Design guide for RF low-noise transistor in UWB applications

RF bipolar transistor

About this document

Scope and purpose

This application note provides application circuit design examples with Infineon's low-noise silicon germanium: carbon (SiGe:C) transistors for ultra wideband (UWB) low-noise amplifiers (LNAs). In this document, the transistor-based LNA schematics, PCB layouts and measurement results are presented. This document is relevant to the following low-noise transistor:

- BGB707L7ESD Low-noise transistor for UWB

Intended audience

This document is intended for engineers who need to design LNAs for UWB applications.

Table of contents

About this document **1**
Table of contents **1**
1 Introduction **2**
1.1 UWB receiver 2
1.2 Infineon RF transistors family 3
2 UWB LNA circuit with BGB707L7ESD for 3.5 to 6.5 GHz frequency **4**
2.1 Performance overview 4
2.2 Schematic 4
2.3 Bill of materials 5
2.4 Evaluation board and layout information 6
2.5 Measurement results of the UWB LNA with BGB707L7ESD transistor 7
3 UWB LNA circuit with BGB707L7ESD for 6.5 to 8 GHz frequency **11**
3.1 Performance overview 11
3.2 Schematic 11
3.3 Bill of materials 12
3.4 Evaluation board and layout information 13
3.5 Measurement results of the UWB LNA with BGB707L7ESD transistor 14
4 Authors **18**
Revision history **19**

1 Introduction

1.1 UWB receiver

UWB is a rapidly emerging technology with uniquely attractive features that invite significant advances in wireless communication, network, radar, imaging and positioning systems. In 2002, the US Federal Communications Commission (FCC) proposed an enormous “new bandwidth” covering 3.6 to 10.1 GHz at the noise floor, where UWB radio overlaying coexistent RF systems can operate using low-power ultra-short information-bearing pulses.

UWB radios come with unique advantages, which include improved ability to penetrate obstacles, ultra-high precision ranging at the centimeter level, the potential for very high data rates along with a proportionate increase in user capacity, and potentially small size and processing power. IEEE 802.15.4 (2015) standard incorporates a UWB PHY into a personal area network standard and allows for power-efficient, high-data-rate communications together with accurate location estimation. The allocated frequency bands for UWB are 3.1 to 10.6 GHz in North America, 6 to 8.5 GHz in Europe, and 3.4 to 4.8 GHz, 7.25 to 10.25 GHz in Japan.

UWB radio characterizes transmission systems with instantaneous spectral occupancy of more than 500 MHz or a fractional bandwidth of more than 20 percent. Especially for wireless communications, the FCC-regulated power level is very low (below -41.3 dBm), which allows UWB technology to overlay GPS and IEEE 802.11 wireless local area networks (WLANs) that coexist in the 3.6 to 10.1 GHz band. To receive such low signal strength for a quiet broadband signal depends strongly on the first-stage signal amplification with a low measure of noise figure (NF) in the receiver. Broadband LNA can be built easily using an Infineon RF transistor with few external components. The Infineon RF LNA provides very low NF and high gain for wide bandwidth.

