BGM1032N7

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

Application Note AN263

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RF and Protection Devices

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

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1 BGM1032N7 GPS and GLONASS Front-End Module

1.1 Features

- Operating frequency: 1575.42 MHz and 1598.06-1605.38 MHz
- High Gain: 14.8 dB
- Low Noise Figure (GPS): 1.65 dB
- Low current consumption: 4.0 mA
- Out-of-band rejection in cellular bands: > 43dBc
- Input compression point in cellular bands: 30 dBm
- Supply voltage: 1.5 V to 3.6 V
- Tiny TSNP-7-10 leadless package (2.3x1.7x0.73mm^3)
- RF output internally matched to 50 Ω
- IEC61000-4-2 contact discharge of RF input pin in the application circuit: +/- 6 kV
- RoHS compliant package (Pb-free)

RoHS

Figure 1 BGM1032N7 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.

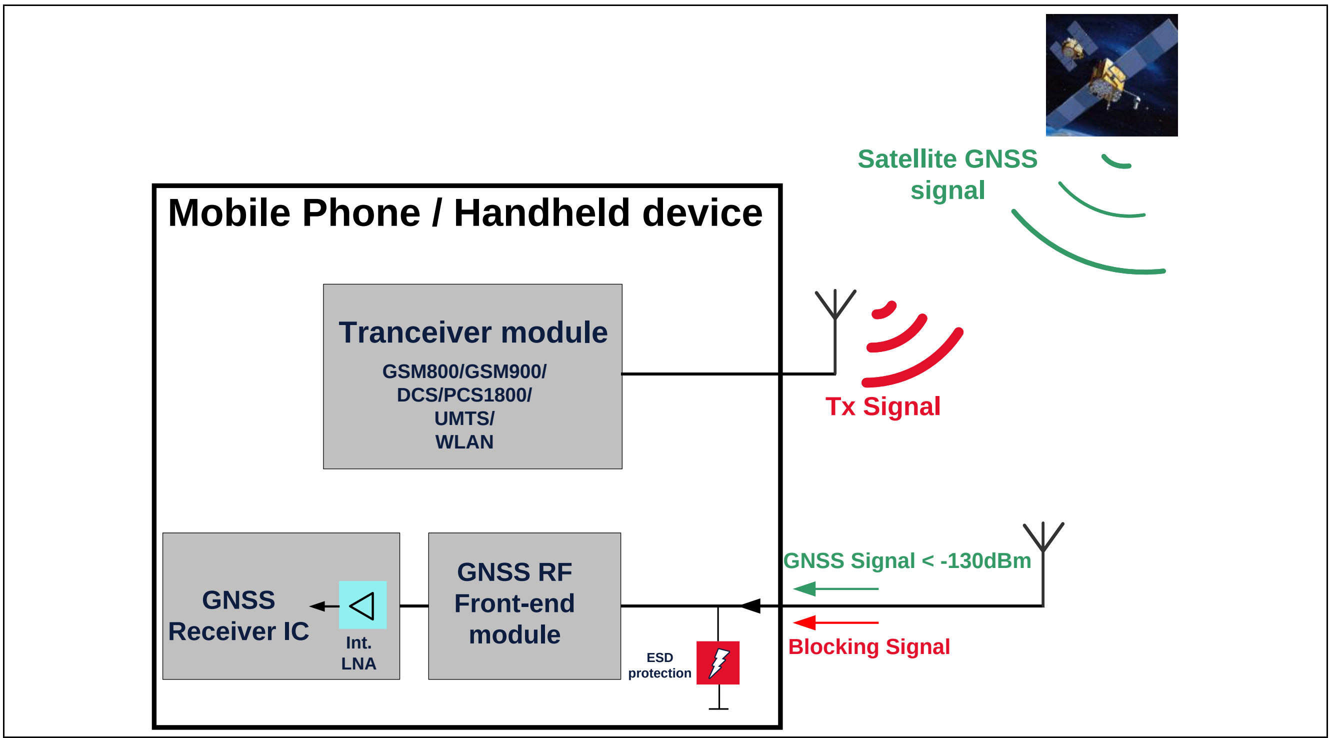

Figure 2 RF System Overview: Mobile Phone

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 BGM1032N7 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. BGM1032N7 supports the designers to minimize the area in the front-end. Such a configuration is shown in Figure 3. The BGM1032N7 can also be used for the active antenna module.

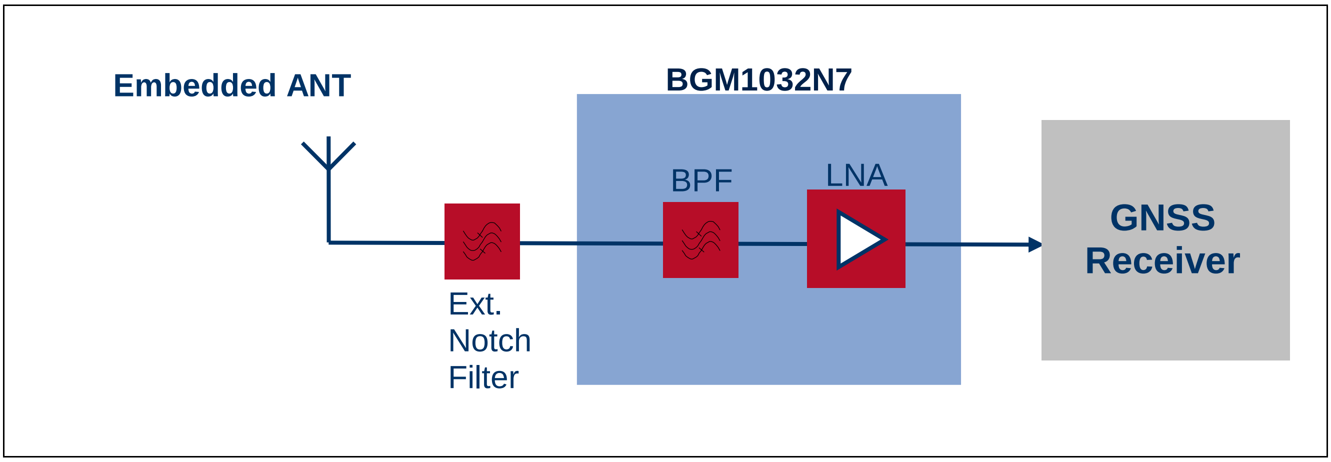

Figure 3 GNSS system with integrated GNSS FEM BGM1032N7 for mobile/portable and personal navigation devices

3 Description

The BGM1032N7 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 BGM1032N7 provides 14.5 dB gain, 1.80 dB noise figure and high linearity performance. In addition BGM1032N7 provides very high out-of-band attenuation in conjunction with a high input compression point. It can withstand IEC ESD contact discharge at the RF input as high as 6 kV. Its current consumption is as low as 4.0 mA. It operates over the 1.5 V to 3.6 V supply voltage range. The external notch filter is introduced to provide higher rejection for 787MHz.

