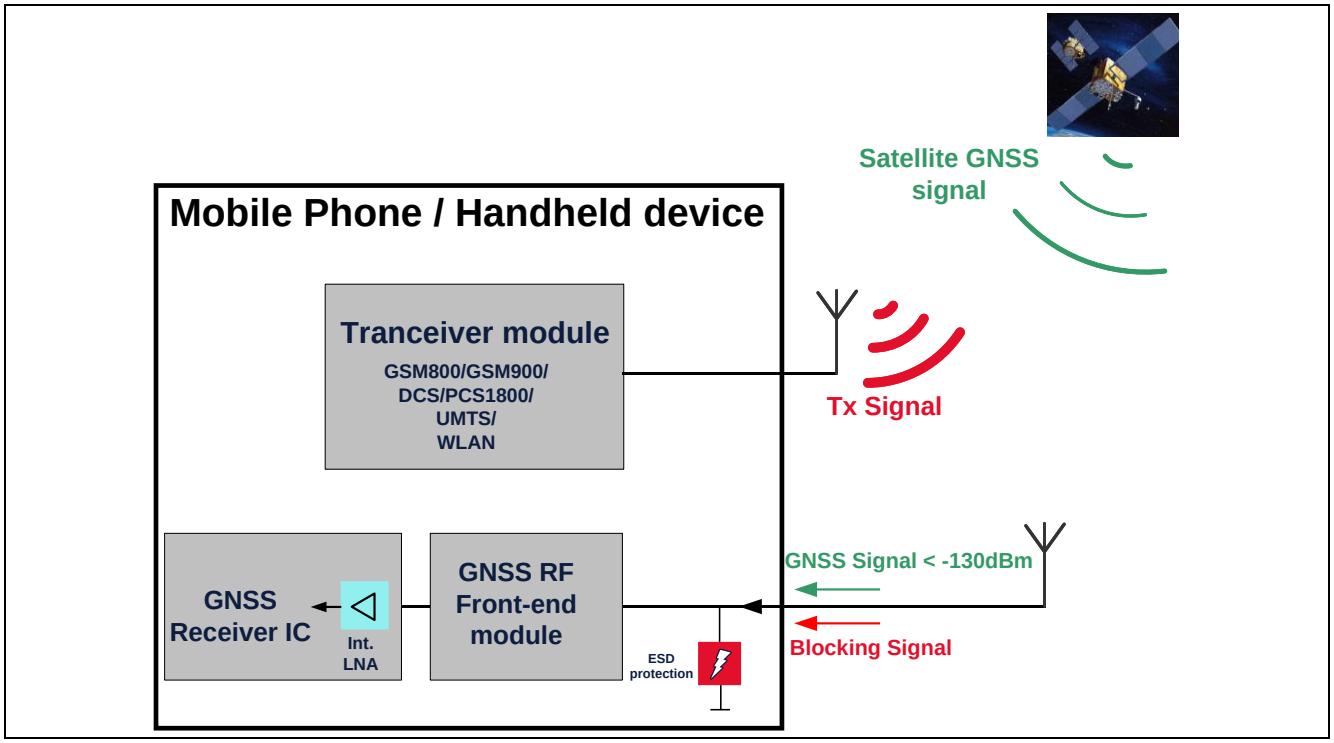

Figure 2 RF System Overview: Mobile Phone

GNSS receivers for mobile or handheld applications are always under the threat of high power cellular signals. Due to the coexistence of GNSS and Cellular services, there is a strong coupling of the DCS/PCS and Cellular signals to the GNSS receiver. The performance of a standard integrated GNSS receiver chip cannot meet the specifications required for the present systems. An external RF front-end is essential to achieve this required performance. The most important prerequisites for the front-end of a GNSS receiver are low noise figure and sufficient amplification of the desired signal together with high attenuation of the jamming signals.

2.1 Systems overview of a GNSS receiver

Several configurations can be adopted for a GNSS receiver chain. In all configurations, as mentioned earlier, a RF front-end like BGM1034N7 is placed between the antenna and the GNSS receiver chip. Mobile/portable devices as well as personal navigation devices request decreasing form factor used by the implementation of the GNSS function in the devices. BGM1034N7 supports the designers to minimize the area in the front-end. Such a configuration is shown in **Figure 3**. The BGM1034N7 can also be used for the active antenna module.

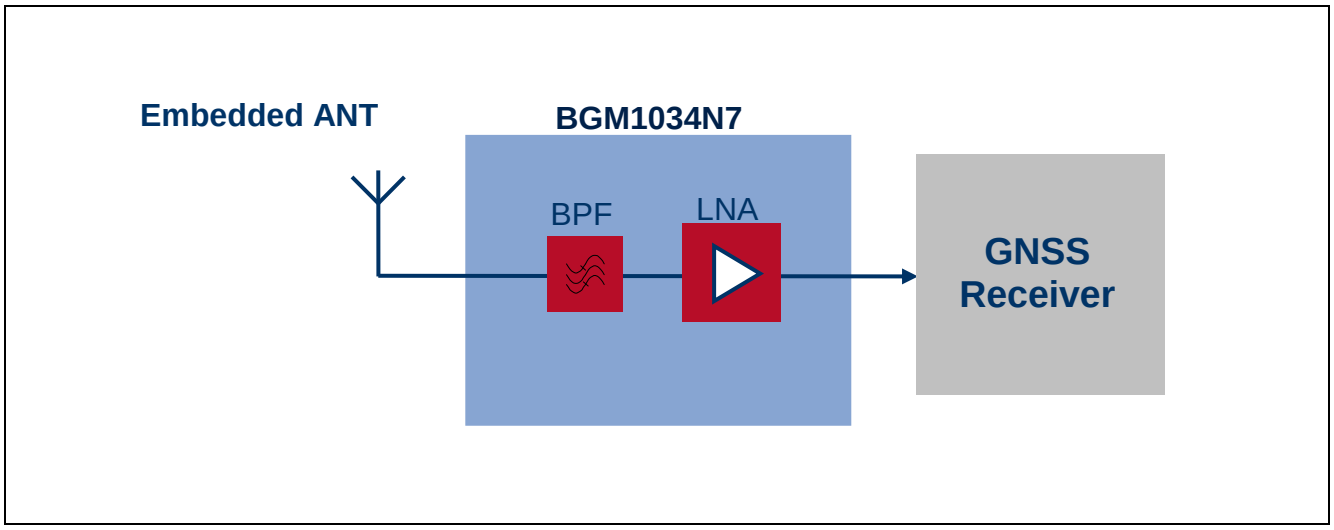

Figure 3 GNSS system with integrated GNSS FEM BGM1034N7 for mobile/portable and personal navigation devices

3 Description

The BGM1034N7 is a combination of a low-insertion-loss pre-filter with Infineon's high performance low noise amplifier (LNA) for Global Positioning System (GPS) and Globalnaya Navigatsionnaya Sputnikovaya Sistema (GLONASS) applications. Both, GPS and GLONASS frequency bands, can be used at the same time. Through the low insertion loss of the filter, the BGM1034N7 provides 17 dB gain, 1.7 dB noise figure and high linearity performance. In addition BGM1034N7 provides very high out-of-band attenuation in conjunction with a high input compression point. It can withstand IEC61000-4-2 ESD contact discharge at the RF input as high as 6 kV in the application circuit shown in **Figure 4**. Its current consumption is as low as 3.9 mA. It operates over the 1.5 V to 3.6 V supply voltage range.

