Application Note No. 181

FM Radio LNA using BGB707L7ESD matched to 50 Ω, including application proposal for ESD protection

RF & Protection Devices

Never stop thinking

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Page	**Subjects (major changes since last revision)**
6	figure 2 pinout names of BGB707 updated
8	figure 6 pinout names of BGB707 updated

1 Introduction

FM Radio has a long history to its credit starting from its development in 1933. Today, FM radio is an integral part of almost all mobile phones. In a common mobile phone, the headset cable serves as antenna for FM reception, wherein the antenna size (~75 cm) is a bit relaxed.

There is a clear market trend to be able to use FM radio also without the headset cable. The antenna needs then to be integrated inside the phone. But in this case, the space constraint poses a challenge on the antenna design. Shrinking the size of the antenna introduces a high loss in the system which deteriorates the receiver performance, namely the receiver sensitivity.

Infineon's latest generation low noise amplifier (LNA) BGB707L7ESD is able to solve this problem by enhancing the receiver sensitivity. Using it in a hand held device also demands low current consumption, power-off function and high linearity due to the co-existence of cellular bands.The LNA is designed for worldwide FM band (76-108 MHz) and high ESD robustness at the RF-in port, which supports outstanding ESD robustness on system level.

Infineon offers its LNA solution BGB707L7ESD, which fulfills all these performance criteria in a very small and leadless package TSLP-7-1 (2.0 x 1.3 x 0.4 mm). A further highlight of the BGB717L7EDS is an integrated active biasing which enables consistent operation with varying temperature and process variations. It finds its application in all kinds of mobile devices like mobile phones, PDAs, portable FM radio, MP3 players etc.

With this application proposal Infineon offers a perfect solution for a ESD robust LNA for embedded FM radio antennas in handsets. The design is suited for miniature and slim handset design due to the small form factor of the TSLP packages.

Figure 1 Pictures of evaluation board

2 Performance Overview

The following table gives a quick overview on the performance of the FM Antenna LNA described in this application note.

Table 1 Electrical characteristics at
T_A = 25°C, V_{CC} = 2.8V, V_{Ctrl} = 2.8V, f = 100MHz

Parameter	Symbol	Values			Unit
		Min.	Typ.	Max.	
Insertion power gain	$\|S_{21}\|^2$		15		dB
Input return loss	RL_{IN}		7.5		dB
Output return loss	RL_{OUT}		14.5		dB
Noise figure (Z_s=50Ohm)	F50ohm		1.35		dB
Input 1dB gain compression point[1)]	P_{-1dB}		-10		dBm
Input 3rd Order Intercept Point[2)]	IIP3		-6		dBm
Quiescent supply current	ICC_q		4.2		mA

1) Icc increases as RF input level approaches P-1dB
2) IP3 value depends on termination of all intermodulation frequency components. Termination used for the measurement is 50 Ω from 0.1 to 6 GHz

3 Application Circuit

In this section, the application circuit for the BGB707L7ESD is described. The circuit requires minimal usage of external SMD components due to the integration of the biasing circuit which saves PCB space and therefore cost. The application schematic is shown in **Figure 2** and the function of each component is explained in **Table 2**.