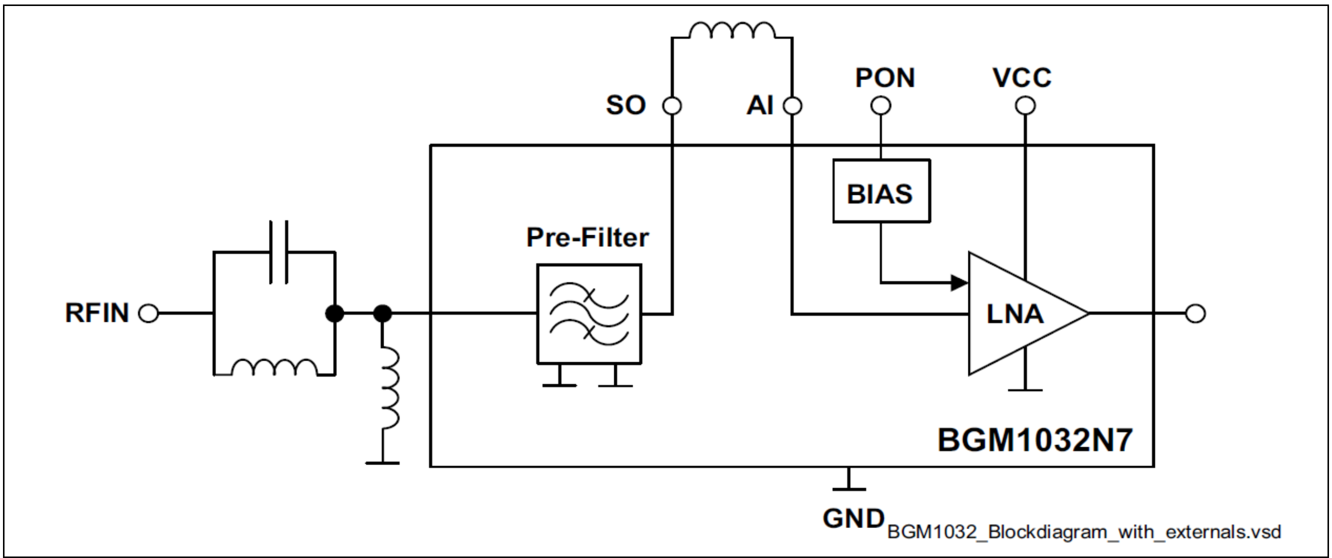

Figure 4 Block Diagram of BGM1032N7

4 Application Circuit and Block Diagram

The BGM1032N7 is internally matched at the output to 50 Ohm. The LNA bias circuitry is also integrated on chip. Two SMDs (one capacitor and one inductor) are used to design the notch filter for 787MHz optimization. Other than those, 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

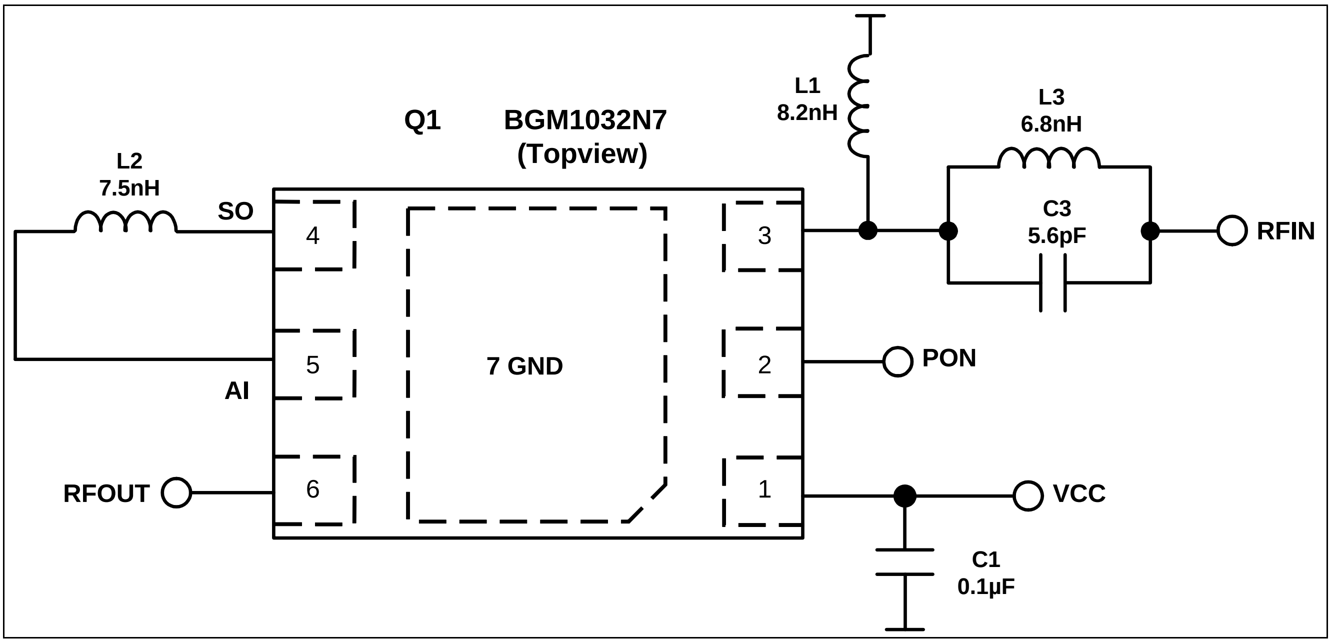

Figure 5 Schematic diagram of the BGM1032N7 (topview) application circuit

Table 1 Pin Assignment of BGM1032N7

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
C3	5.6	pF	0402	Murata GRM series	787MHz Optimization
L1	8.2	nH	0402	Murata LQG15 series	Matching / ESD Inductor
L2	7.5	nH	0402	Murata LQG15 series	Input Matching
L3	6.8	nH	0402	Murata LQG15 series	787MHz Optimization
Q1	BGM1032N7		TSNP-7-10	Infineon	GPS/GLONASS FEM