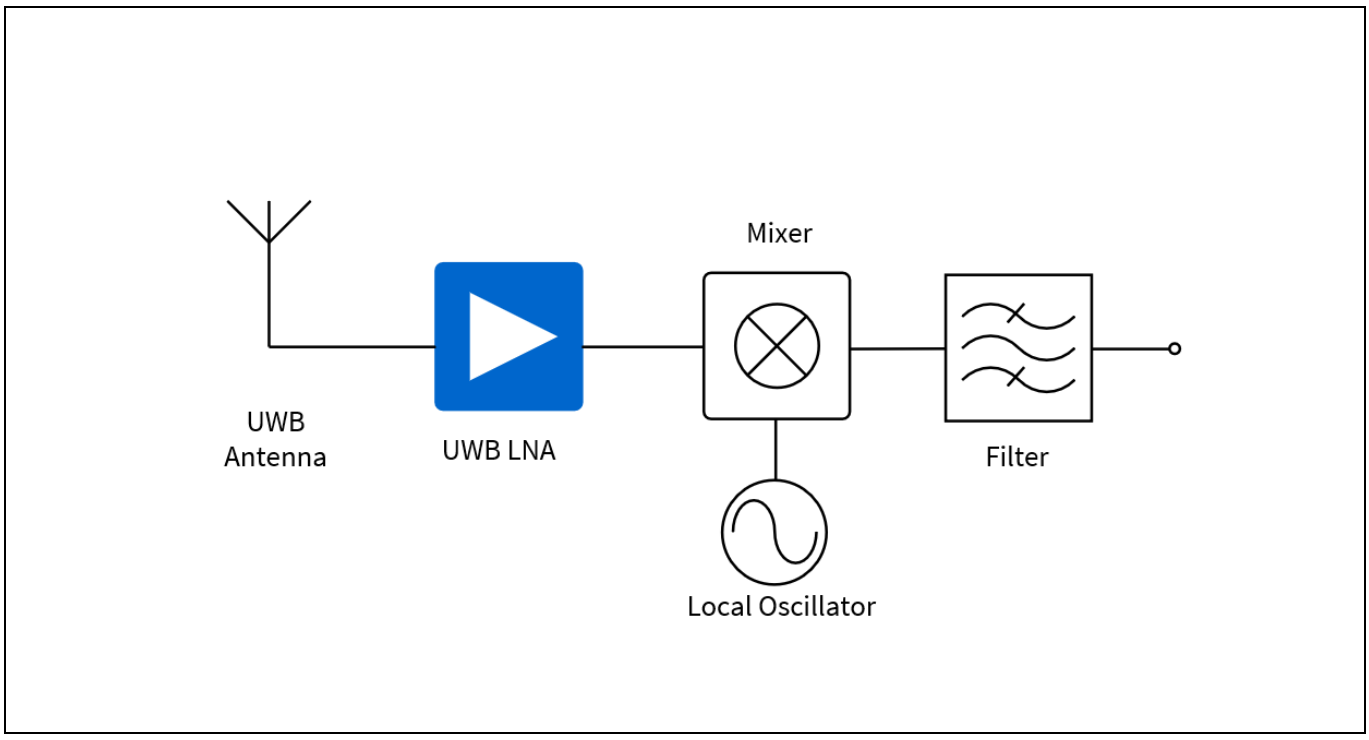

Figure 1 A block diagram example of the simplified UWB receiver system

1.2 Infineon RF transistors family

Infineon provides high-performance RF transistors targeting UWB LNA applications. Infineon's reliable high-volume RF transistors offer exceptionally low NF, high gain and high linearity at low power consumption levels for RF applications. The BGB707L7ESD is a SiGe:C low-noise monolithic microwave integrated circuit (MMIC) with integrated ESD protection and active biasing. The device is as flexible as discrete transistors and features high gain, reduced power consumption and very low distortion for a very wide range of applications.

2 UWB LNA circuit with BGB707L7ESD for 3.5 to 6.5 GHz frequency

2.1 Performance overview

The following table shows the UWB LNA performance with RF low-noise MMIC BGB707L7ESD at 3500, 5000 and 6500 MHz.

Table 1 Summary of measurement results for the UWB LNA with BGB707L7ESD transistor

Parameter	Symbol	Value			Unit	Notes
Device		BGB707L7ESD				
Bias voltage	V_{CC}	3.3			V	
Bias current	I_{CC}	9.7			mA	
Frequency	f	3500	5000	6500	MHz	
Gain	G	17.5	15.7	14.6	dB	
NF	NF	1.04	1.09	1.14	dB	PCB and SMA connector losses subtracted: 0.15 dB
Input return loss	RL_{in}	5.5	8.9	9.1	dB	
Output return loss	RL_{out}	7.6	8.3	9.4	dB	
Reverse isolation	ISO_{rev}	28.2	25.6	24.3	dB	
Output 1 dB compression point	OP_{1dB}	1.5	5.9	7.5	dBm	
Stability	K	More than 1				Measured from 10 MHz to 15 GHz

2.2 Schematic

The following figure shows the general schematic of the UWB LNA with low-noise MMIC BGB707L7ESD. In the circuit, the resistor R1 sets up the biasing current. The resistors R2 and R3 stabilize the circuit, whose stability is measured up to 15 GHz. The circuit input matching is achieved by the network of capacitors C1, C2 and the inductor L1. The network of L2, C4, C5 and C6 matches the transistor to the output port. The capacitor C3 serves as the RF bypass.