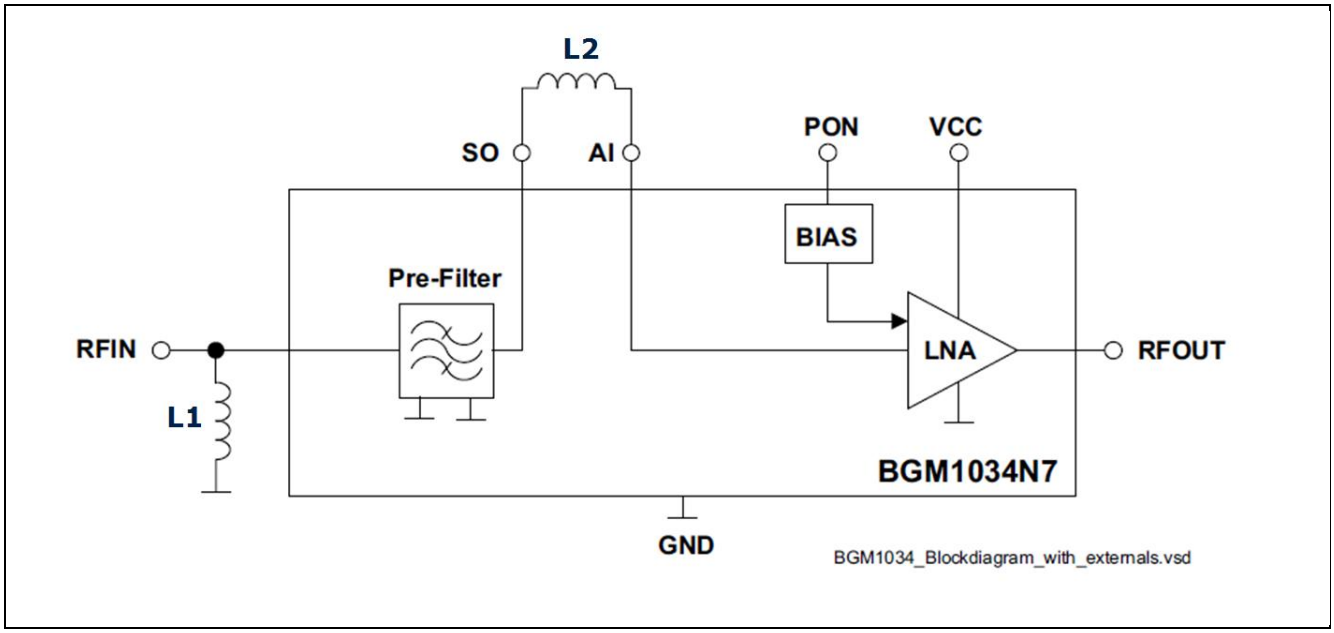

Figure 4 Block Diagram of BGM1034N7

4 Application Circuit and Block Diagram

The BGM1034N7 is internally matched at the output to 50 Ohm. The LNA bias circuitry is also integrated on chip. Therefore, only three external components are required in the application. The application schematic is shown in **Figure 5** and the function of the external passives is listed in **Table 2**.

4.1 Application Schematic

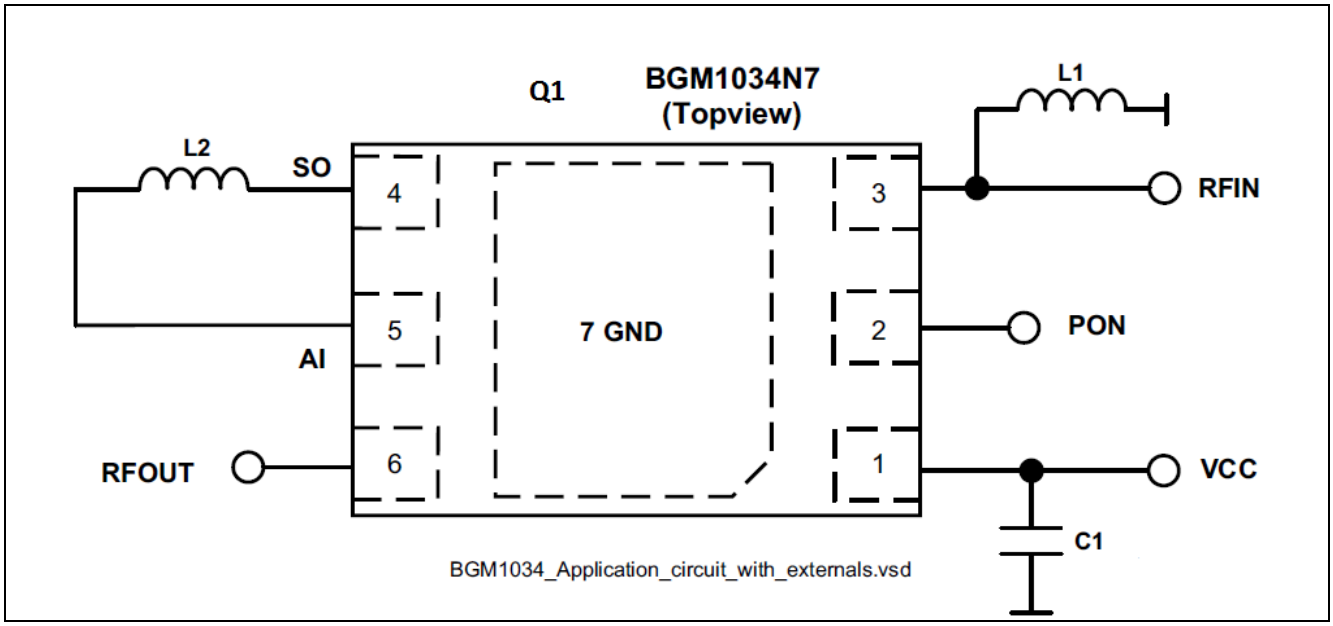

Figure 5 Schematic diagram of the BGM1034N7 application circuit

Table 1 Pin Assignment of BGM1034N7

Pin No.	Symbol	Function
1	VCC	Power Supply
2	PON	Power ON/OFF
3	RFIN	RF Input
4	SO	Pre-Filter Output
5	AI	LNA Input
6	RFOUT	RF Output
7	GND	DC ground

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	0.1	µF	0402	Various	Supply filtering
L1	8.2	nH	0402	Murata LQW15A	Matching / ESD Inductor
L2	8.2	nH	0402	Murata LQW15A	Matching Inductor
Q1	BGM1034N7		TSNP-7-10	Infineon	GPS/GLONASS FEM

5 Measurement Results

Measurement results of the BGM1034N7 are presented in this section. The measurements are performed on the Infineon application board at room temperature. The performances of the BGM1034N7 are here provided for the voltage of 1.8V (**Table 3**) and 2.8V (**Table 4**). The data exclude PCB and SMA connector losses, unless otherwise mentioned.