5 Measurement Results

Measurement results of the BGM1032N7 are presented in this section. The measurements are performed on the Infineon application board at room temperature. The performances of the BGM1032N7 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	4.2		mA	
Navigation System	Sys	GPS	GLONASS		
Frequency Range	Freq	1575.42	1598-1606	MHz	
Gain	G	14.4	14.3	dB	
Noise Figure	NF	1.79	2.3	dB	PCB and SMA connectors of 0.1 dB losses substracted
Input Return Loss	RLin	10.0	12.8	dB	
Output Return Loss	RLout	16.9	16.8	dB	
Reverse Isolation	IRev	22.2	22.0	dB	
Input P1dB	IP1dB	-8.5	-8.0	dBm	f_{gps} = 1575.42 MHz $f_{GLONASS}$ = 1605 MHz
Output P1dB	OP1dB	4.9	5.3	dBm	
Input IP3 In-band	IIP3	-6	-6.2	dBm	
Output IP3 In-band	OIP3	8.4	8.1	dBm	f_{1gps} = 1575.42 MHz, f_{2gps} = 1576.42 MHz $f_{1GLONASS}$ =1602 MHz, $f_{2GLONASS}$ =1603 MHz $P_{1IN} = P_{2IN}$ = -30 dBm
Rejection 750MHz[1]	Rej_{750M}	72.7		dBc	f = 750 MHz
Rejection 900MHz[1]	Rej_{900M}	45.3		dBc	f = 806 MHz - 928 MHz
Rejection 1800MHz[1]	Rej_{1800M}	42.2		dBc	f = 1710 MHz - 1980 MHz
Rejection 2400MHz[1]	Rej_{2400M}	54.9		dBc	f = 2400 MHz - 2500 MHz
Input P1dB	$IP1dB_{900M}$	30		dBm	f = 900 MHz
Input P1dB	$IP1dB_{1710M}$	30.5		dBm	f = 1710 MHz
LTE band-13 2nd Harmonic	H2 – input referred	-73.4		dBm	f_{IN} = 787.76 MHz P_{IN} = +15 dBm
Input IP3 out-of-band	$IIP3_{OOB}$	66.8		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	4.4		mA	
Navigation System	Sys	GPS	GLONASS		
Frequency Range	Freq	1575.42	1598-1606	MHz	
Gain	G	14.5	14.3	dB	
Noise Figure	NF	1.80	2.2	dB	PCB and SMA connectors of 0.1 dB losses substracted
Input Return Loss	RLin	10.3	13.5	dB	
Output Return Loss	RLout	15.8	17.6	dB	
Reverse Isolation	IRev	22.6	22.4	dB	
Input P1dB	IP1dB	-7.9	-7.0	dBm	f_{gps} = 1575.42 MHz $f_{GLONASS}$ = 1605 MHz
Output P1dB	OP1dB	5.6	6.3	dBm	
Input IP3 In-band	IIP3	-6.6	-5.9	dBm	
Output IP3 In-band	OIP3	7.9	8.4	dBm	f_{1gps} = 1575.42 MHz, f_{2gps} = 1576.42 MHz $f_{1GLONASS}$ =1602 MHz, $f_{2GLONASS}$ =1603 MHz Input power= -30 dBm
Rejection 750MHz[1]	Rej_{750M}	72.5		dBc	f = 750 MHz
Rejection 900MHz[1]	Rej_{900M}	45.2		dBc	f = 806 MHz - 928 MHz
Rejection 1800MHz[1]	Rej_{1800M}	42.2		dBc	f = 1710 MHz - 1980 MHz
Rejection 2400MHz[1]	Rej_{2400M}	54.7		dBc	f = 2400 MHz - 2500 MHz
Input P1dB	$IP1dB_{900M}$	30		dBm	f = 900 MHz
Input P1dB	$IP1dB_{1710M}$	30.6		dBm	f = 1710 MHz
LTE band-13 2nd Harmonic	H2 – input referred	-73.6		dBm	f_{IN} = 787.76 MHz P_{IN} = +15 dBm
Input IP3 out-of-band	$IIP3_{OOB}$	65.9		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