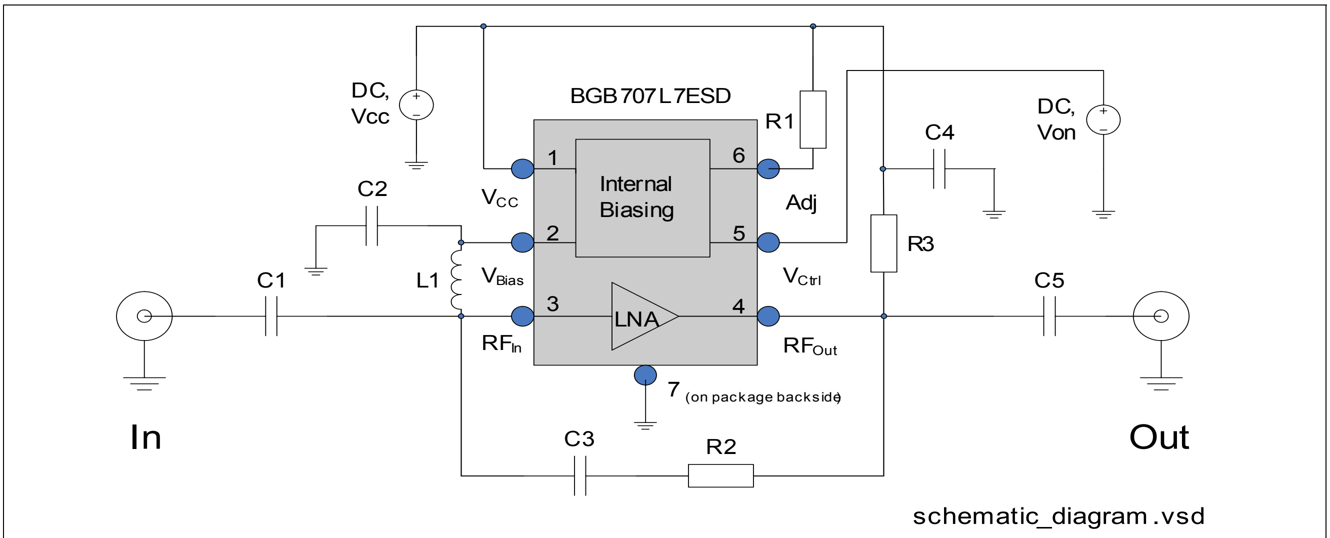

Figure 2 Application schematic for FM Radio

Table 2 Bill of material

Component	Value	Manufacturer/Type	Function
C1	330 pF	Various / 0402	DC blocking
C2	47 nF	Various / 0402	RF bypass
C3	330 pF	Various / 0402	DC blocking
C4	47 nF	Various / 0402	RF bypass
C5	330 pF	Various / 0402	DC blocking
R1	4.7 kΩ	Various / 0402	Current adjustment
R2	680 Ω	Various / 0402	Feedback, matching
R3	180 Ω	Various / 0402	Stability, output matching
L1	470 nH	Taiyo Yuden LK1608R47K-T / 0603	RF choke, value and size important for stability
IC1	BGB707L7ESD	Infineon / TSLP-7-1	

Figure 3 shows the layout and the component placement of the PCB used to assemble and test the LNA