Table 3 Electrical Characteristics (at room temperature), Vcc = Vpon = 1.8 V

Parameter	Symbol	Value		Unit	Comment/Test Condition
DC Voltage	Vcc	1.8		V	
DC Current	Icc	4.1		mA	
Navigation System	Sys	GPS	GLONASS		
Frequency Range	Freq	1575.42	1598-1606	MHz	
Gain	G	16.8	16.5	dB	
Noise Figure	NF	1.58	1.95	dB	PCB and SMA connectors of 0.1 dB losses substracted
Input Return Loss	RLin	16.2	12.2	dB	
Output Return Loss	RLout	12.6	16.2	dB	
Reverse Isolation	IRev	33.0	34.5	dB	
Input P1dB	IP1dB	-13.5	-13.0	dBm	f_{gps} = 1575.42 MHz $f_{GLONASS}$ = 1605 MHz
Output P1dB	OP1dB	2.3	2.5	dBm	
Input IP3 In-band	IIP3	-9.0	-8.7	dBm	
Output IP3 In-band	OIP3	7.8	7.8	dBm	f_{1gps} = 1574.5 MHz, f_{2gps} = 1575.5MHz $f_{1GLONASS}$ =1603 MHz, $f_{2GLONASS}$ =1604 MHz $P_{1IN} = P_{2IN}$ = -30 dBm
Rejection 750MHz[1]	Rej_{750M}	56.0		dBc	f = 750 MHz
Rejection 900MHz[1]	Rej_{900M}	55.7		dBc	f = 806 MHz - 928 MHz
Rejection 1800MHz[1]	Rej_{1800M}	49.6		dBc	f = 1710 MHz - 1980 MHz
Rejection 2400MHz[1]	Rej_{2400M}	62.5		dBc	f = 2400 MHz - 2500 MHz
Input P1dB	$IP1dB_{900M}$	22		dBm	f = 900 MHz
Input P1dB	$IP1dB_{1710M}$	26		dBm	f = 1710 MHz
Input IP3 out-of-band	$IIP3_{OOB}$	64.6		dBm	f_1 = 1712.7 MHz, f_2 = 1850 MHz P_{1IN} = +10 dBm, P_{2IN} = +10 dBm
Stability	k	>1		--	Unconditionnally Stable from 0 to 10GHz

[1] Rejection is defined as following: [Gain at 1575.42 MHz] – [Attenuation@stopband frequency

Table 4 Electrical Characteristics (at room temperature), Vcc = Vpon = 2.8 V

Parameter	Symbol	Value		Unit	Comment/Test Condition
DC Voltage	Vcc	2.8		V	
DC Current	Icc	4.2		mA	
Navigation System	Sys	GPS	GLONASS		
Frequency Range	Freq	1575.42	1598-1606	MHz	
Gain	G	16.8	16.5	dB	
Noise Figure	NF	1.58	1.95	dB	PCB and SMA connectors of 0.1 dB losses substracted
Input Return Loss	RLin	15.9	12.2	dB	
Output Return Loss	RLout	12.1	15.4	dB	
Reverse Isolation	IRev	33.0	34.5	dB	
Input P1dB	IP1dB	-13.2	-12.9	dBm	f_{gps} = 1575.42 MHz $f_{GLONASS}$ = 1605 MHz
Output P1dB	OP1dB	2.6	2.6	dBm	
Input IP3 In-band	IIP3	-8.9	-8.3	dBm	
Output IP3 In-band	OIP3	7.9	8.2	dBm	f_{1gps} = 1574.5 MHz, f_{2gps} = 1575.5MHz $f_{1GLONASS}$ =1603 MHz, $f_{2GLONASS}$ =1604 MHz Input power= -30 dBm
Rejection 750MHz[1]	Rej_{750M}	56.0		dBc	f = 750 MHz
Rejection 900MHz[1]	Rej_{900M}	55.7		dBc	f = 806 MHz - 928 MHz
Rejection 1800MHz[1]	Rej_{1800M}	49.6		dBc	f = 1710 MHz - 1980 MHz
Rejection 2400MHz[1]	Rej_{2400M}	62.5		dBc	f = 2400 MHz - 2500 MHz
Input P1dB	$IP1dB_{900M}$	22.0		dBm	f = 900 MHz
Input P1dB	$IP1dB_{1710M}$	26.0		dBm	f = 1710 MHz
Input IP3 out-of-band	$IIP3_{OOB}$	65.1		dBm	f_1 = 1712.7 MHz, f_2 = 1850 MHz P_{1IN} = +10 dBm, P_{2IN} = +10 dBm
Stability	k	>1		--	Unconditionnally Stable from 0 to 10GHz

[1] Rejection is defined as following: [Gain at 1575.42 MHz] – [Attenuation@stopband frequency