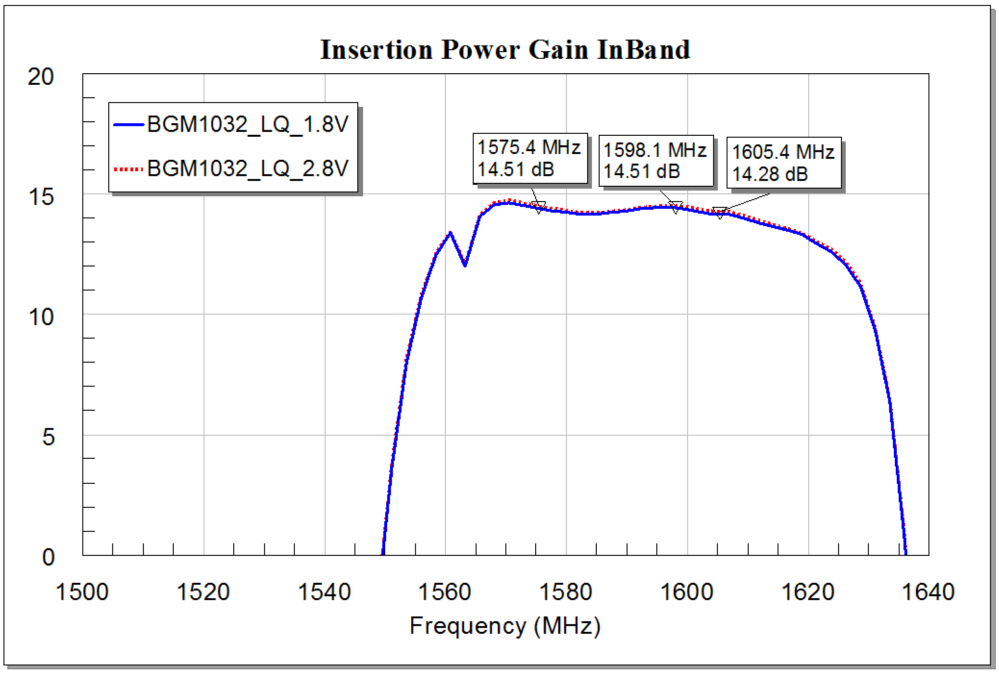

Figure 6 Power Gain of BGM1032N7 for GPS and GLONASS bands

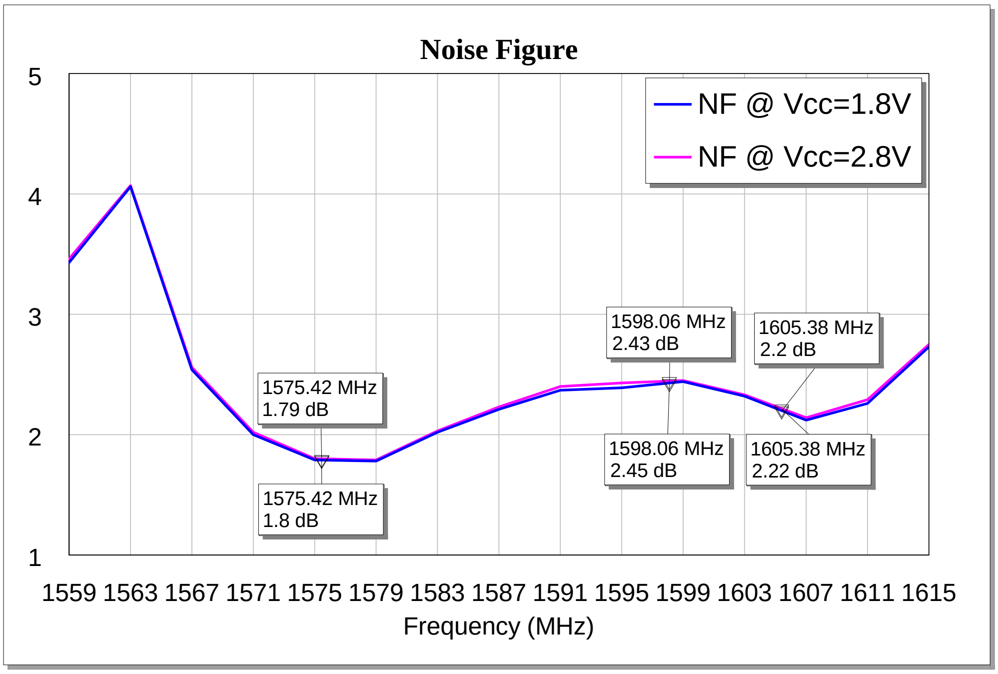

Figure 7 Noise Figure of BGM1032N7 for GPS and GLONASS bands

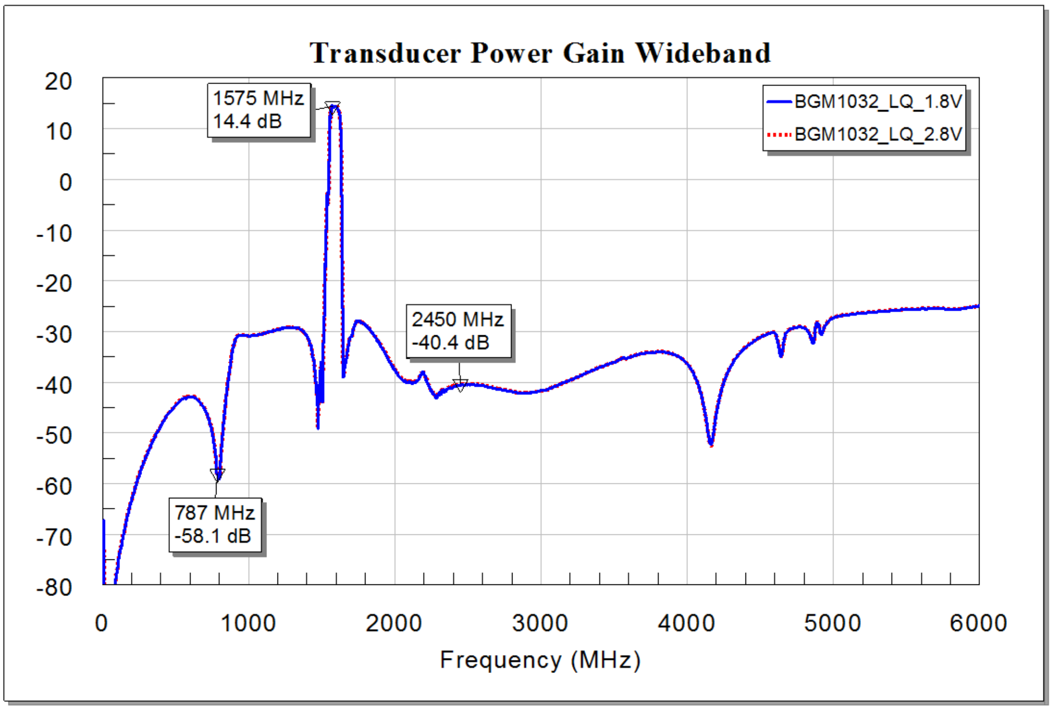

Figure 8 Wideband Insertion Power Gain including out-of-band attenuation of the BGM1032N7