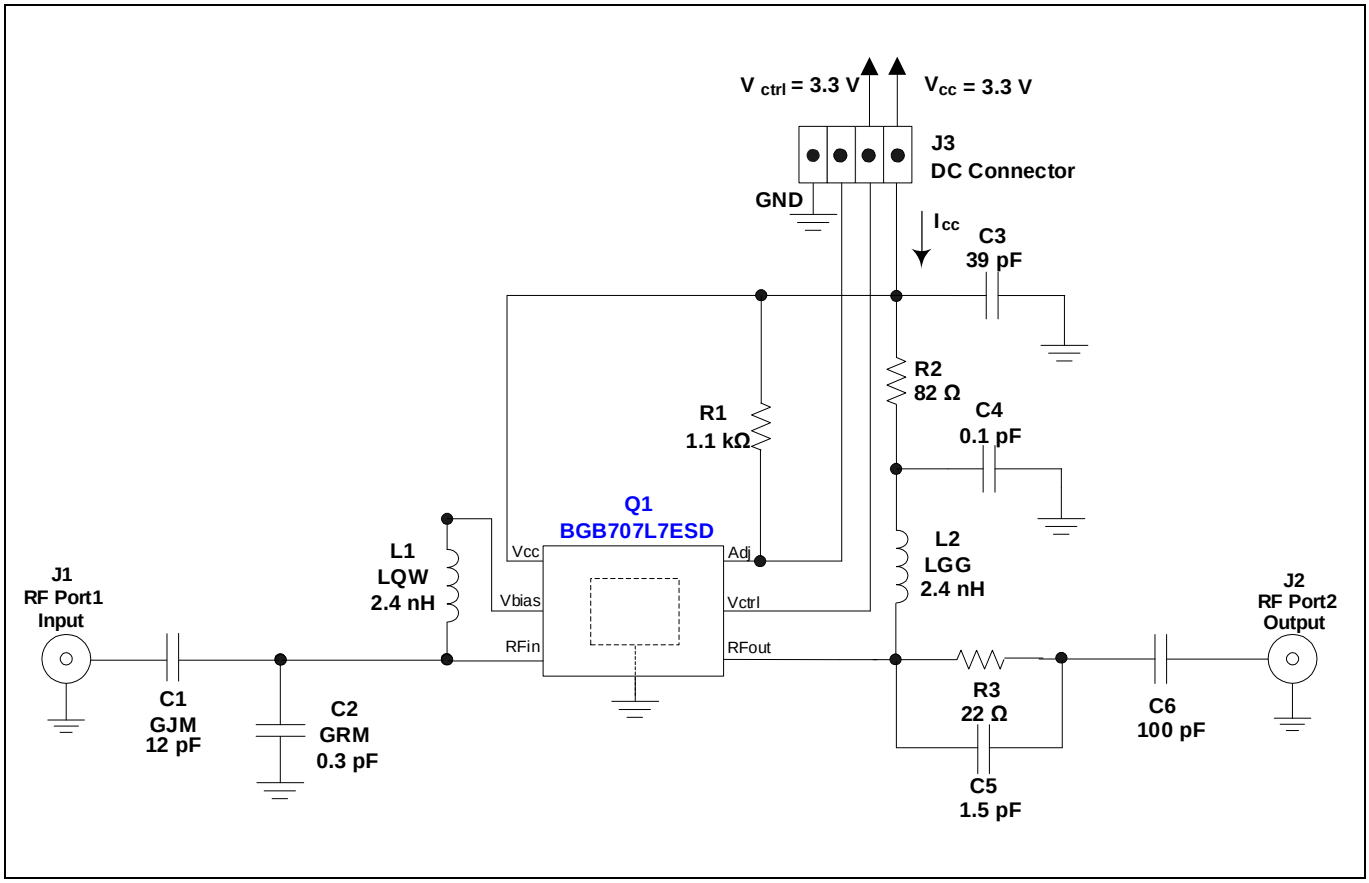

Figure 2 Schematic of the UWB LNA with BGB707L7ESD transistor

2.3 Bill of materials

Table 2 Bill of materials of the UWB LNA with BGB707L7ESD transistor

Symbol	Value	Unit	Package	Manufacturer	Comment
Q1	BGB707L7ESD		TSLP-7-1	Infineon Technologies	SiGe:C MMIC LNA
C1	12	pF	0402	Murata GJM	Input matching and DC block
C2	0.3	pF	0402	Murata GRM	Input matching
C3	39	pF	0402	Various	RF bypass
C4	0.1	pF	0402	Murata GRM	Output matching
C5	1.5	pF	0402	Murata GRM	Output matching
C6	100	pF	0402	Various	Output matching and DC block
L1	2.4	nH	0402	Murata LQW	DC feed and input matching
L2	2.4	nH	0402	Murata LQG	DC feed and output matching
R1	1.1	kΩ	0402	Various	Base bias
R2	82	Ω	0402	Various	Stability improvement
R3	22	Ω	0402	Various	Stability improvement

2.4 Evaluation board and layout information

The UWB LNA evaluation board with BGB707L7ESD transistor:

- PCB material: Rogers RO4003C
- PCB marking: BGB7 family V5.2 M170302

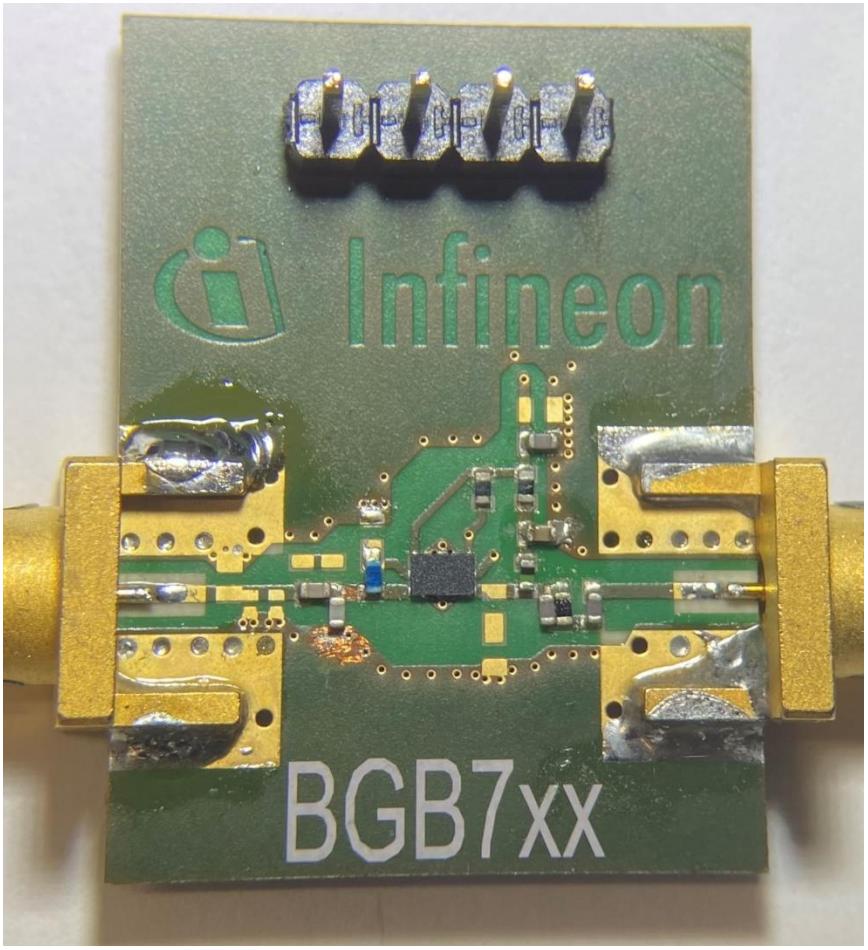

Figure 3 PCB layout and photo of the BGB707L7ESD UWB LNA evaluation board

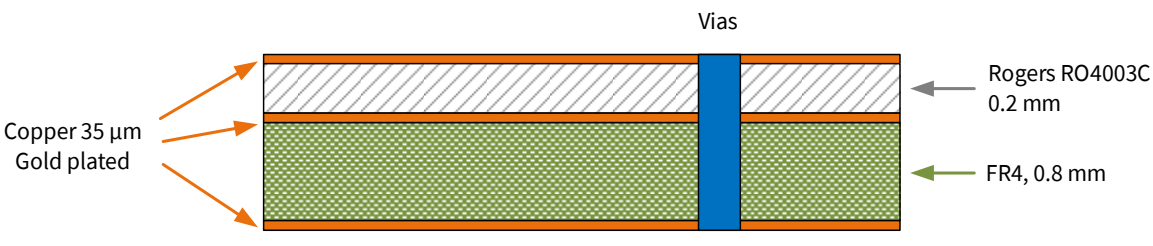

Figure 4 PCB stack information for the evaluation board

2.5 Measurement results of the UWB LNA with BGB707L7ESD transistor