6 Measured Graphs for GPS and GLONASS Bands

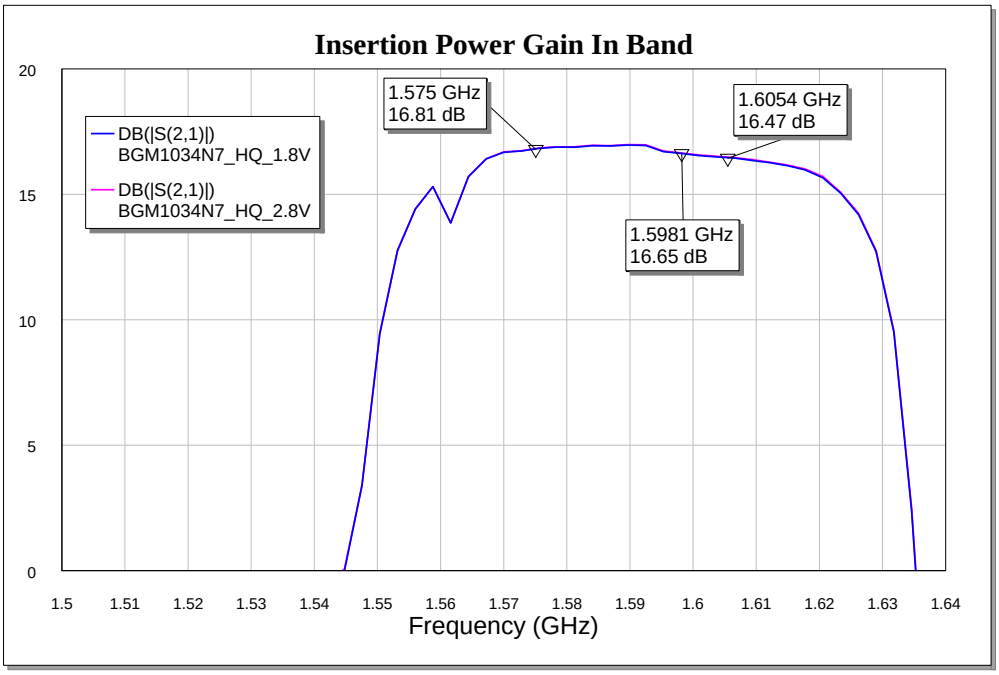

Figure 6 Power Gain of BGM1034N7 for GPS and GLONASS bands

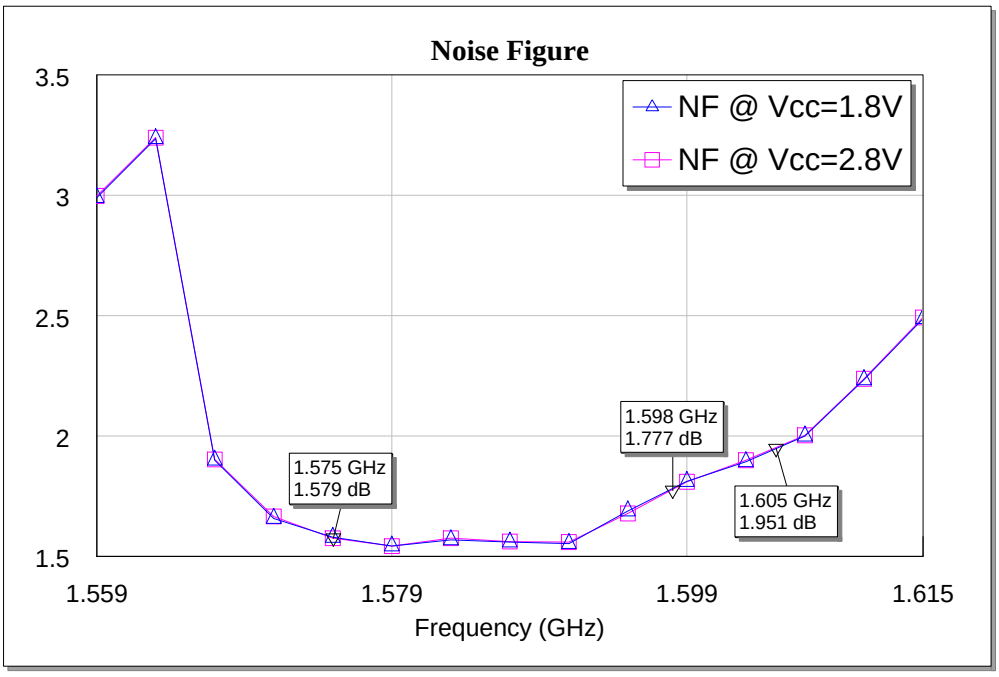

Figure 7 Noise Figure of BGM1034N7 for GPS and GLONASS bands

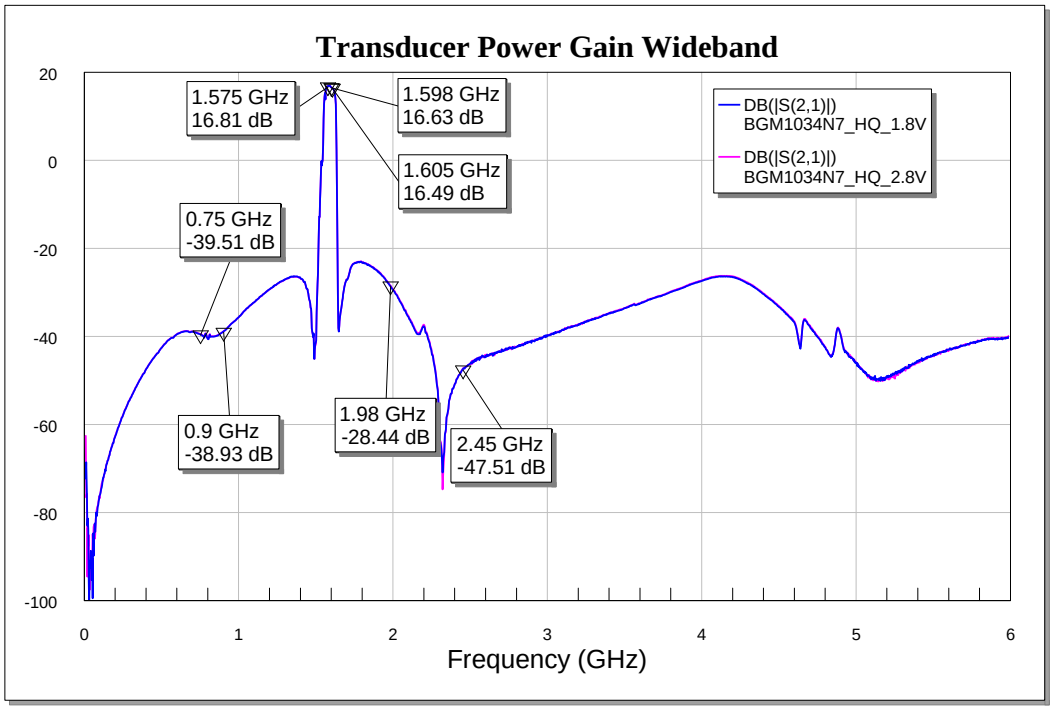

Figure 8 Wideband Insertion Power Gain including out-of-band attenuation of the BGM1034N7