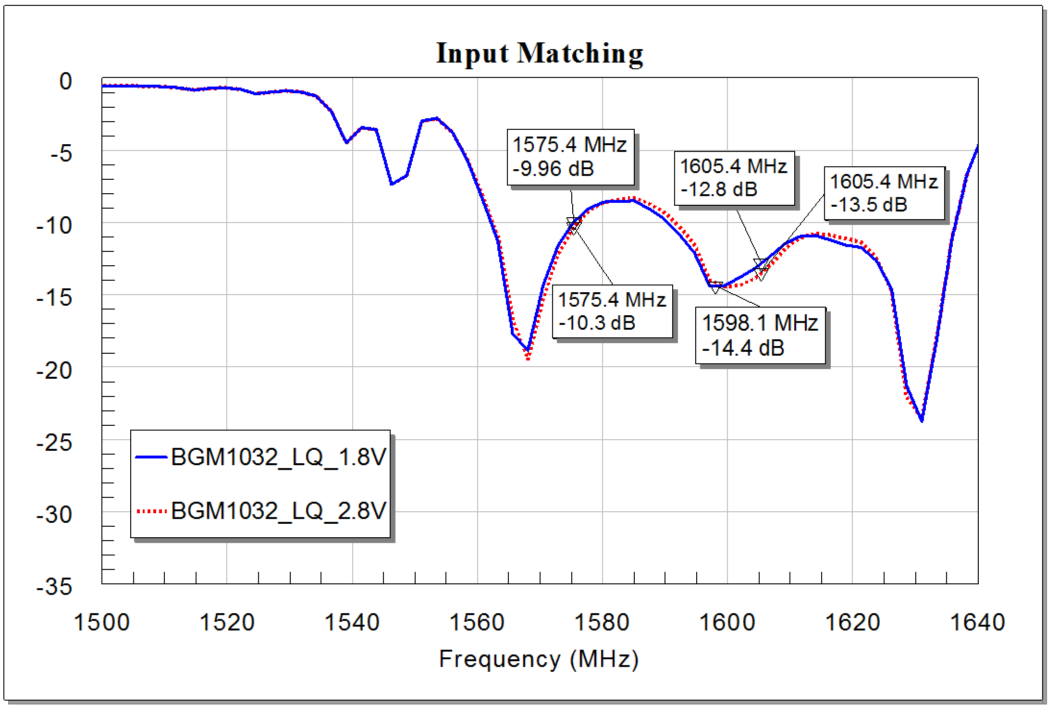

Figure 9 Input Matching of BGM1032N7 for GPS and GLONASS bands

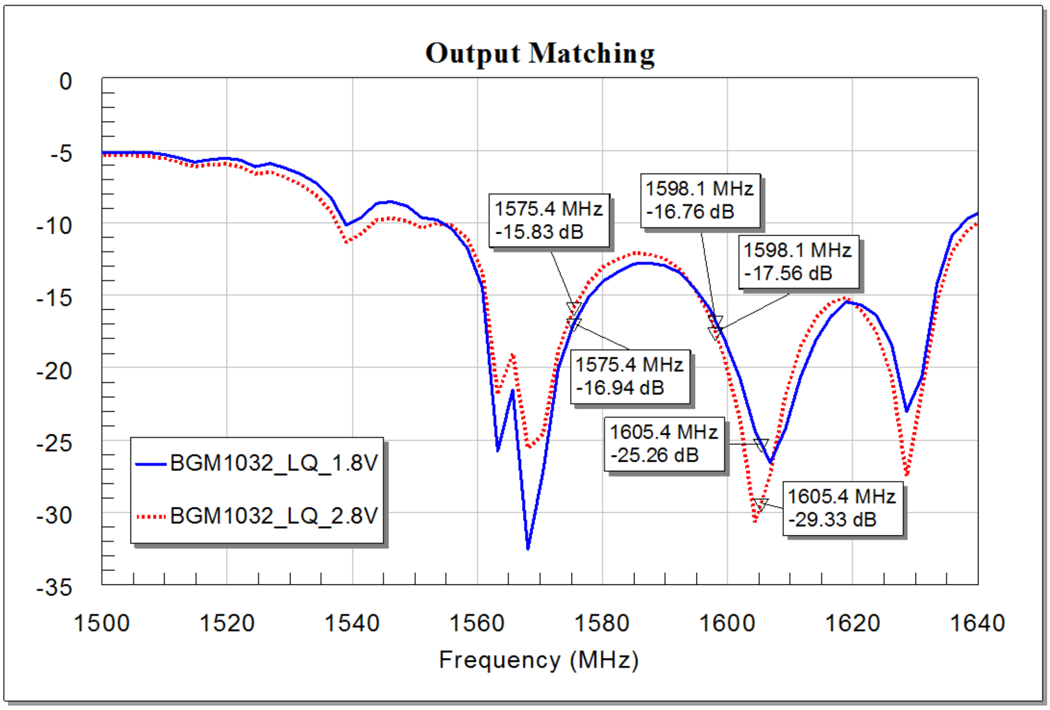

Figure 10 Output Matching of BGM1032N7 for GPS and GLONASS bands

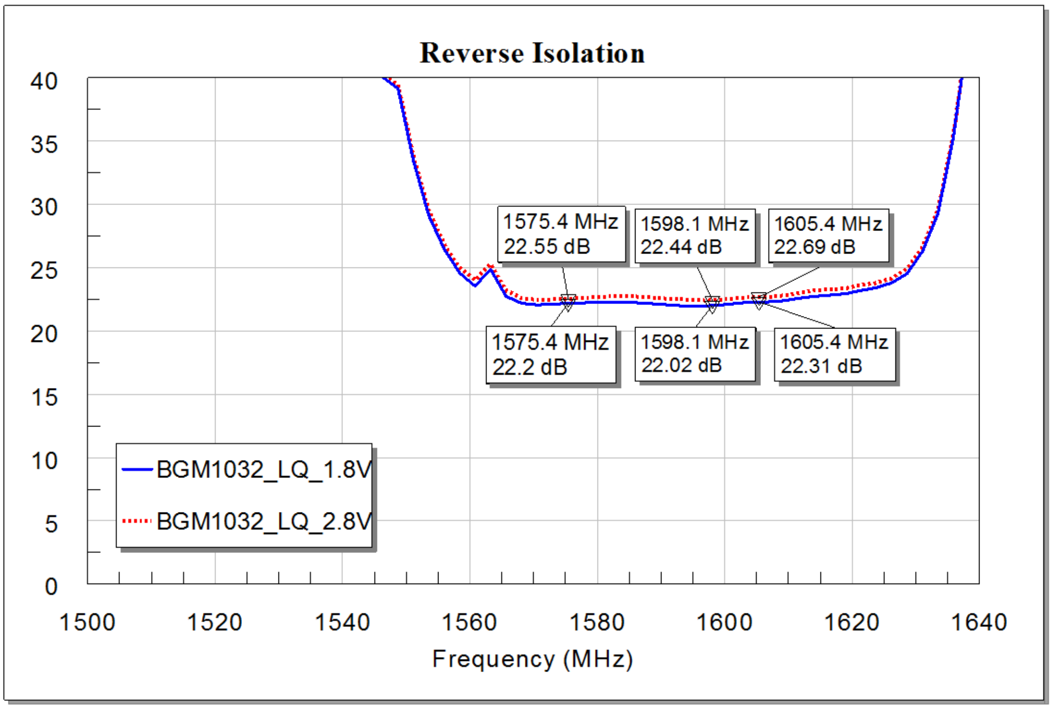

Figure 11 Reverse Isolation of BGM1032N7 for GPS and GLONASS bands

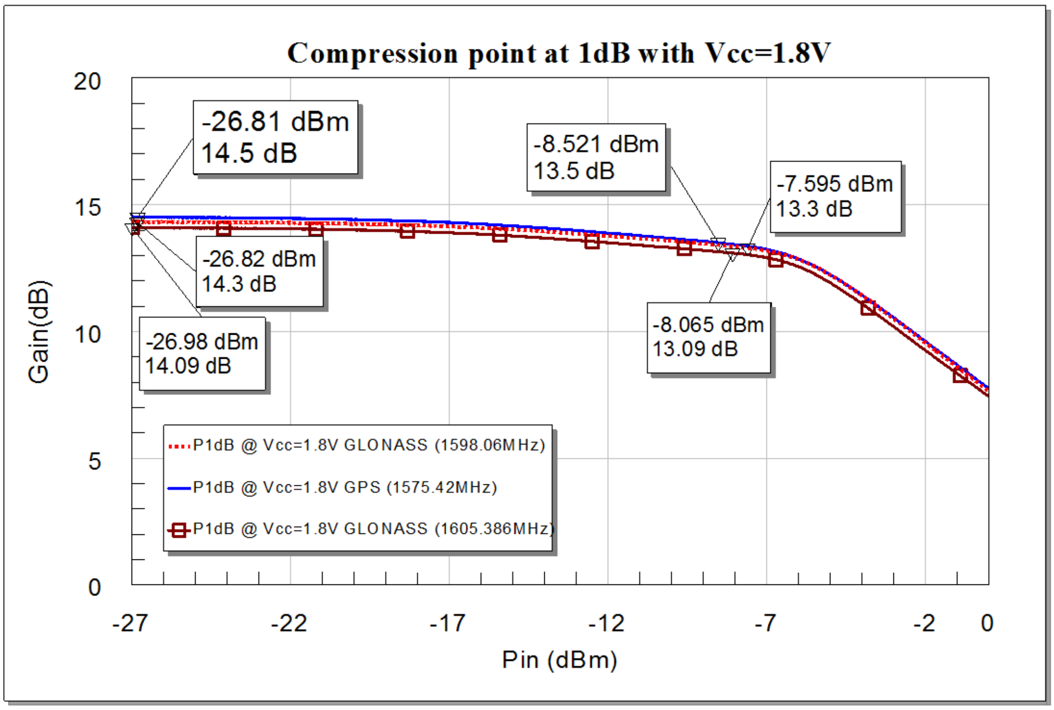

Figure 12 Input 1dB Compression Point of BGM1032N7 at supply voltage of 1.8V for GPS and GLONASS bands