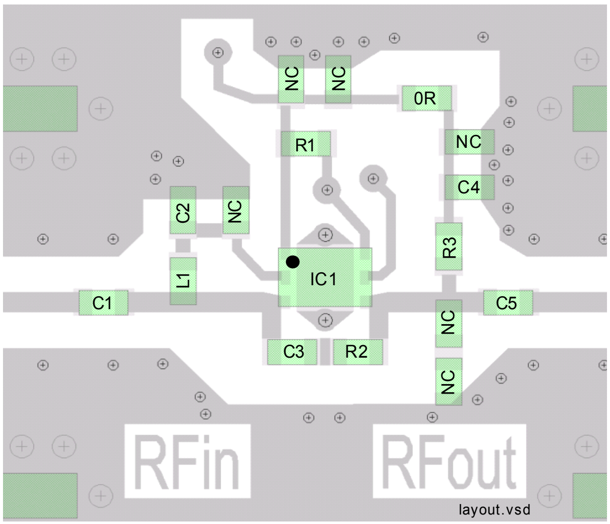

Figure 3 PCB layout

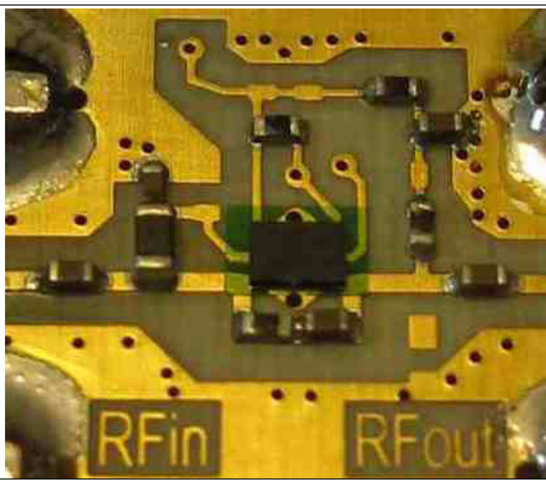

Figure 4 Picture of circuit

3.1 ESD protection improvement for the FM Radio application circuit

More and more **e**lectro**s**tatic **d**ischarge (ESD) protection performance according IEC61000-4-2 is demanded for electronic products.

To enhance the ESD robustness of the BGB707L7ESD to the more stringent requirement according IEC61000-4-2, an external ESD protection circuit should be implemented. The ESD protection configuration has no impact on any performance parameter.

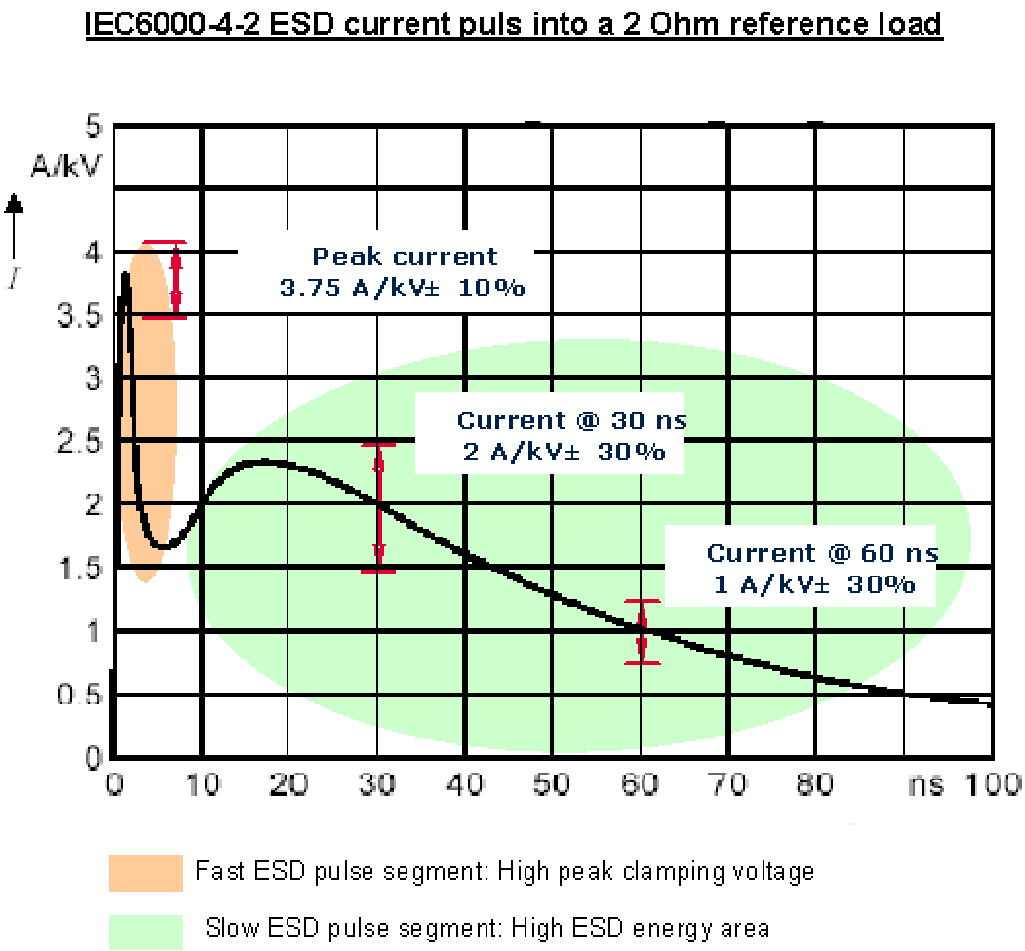

Figure 5 IEC6000 4-2 ESD Pulse

For an ESD event (see **Figure 5**), the dynamic peak clamping voltage (stated after 1...2 ns, the IEC61000-4-2 ESD strike started) has to be kept as low as possible.