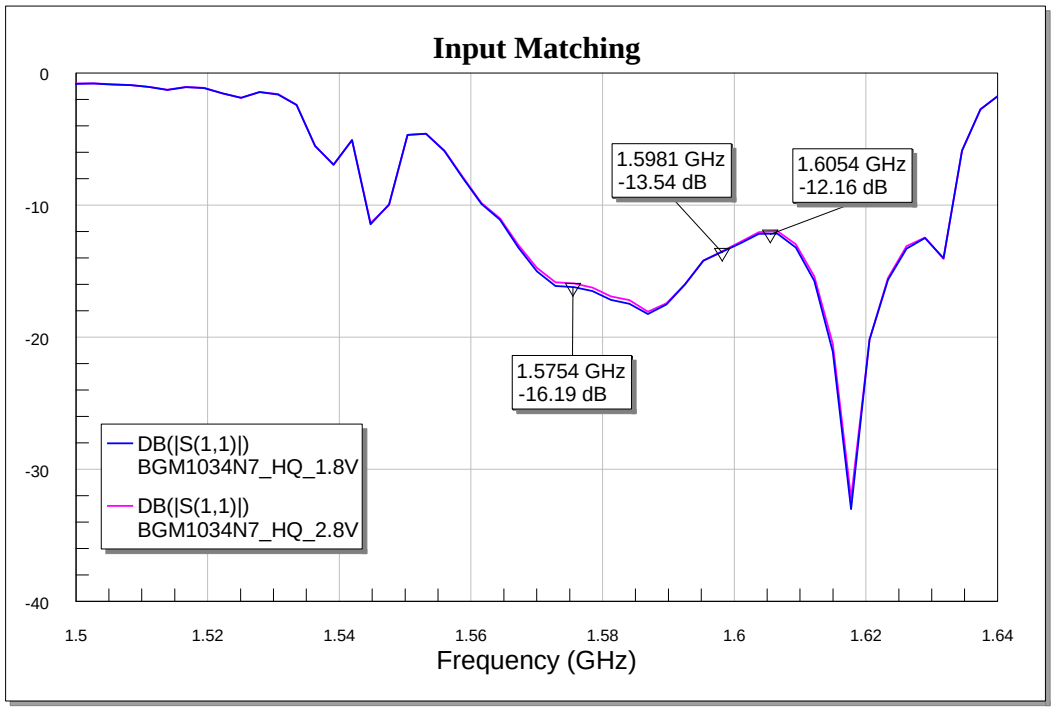

Figure 9 Input Matching of BGM1034N7 for GPS and GLONASS bands

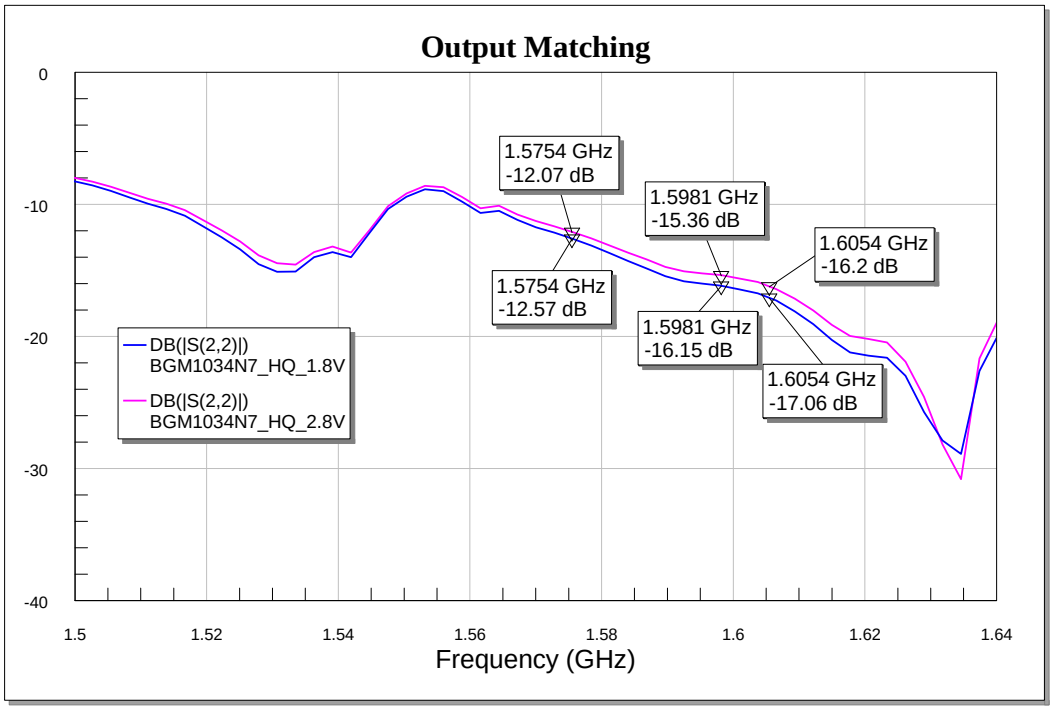

Figure 10 Output Matching of BGM1034N7 for GPS and GLONASS bands

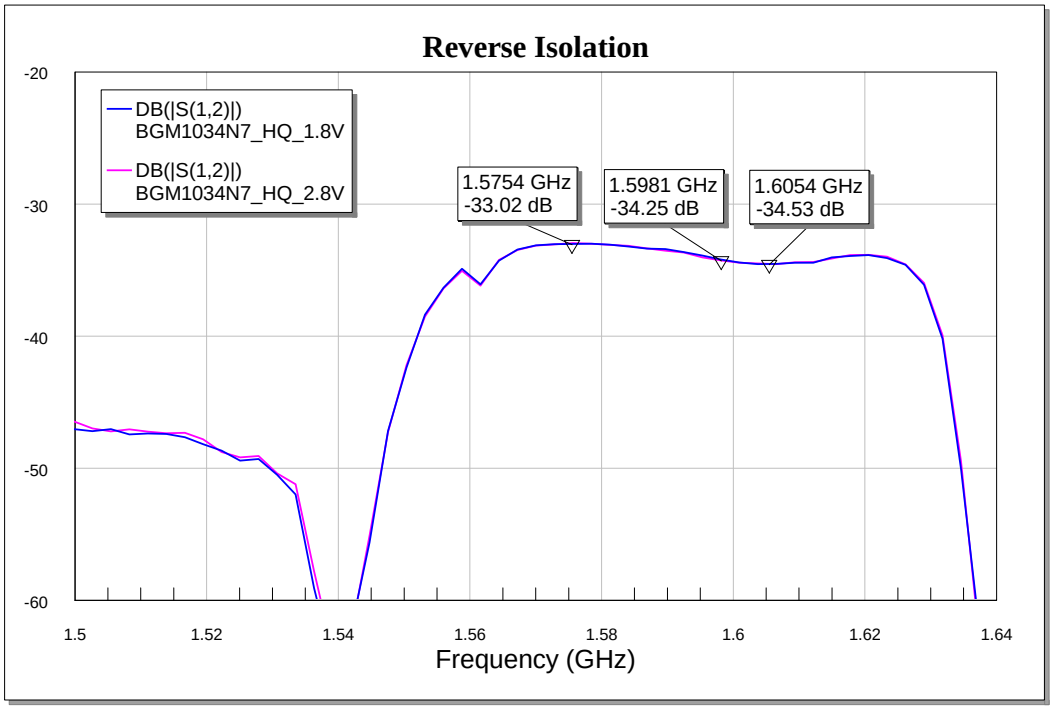

Figure 11 Reverse Isolation of BGM1034N7 for GPS and GLONASS bands

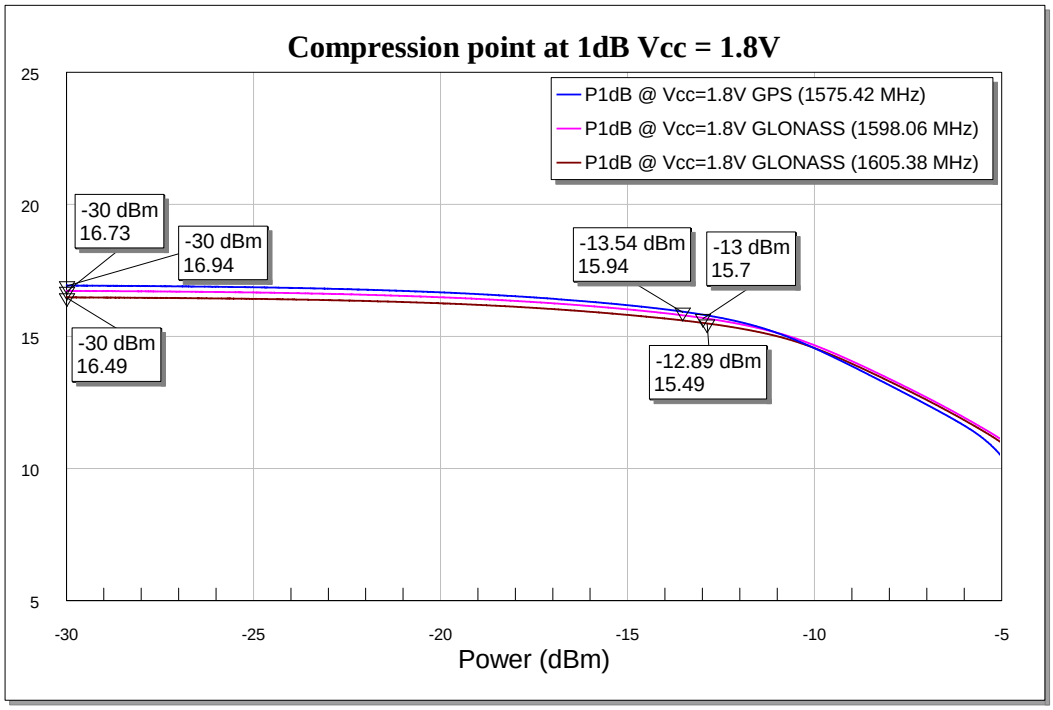

Figure 12 Input 1dB Compression Point of BGM1034N7 at supply voltage of 1.8V for GPS and GLONASS bands

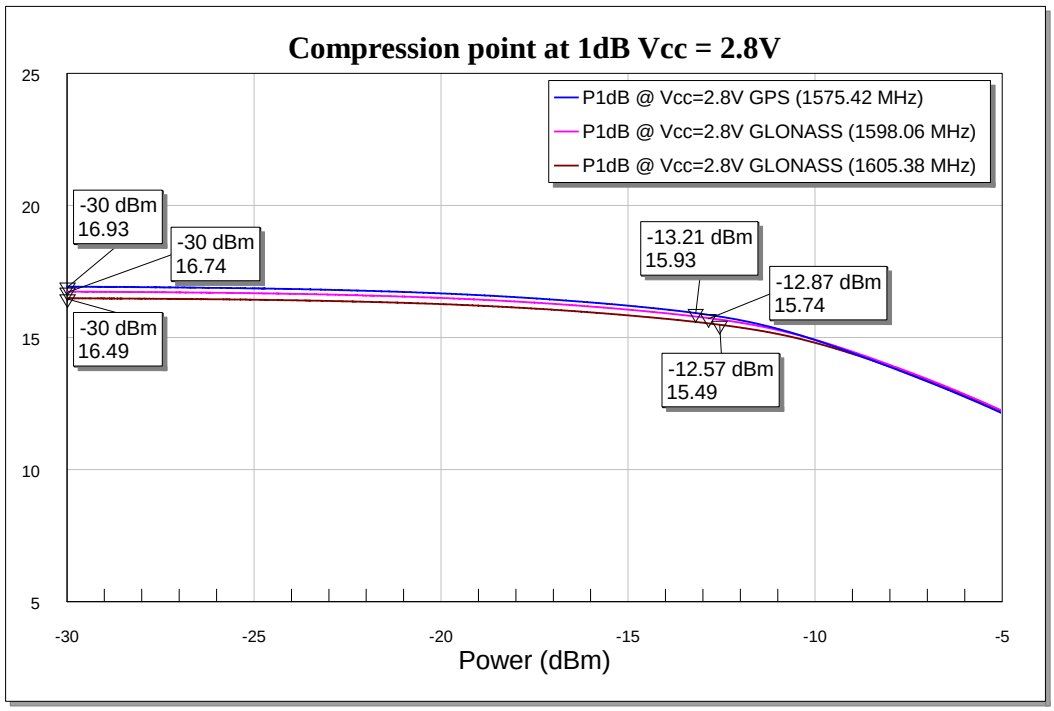

Figure 13 Input 1dB Compression Point of BGM1034N7 at supply voltage of 2.8V for GPS and GLONASS bands