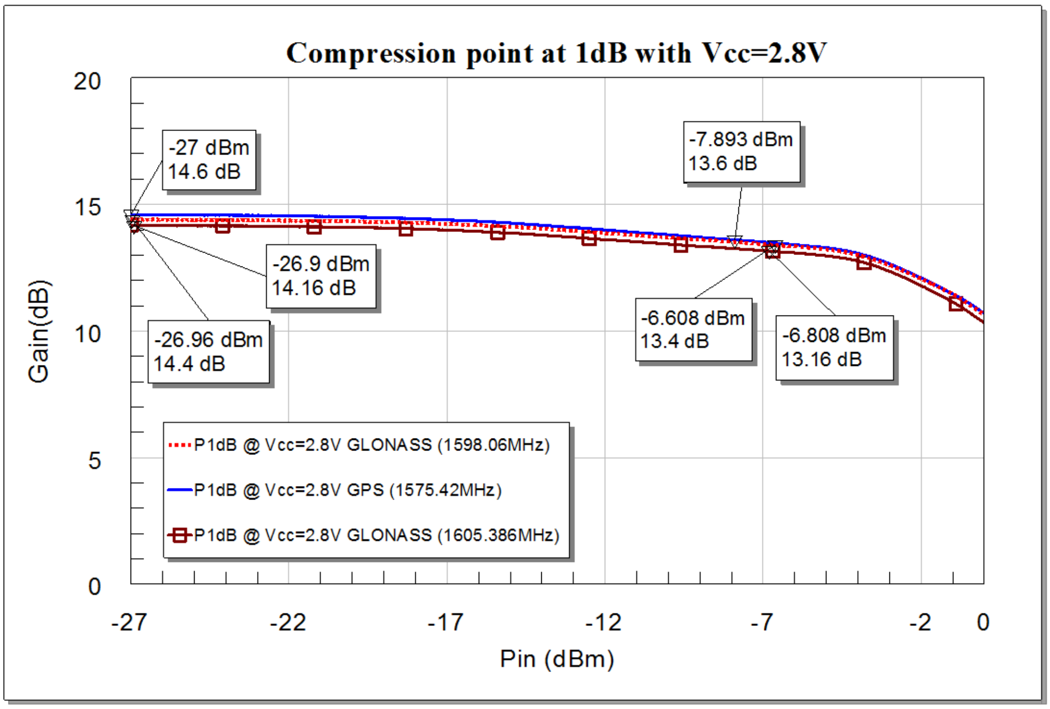

Figure 13 Input 1dB Compression Point of BGM1032N7 at supply voltage of 2.8V for GPS and GLONASS bands

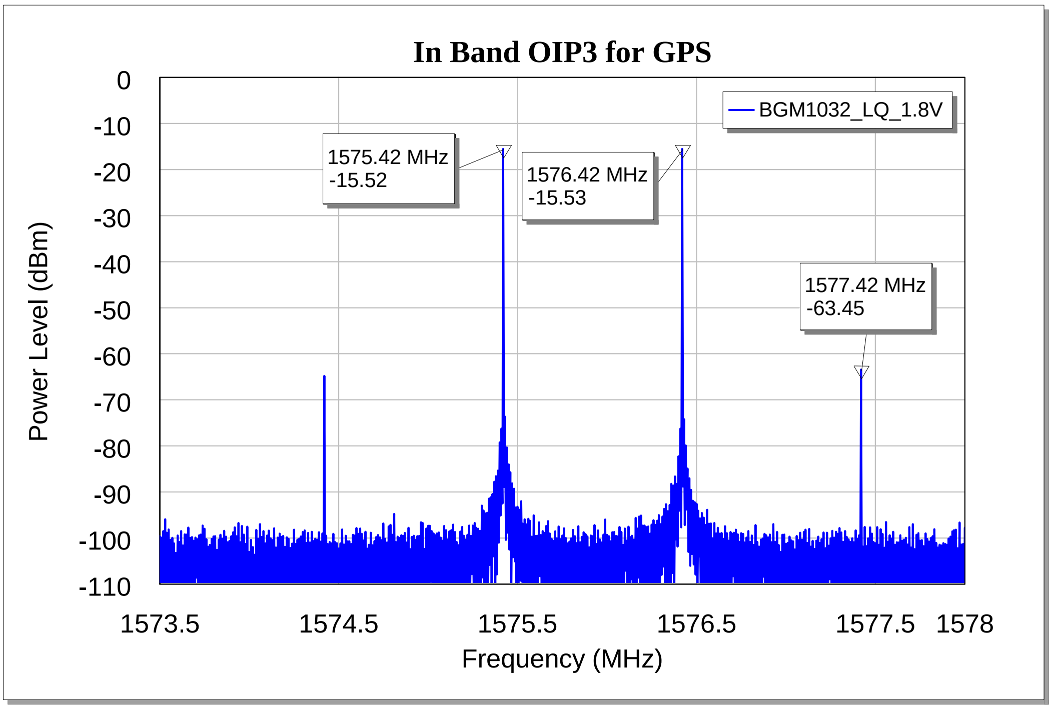

Figure 14 Carrier and intermodulation products of BGM1032N7 for GPS band at Vcc=1.8V