The external ESD protection circuit is show in **Figure 6**. The Infineon TVS diode ESD0P4RFL in parallel together with the DC decoupling capacitor C1 and optional serial inductor L2 forms the ESD protection configuration

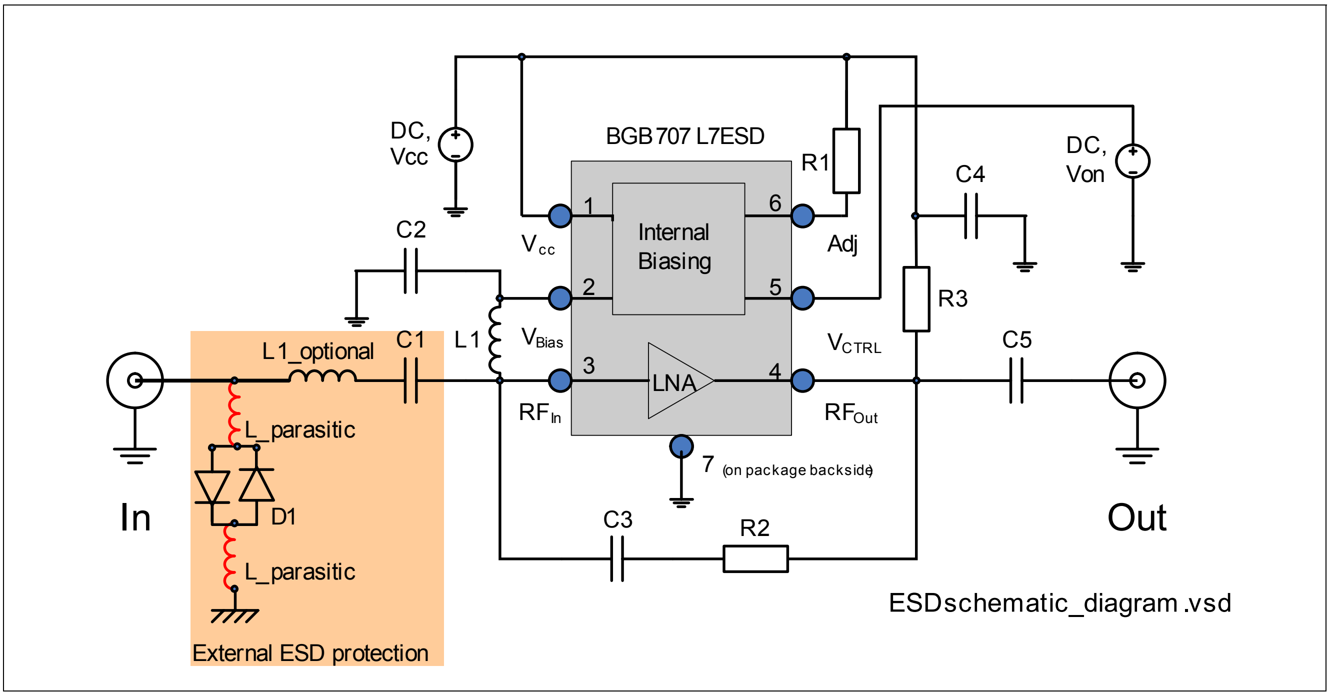

Figure 6 ESD protection Circuit

All parasitic inductances in series to the TVS diode have to be minimized. The amount of these parasitic inductances influence directly the maximum ESD voltage which can be handled.

Therefor all interconnects (L-parasitic) attached to the TVS diode D1 has to be kept short as possible. GND via holes have to be placed directly beside the GND pad of D1.