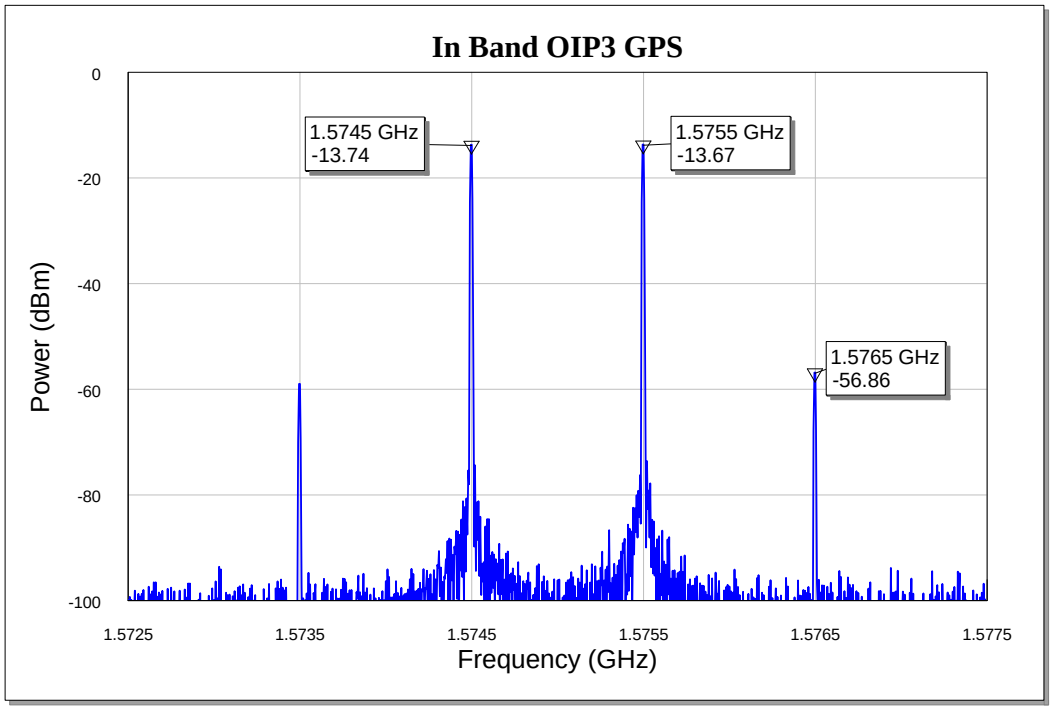

Figure 14 Carrier and intermodulation products of BGM1034N7 for GPS band at Vcc=1.8V

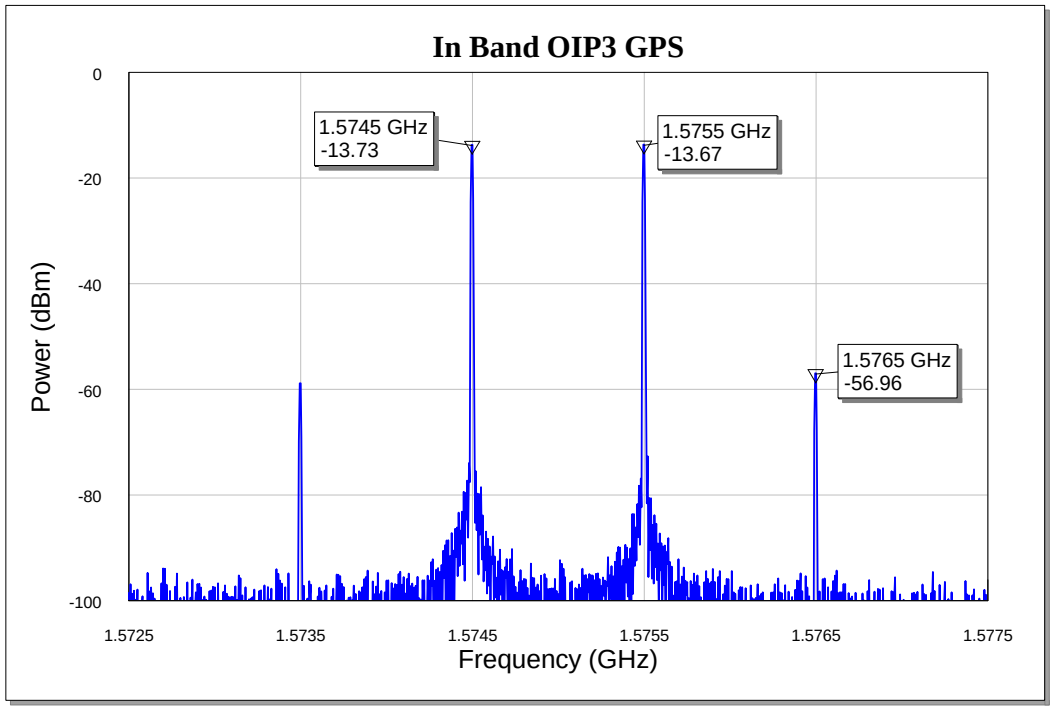

Figure 15 Carrier and intermodulation products of BGM1034N7 for GPS band at Vcc=2.8V

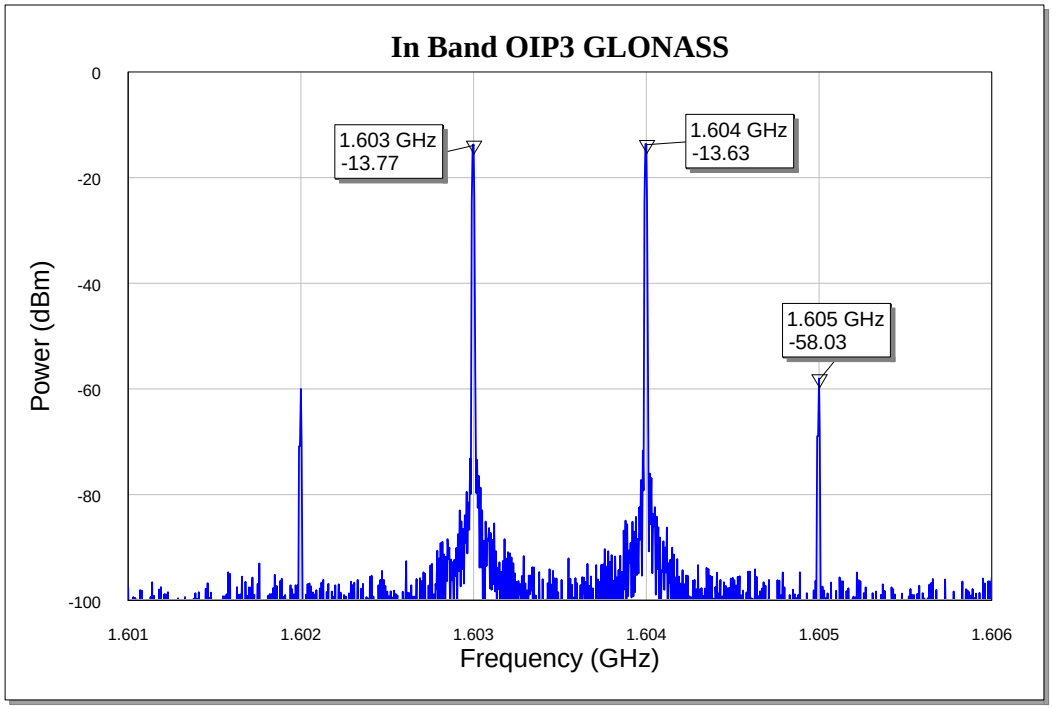

Figure 16 Carrier and intermodulation products of BGM1034N7 for GLONASS band at Vcc=1.8V