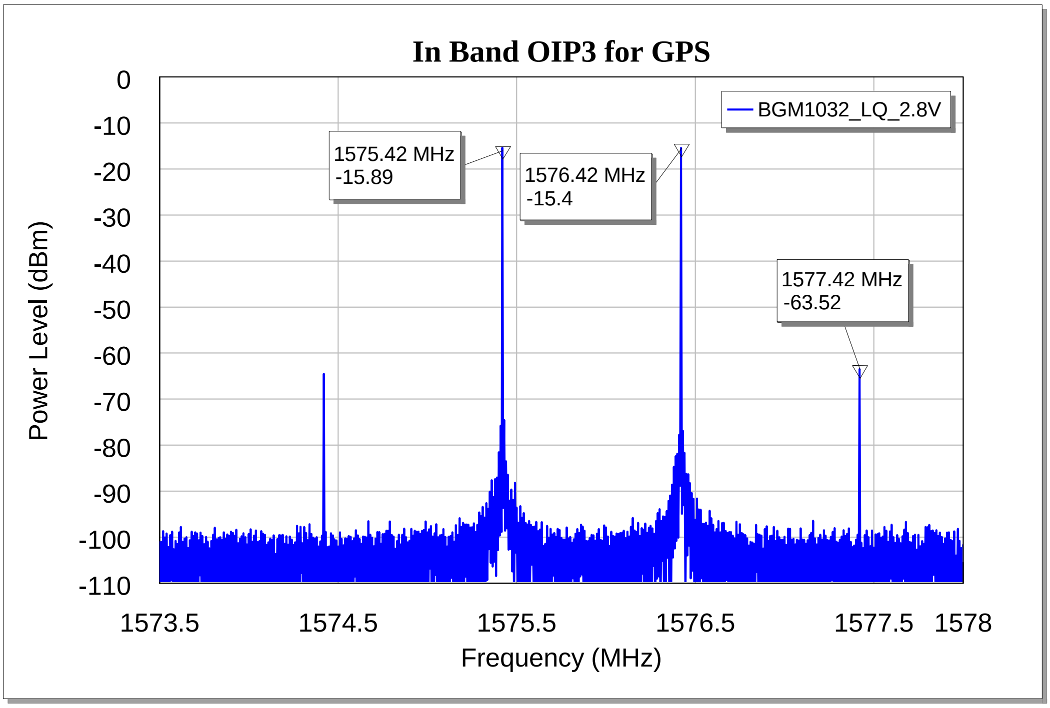

Figure 15 Carrier and intermodulation products of BGM1032N7 for GPS band at Vcc=2.8V