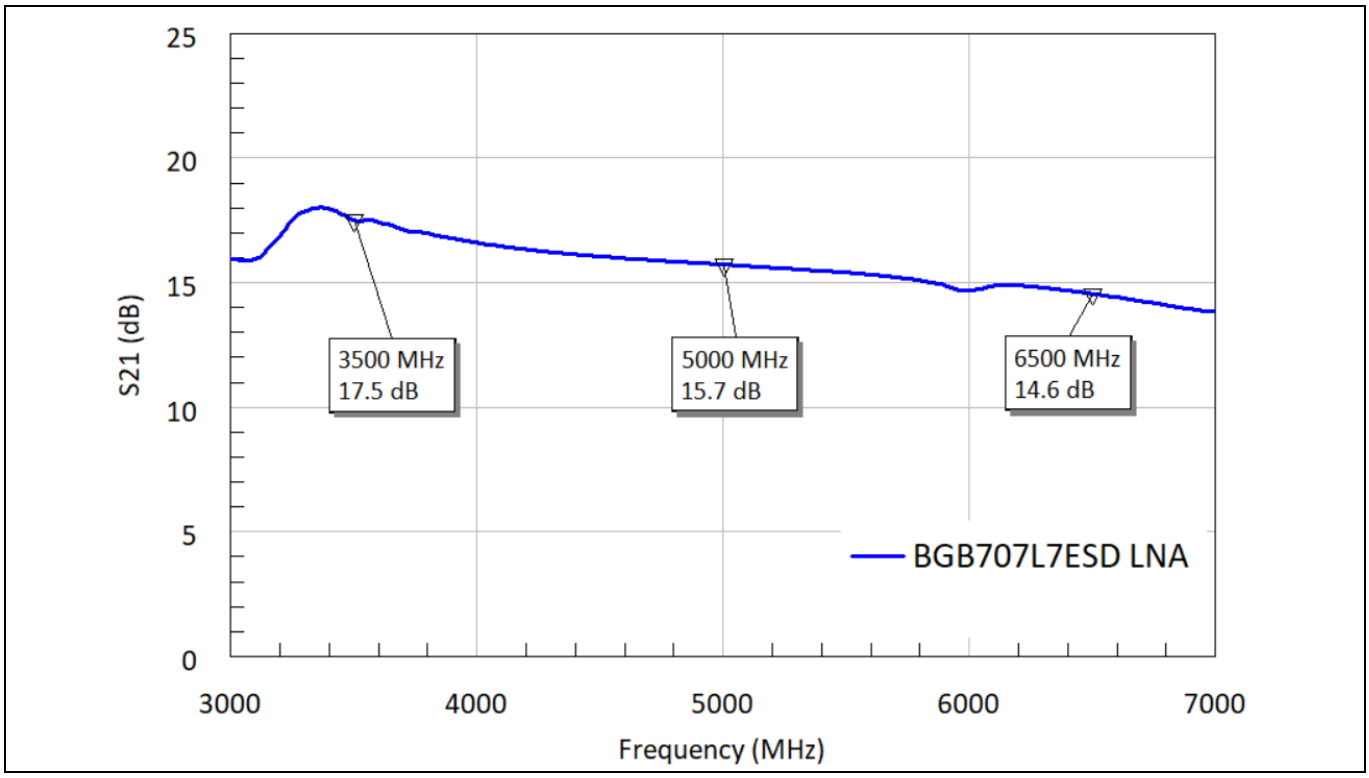

Figure 5 Small-signal gain of the UWB LNA with BGB707L7ESD transistor

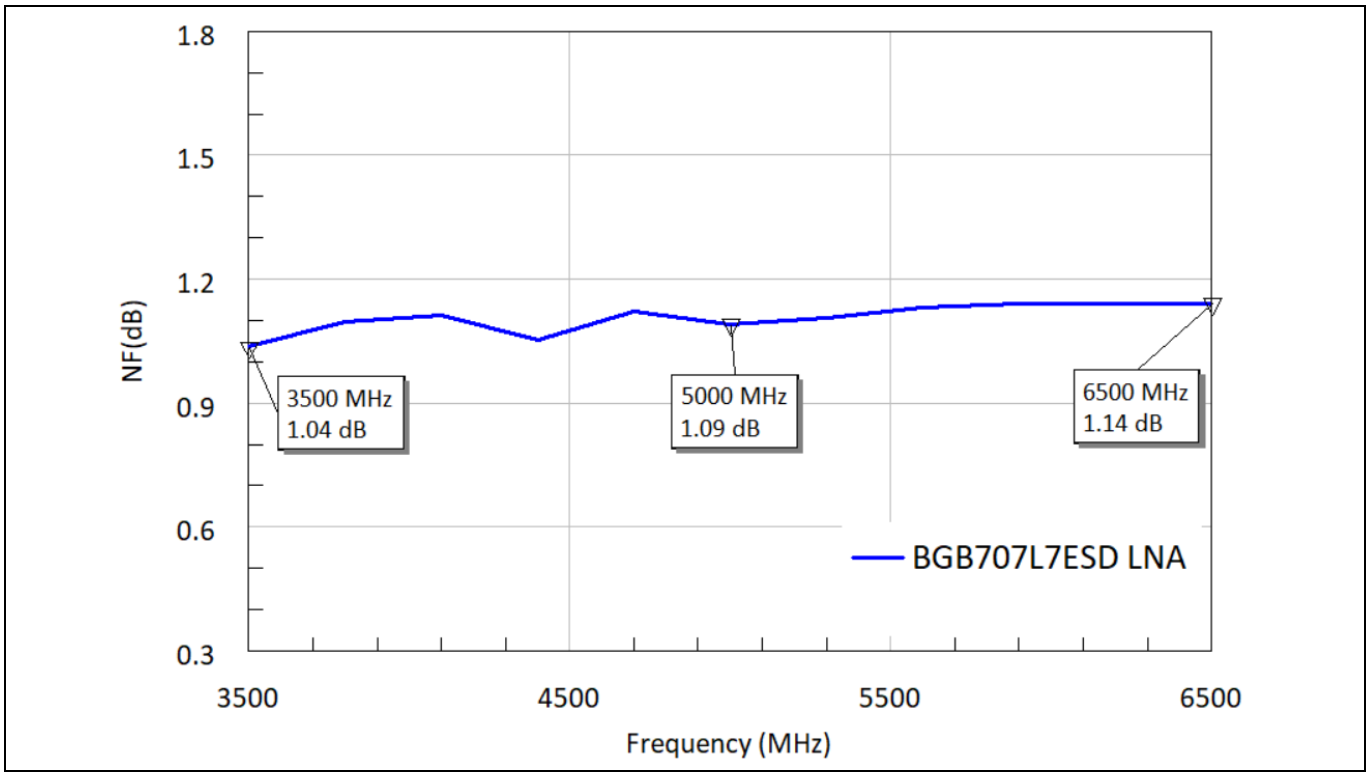

Figure 6 NF measurement of the UWB LNA with BGB707L7ESD transistor

Note: The graphs are generated with the AWR electronic design automation (EDA) software Microwave Office®.