The optional serial inductor L2 (or a narrow microstrip line providing ~5nH) isolates the ESD diode from the amplifier input and reduces the residual peak clamping voltage further more. In the Infineon's application circuit shown in this application note, there is no serial inductor (L2) implemented.

10 kV ESD robustness according IEC61000-4-2 has been achieved.

The serial capacitor C1 acts as a DC block and at the same time protects the RF-Input node of the BGB707L7ESD from ESD pulses. So the antenna pin is isolated from the LNA input biasing and the slow slope (see green area in figure 5) of the ESD IEC61000-4-2 test pulse is blocked.

Main reason for selection of the TVS diode ESD0P4RFL is the very low diode capacitance of 0.4 pF and the very low peak clamping voltage. This is mandatory to keep the residual ESD voltage (and current) at the BGB707L7ESD RF-In pad as small as possible. The residual ESD current has to be handled by the internal ESD protection of the BGB707L7ESD.

Through implementing the optional serial inductor L2 (~5nH) ESD robustness can be enhanced upto 20kV, because of better separation of TVS diode and BGB707L7ESD RF Input. Noise figure will be in the range of 1.45 to 1.5dB with L2 (Murata LQG) implemented.

Replacing the inductor L2 by a 2.2 Ohm series resistor (for cost reduction reason) delivers an ESD performance of 15 kV. In this case noise figure is about 1.6...1.7dB

4 Measurement results

The following graphs show measured performance of the LNA described here. Please note that all this data includes both losses of microstrip lines and SMA connectors.