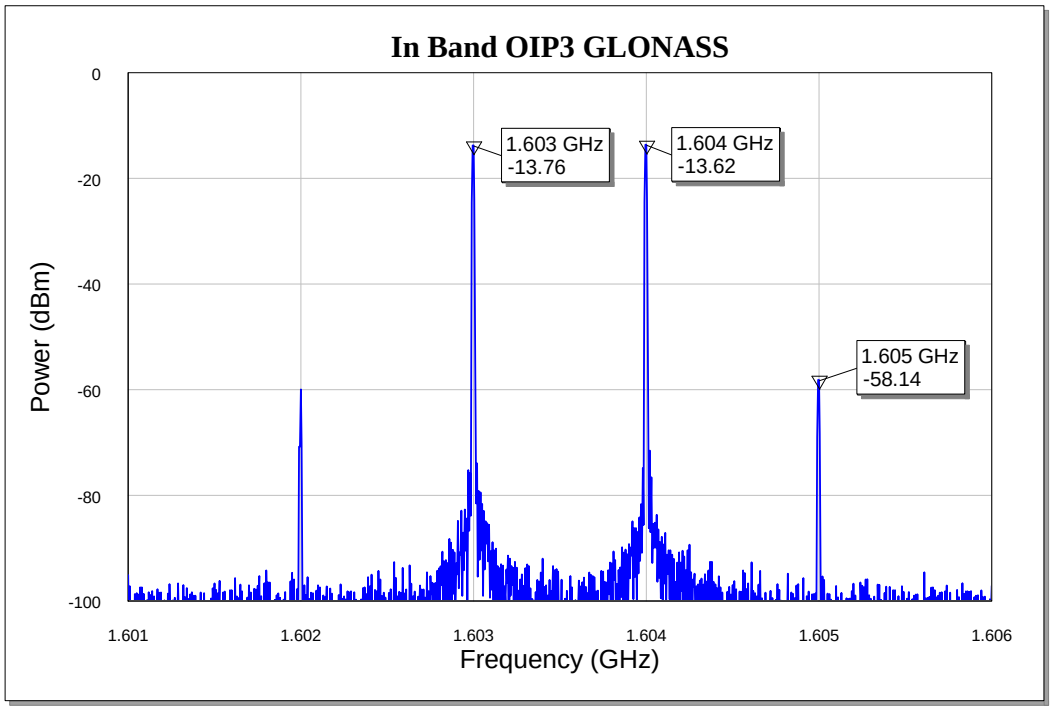

Figure 17 Carrier and intermodulation products of BGM1034N7 for GLONASS band at Vcc=2.8V