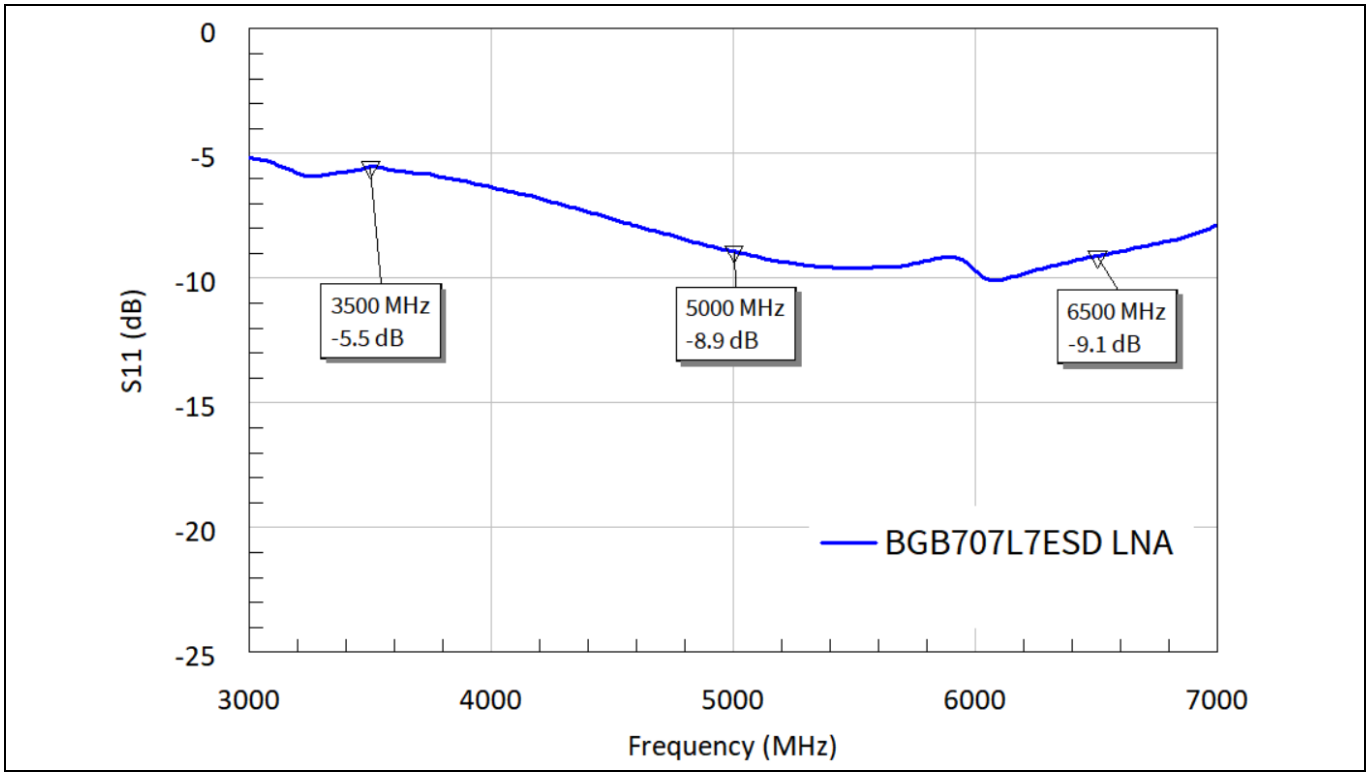

Figure 7 Input return loss of the UWB LNA with BGB707L7ESD transistor

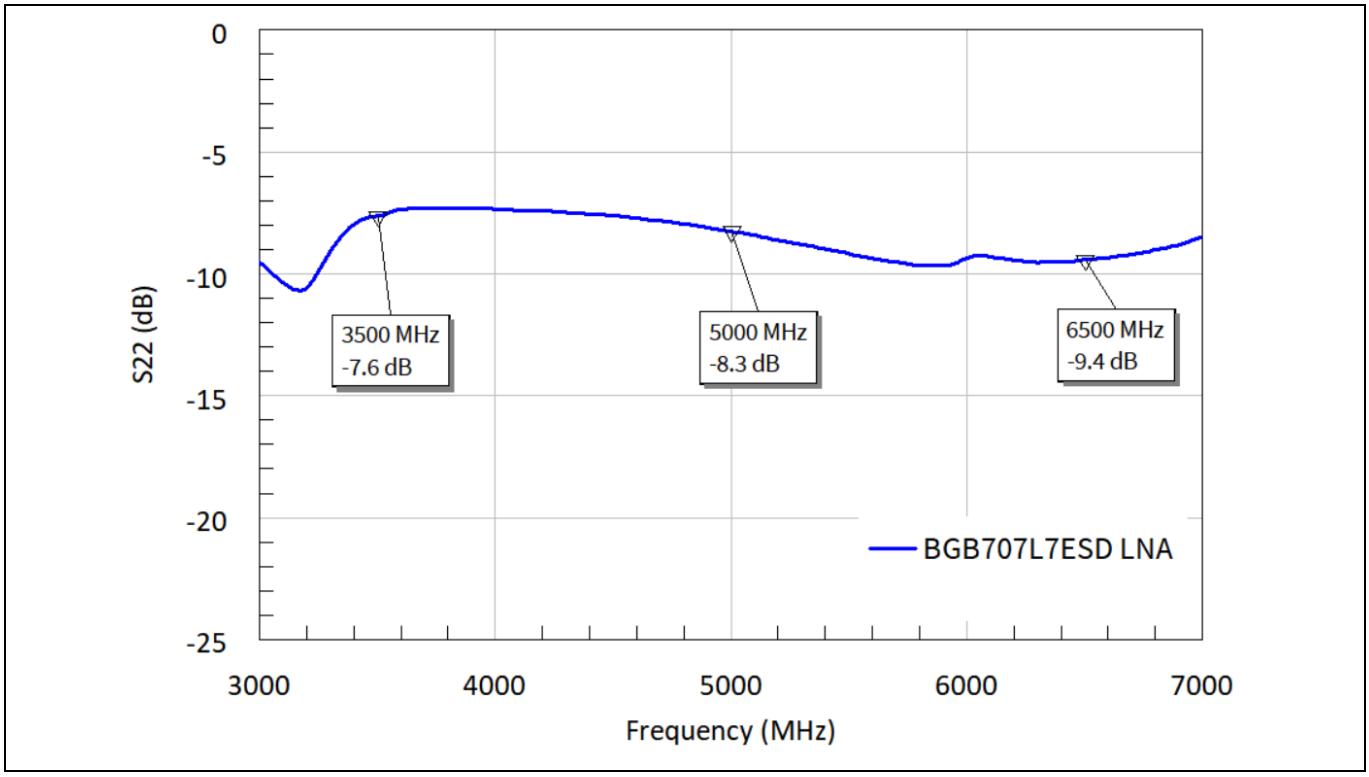

Figure 8 Output return loss of the UWB LNA with BGB707L7ESD transistor

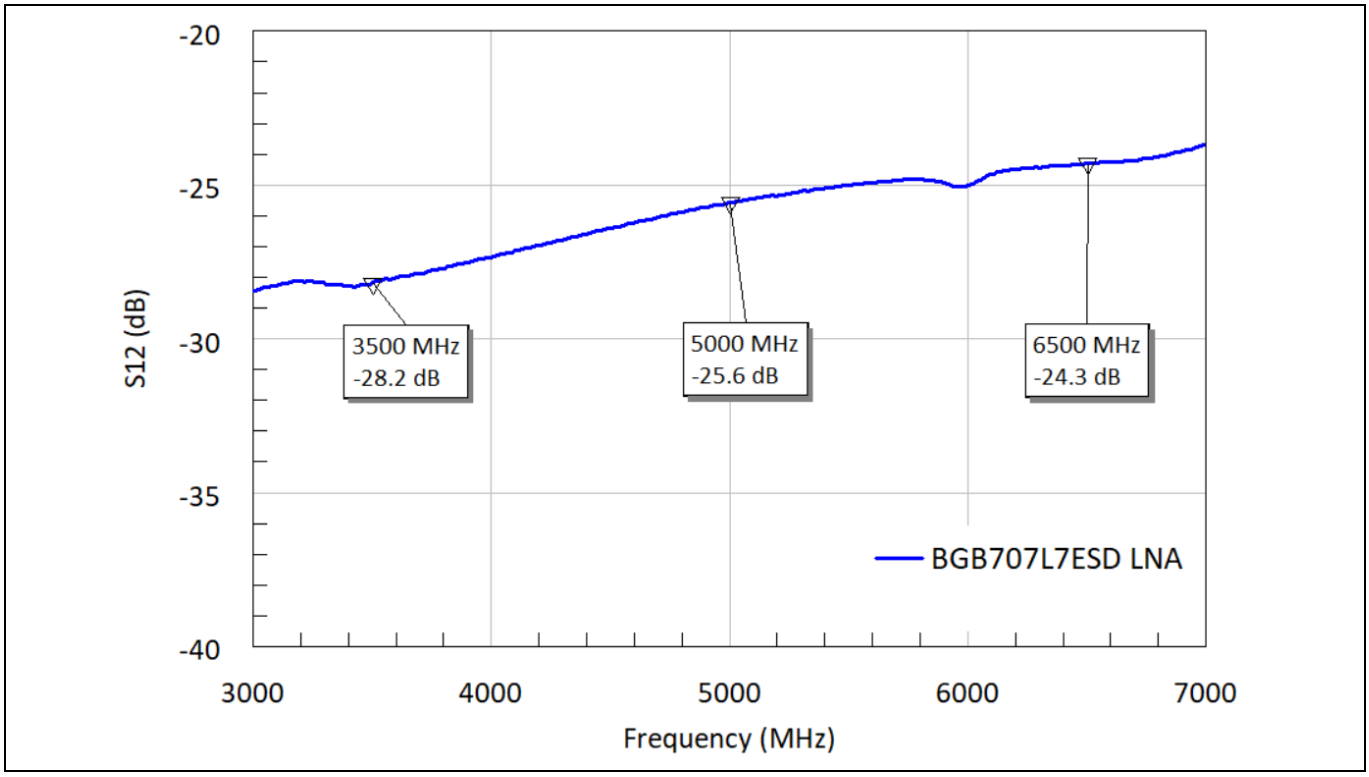