4.1 Narrowband graphs

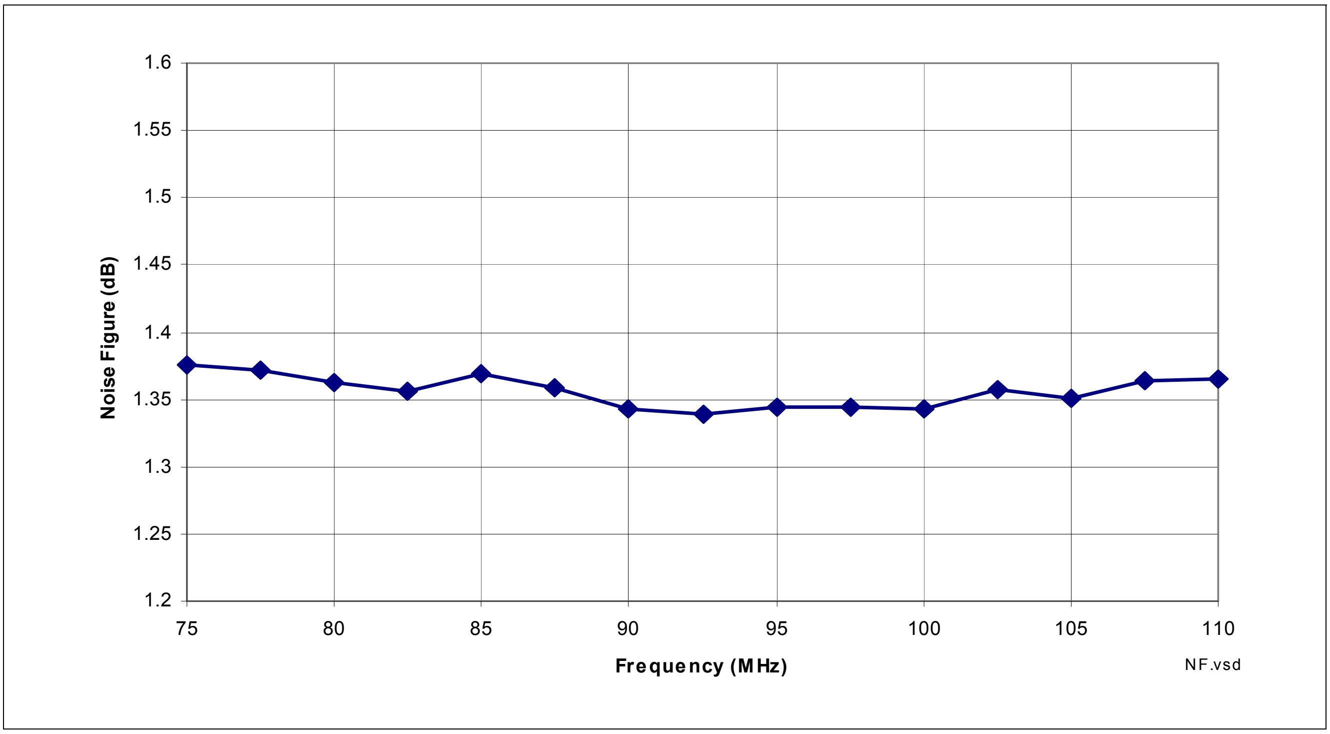

Figure 7 Noise figure with a 50 Ω termination at input and output