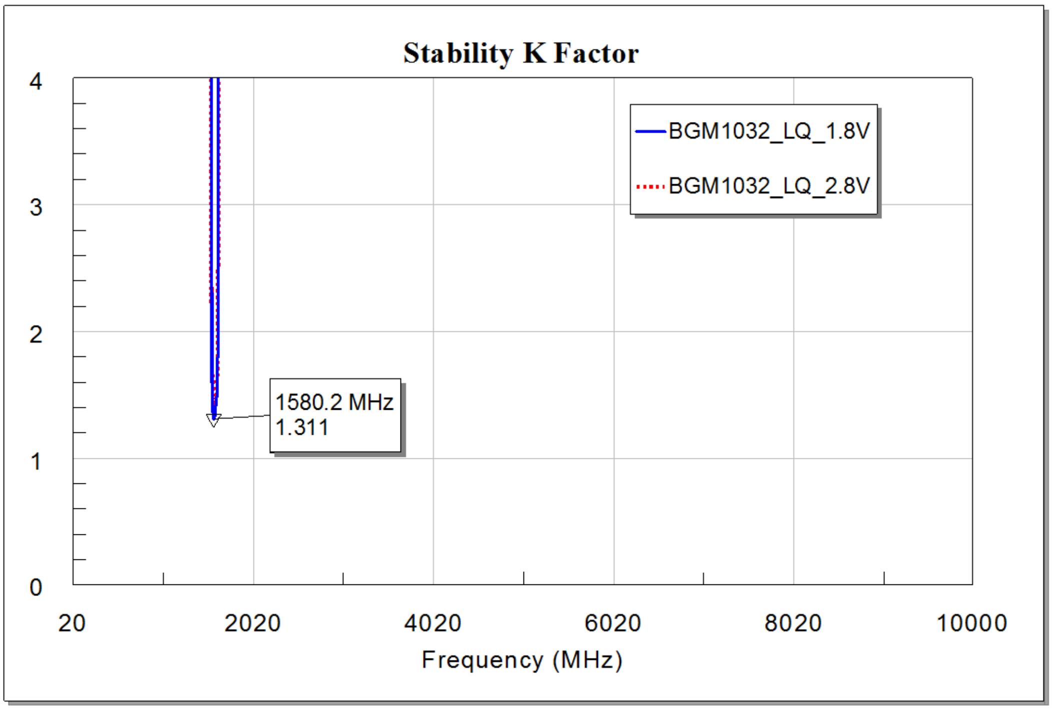

Figure 16 Stability Factor K of BGM1032N7 for GPS and GLONASS applications

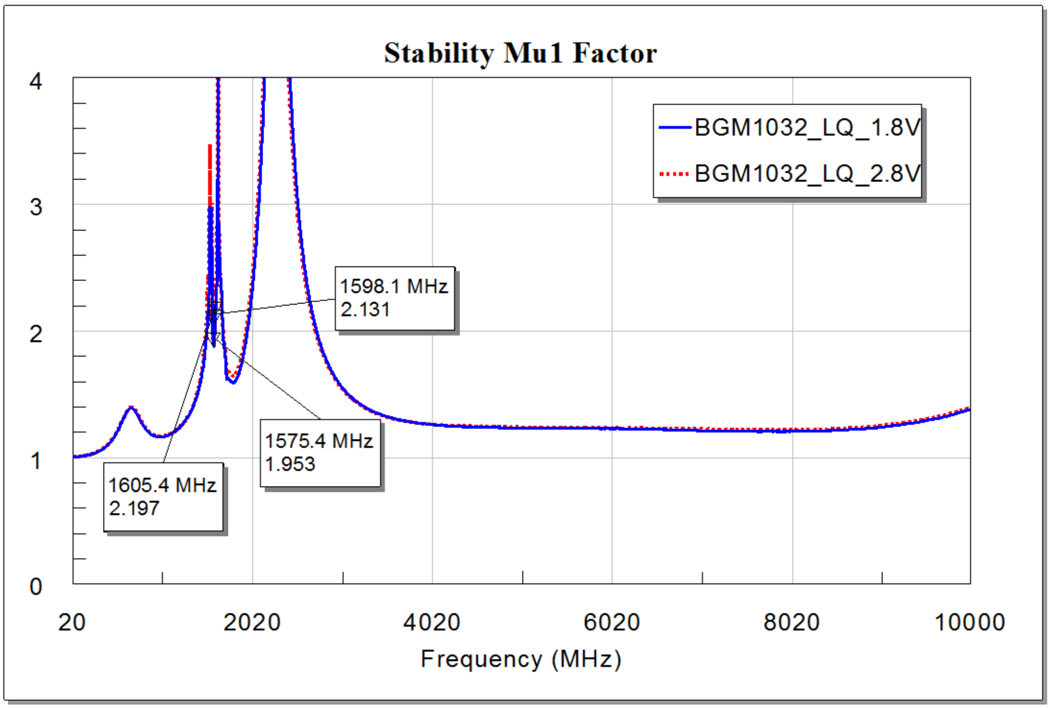

Figure 17 Stability Factor µ1 of BGM1032N7 for GPS and GLONASS applications

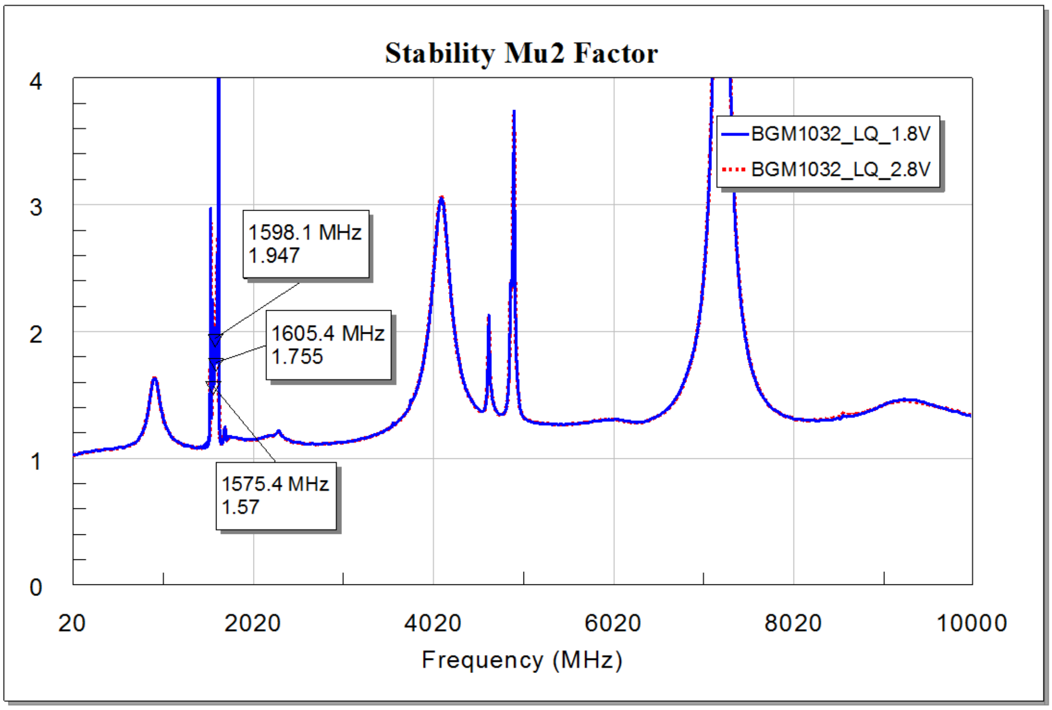

Figure 18 Stability Factor µ2 of BGM1032N7 for GPS and GLONASS applications

7 Evaluation Board and layout Information

In this application note, the following PCB is used:

PCB Marking: M110416 V3.0

PCB material: FR4

ε_r of PCB material: 4.3

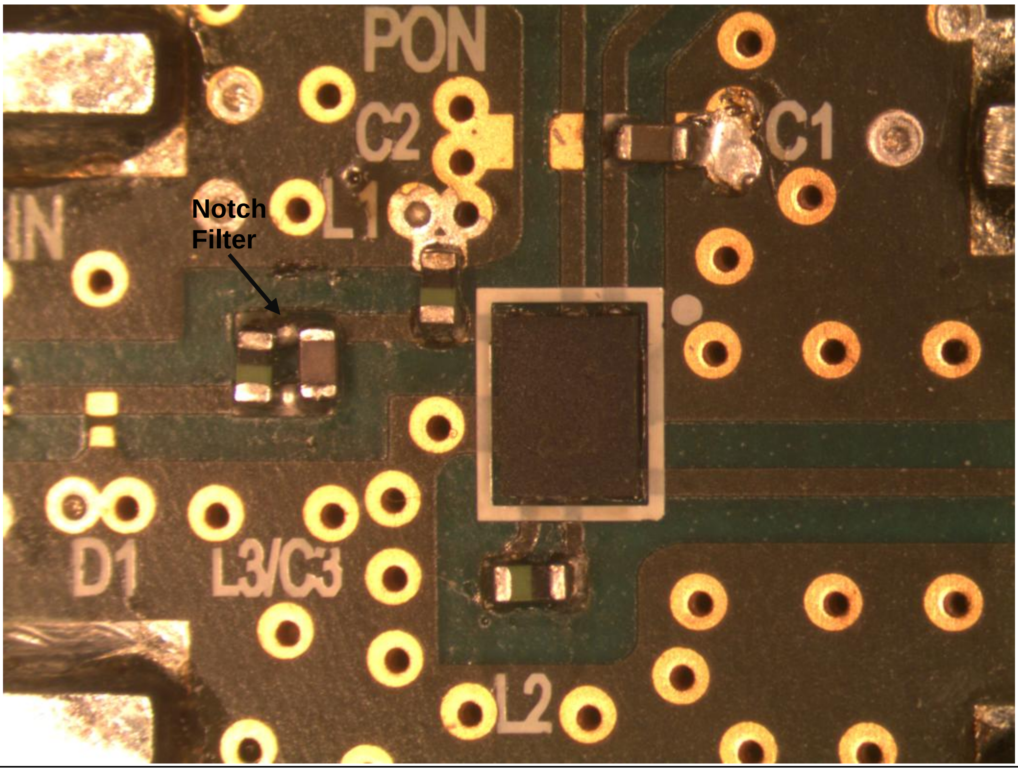

Figure 19 Picture of Evaluation Board (detailed view) M110416 V3.0

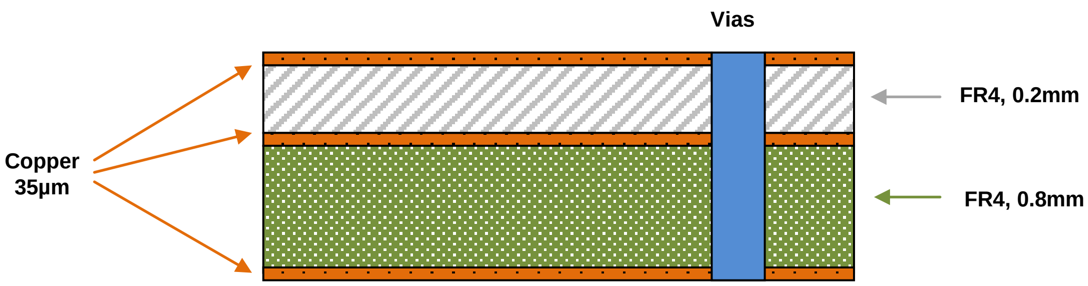

Figure 20 PCB Layer Information

8 Authors

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