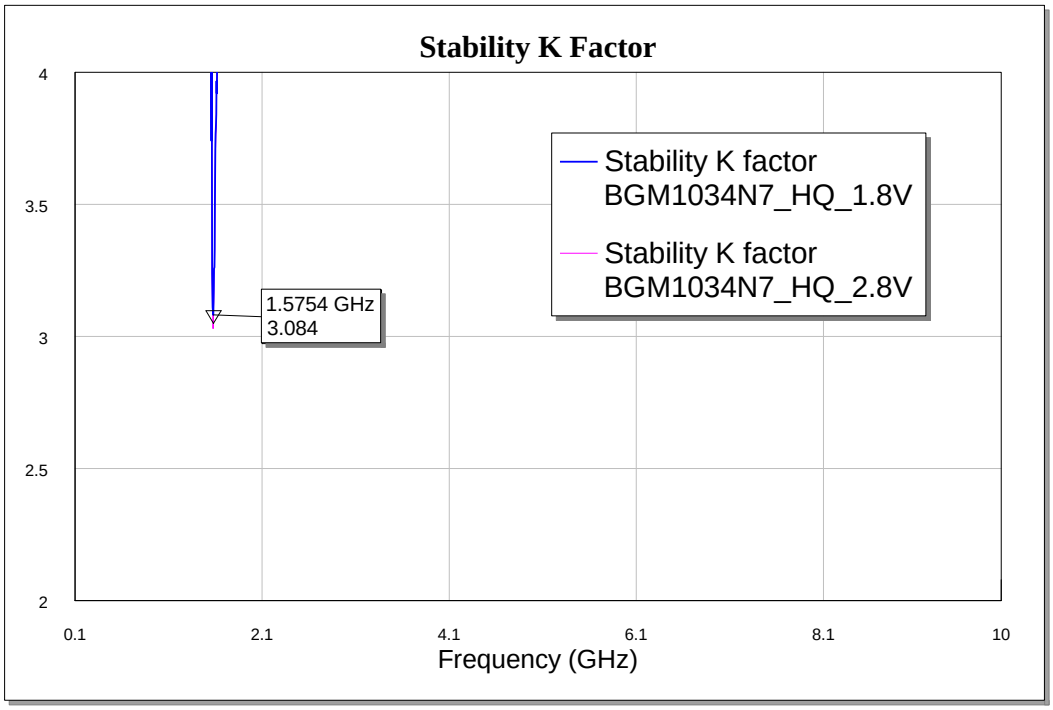

Figure 18 Stability Factor K of BGM1034N7 for GPS and GLONASS applications

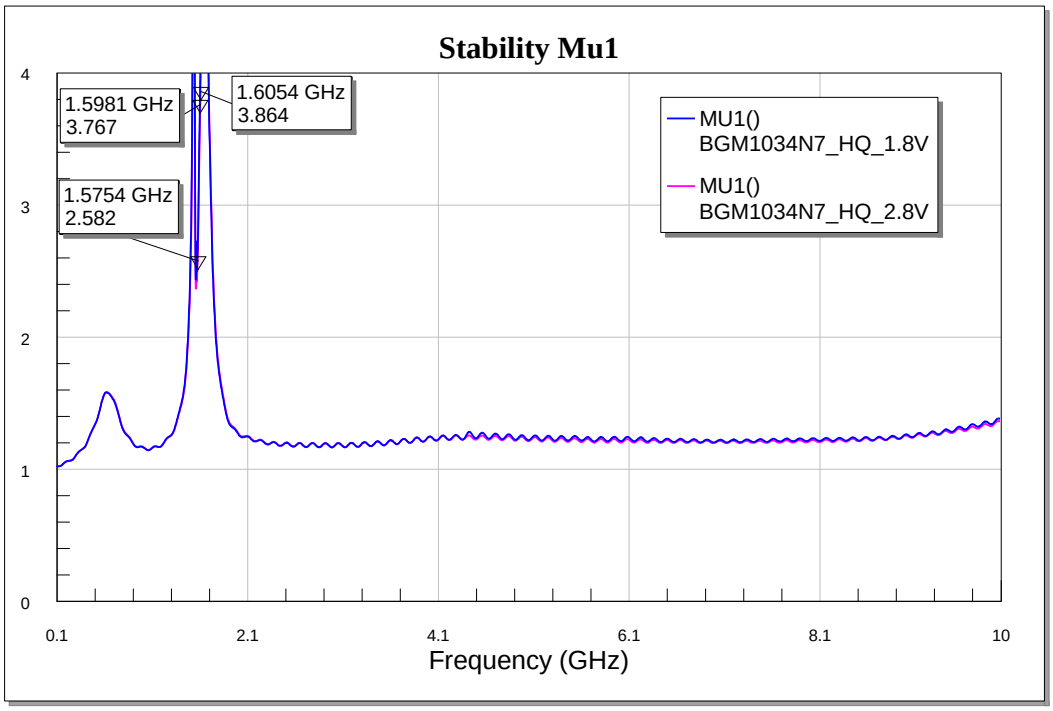

Figure 19 Stability Factor µ1 of BGM1034N7 for GPS and GLONASS applications

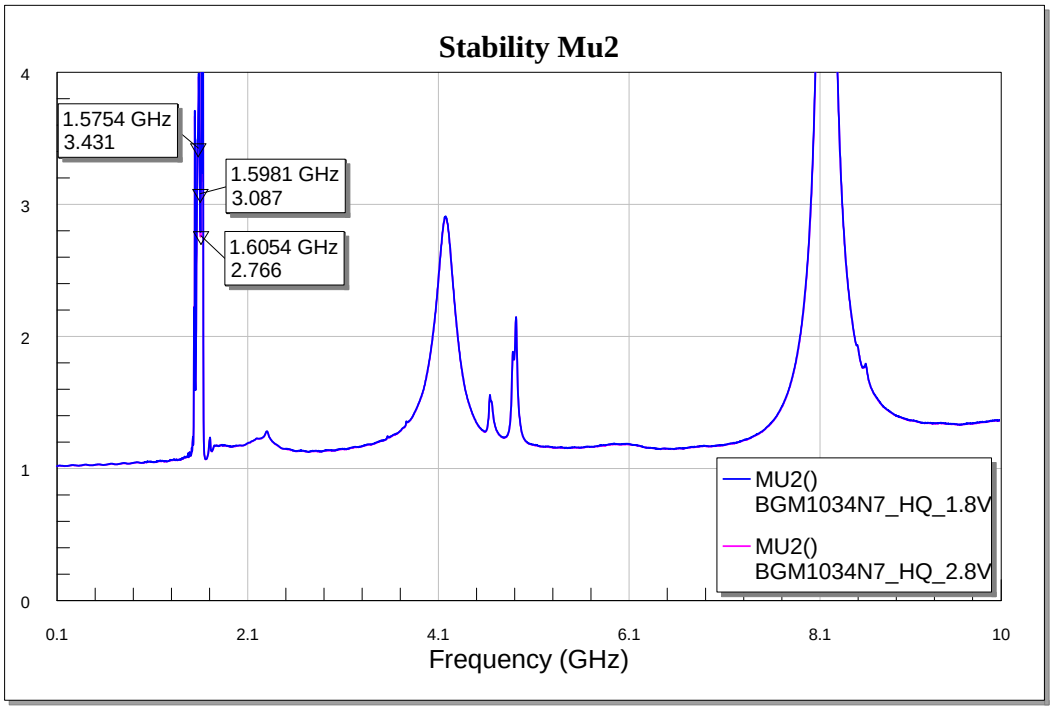

Figure 20 Stability Factor µ2 of BGM1034N7 for GPS and GLONASS applications

7 Evaluation Board and layout Information

In this application note, the following PCB is used:

PCB Marking: M110718 V3.0

PCB material: FR4

ε_r of PCB material: 4.3

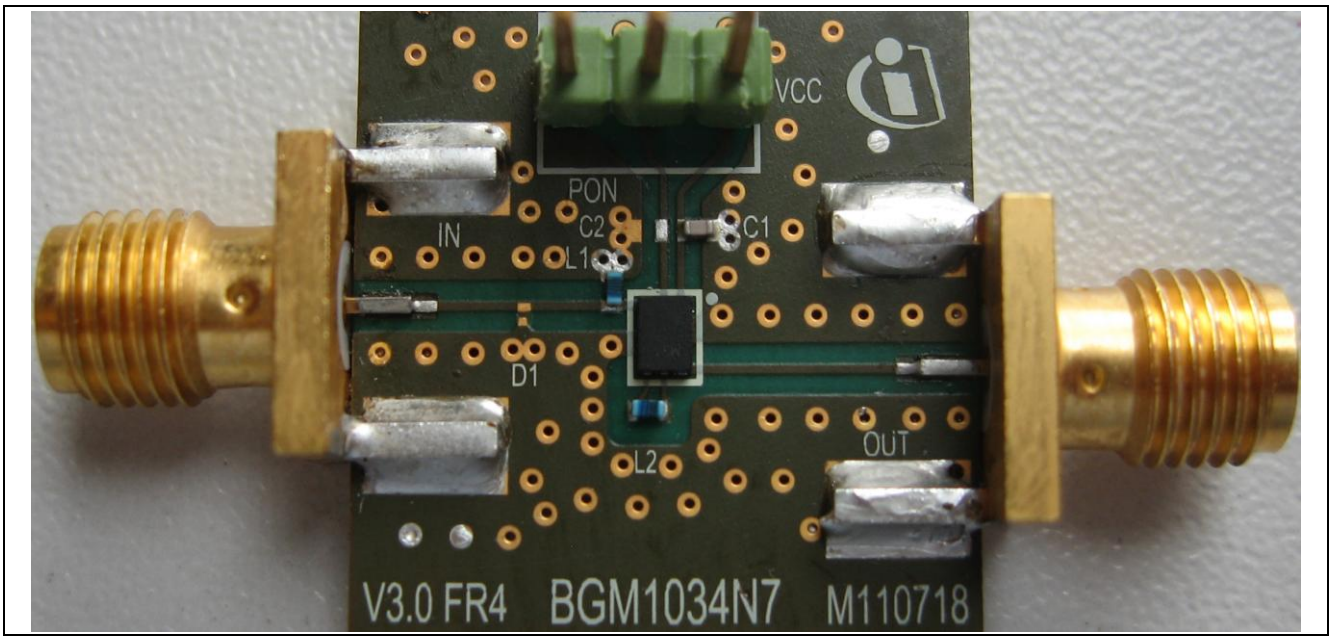

Figure 21 Picture of Evaluation Board M110718 V3.0

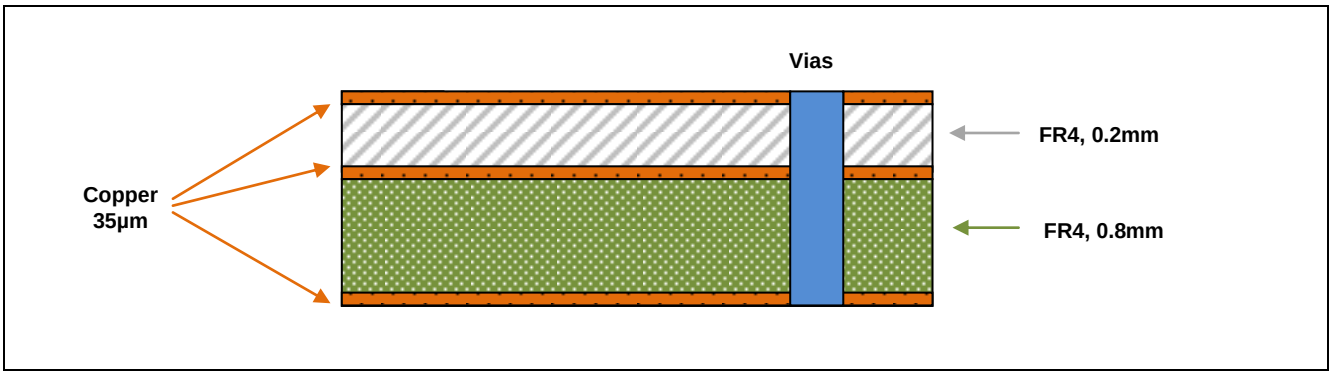

Figure 22 PCB Layer Information

8 Authors

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