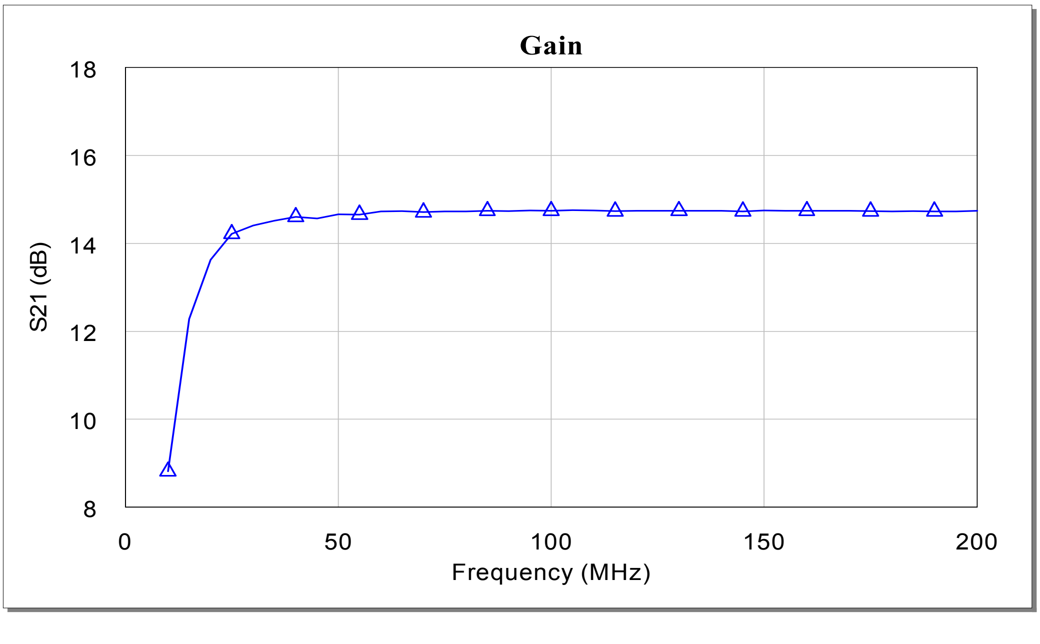

Figure 8 Gain

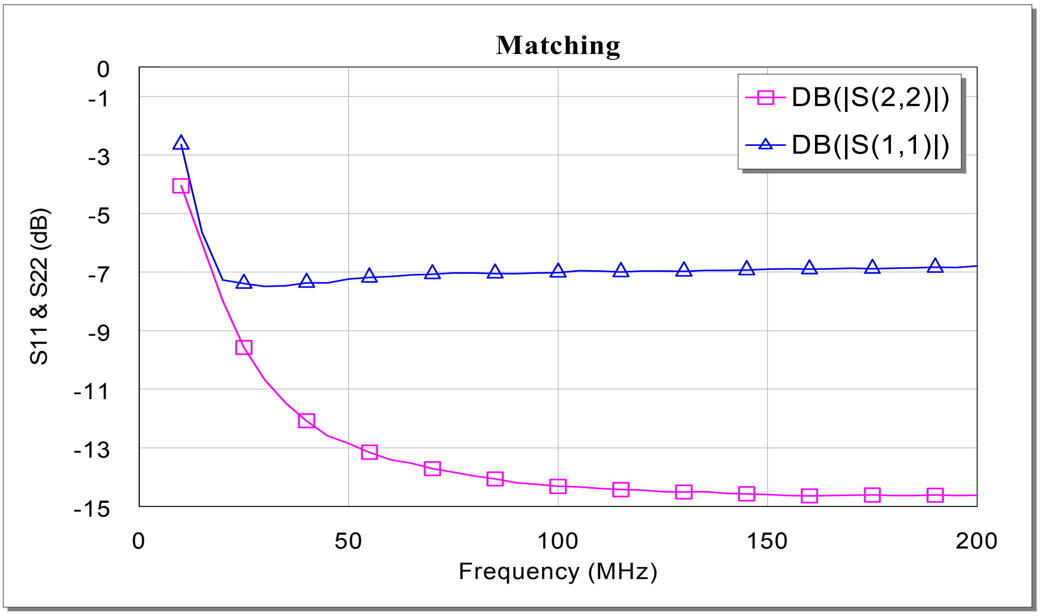

Figure 9 Input and output matching

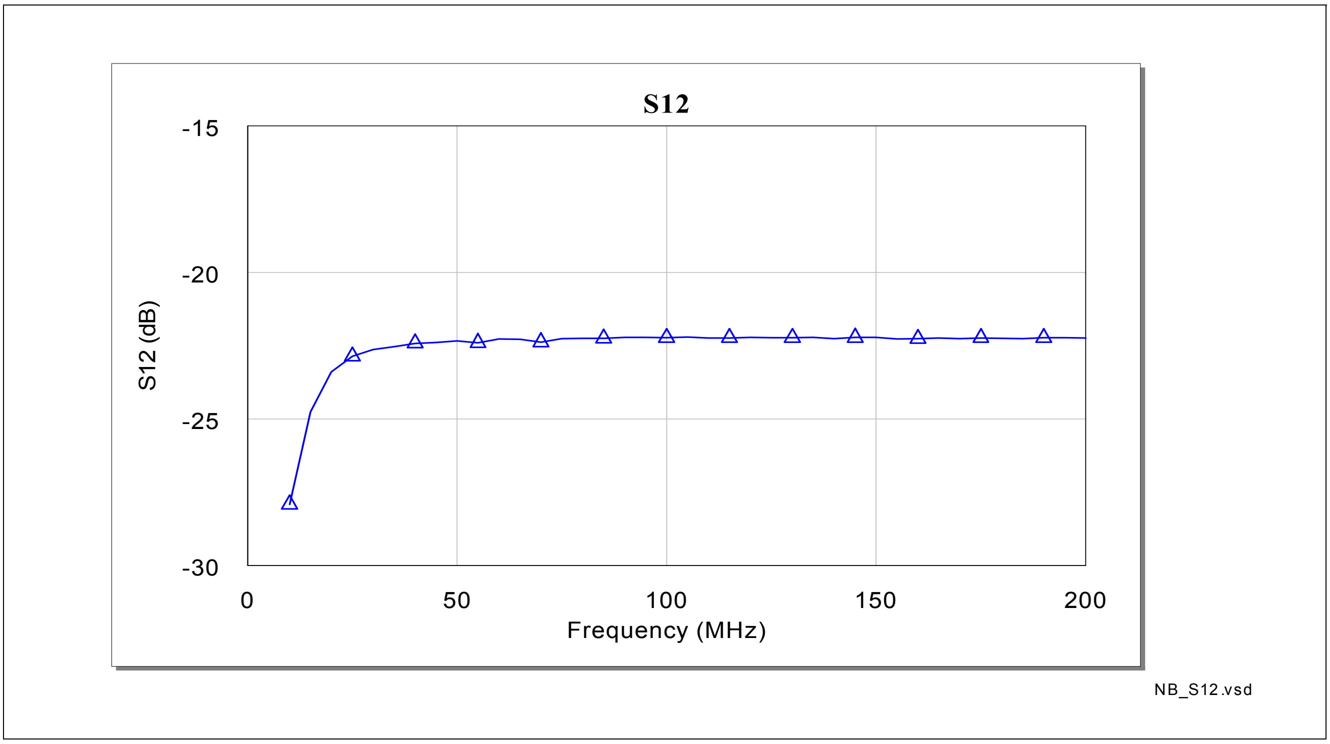

Figure 10 Isolation

4.2 Wideband stability

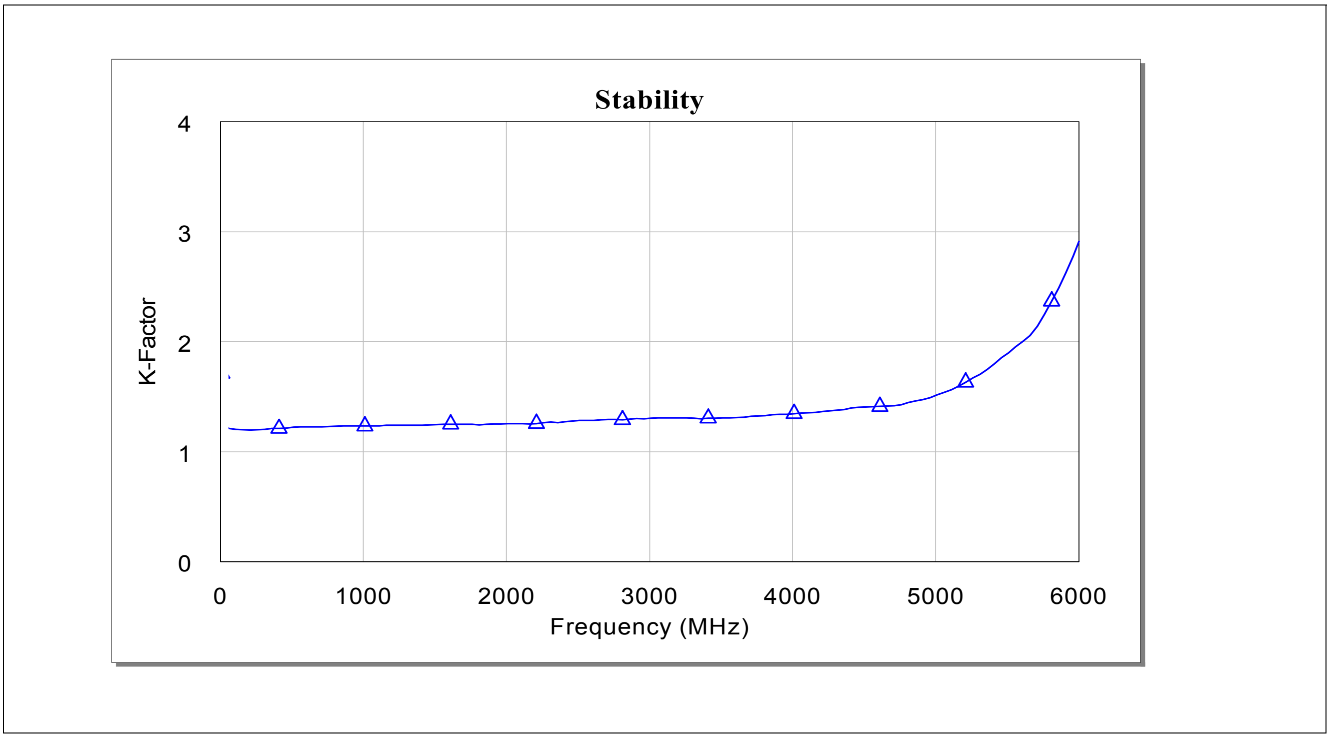

Figure 11 Stability