Figure 9 Reverse isolation of the UWB LNA with BGB707L7ESD transistor

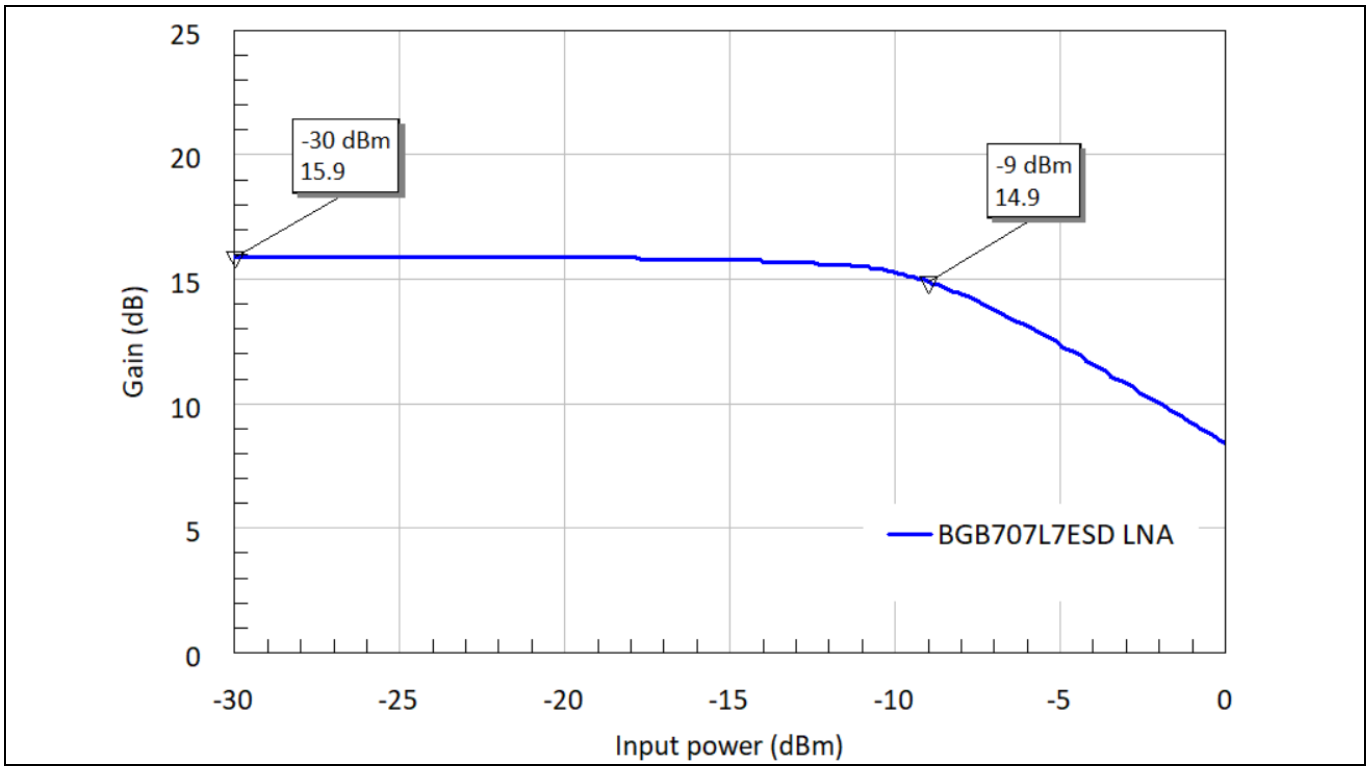

Figure 10 Input 1 dB compression point of the UWB LNA with BGB707L7ESD transistor at 5 GHz

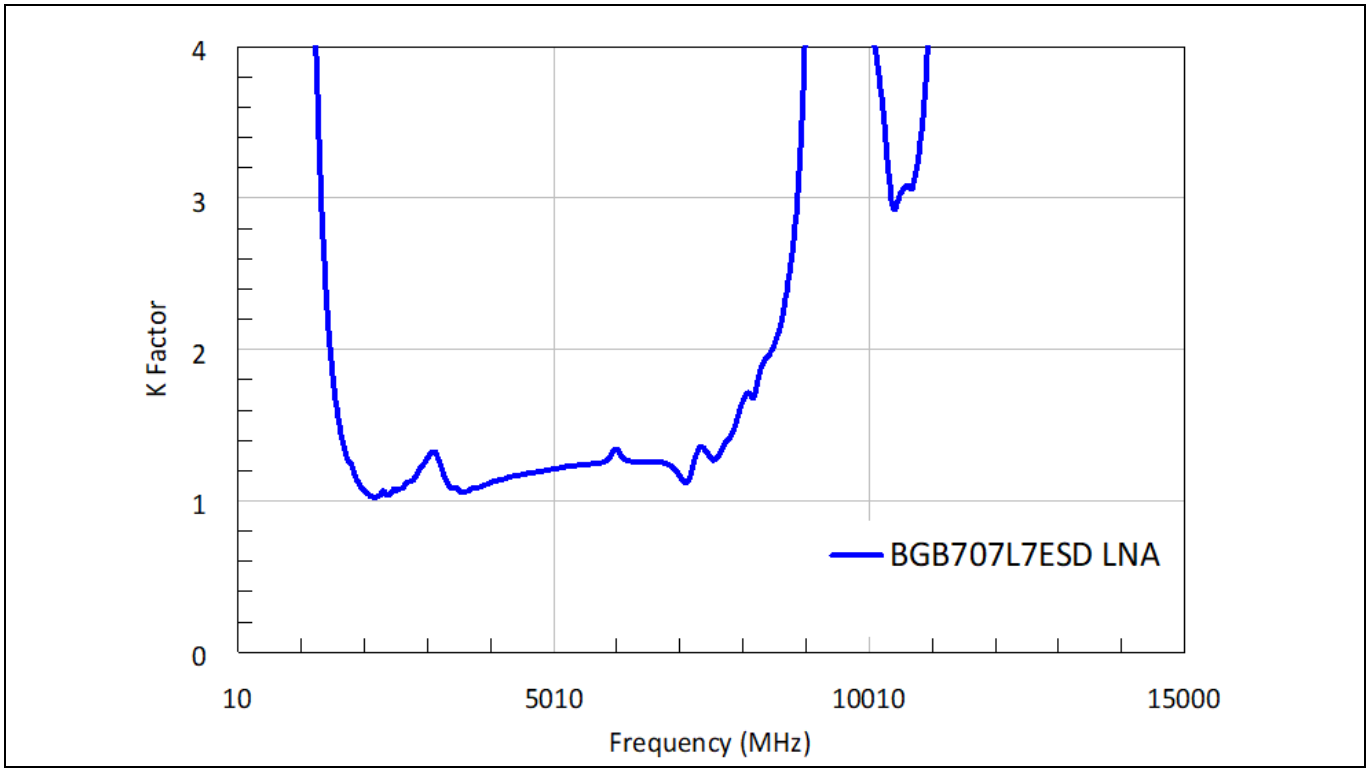

Figure 11 K-factor measurement of the UWB LNA with BGB707L7ESD transistor

3 UWB LNA circuit with BGB707L7ESD for 6.5 to 8 GHz frequency

3.1 Performance overview

The following table shows the UWB LNA performance with RF low-noise MMIC BGB707L7ESD at 6500, 7000, 7500 and 8000 MHz.

Table 3 Summary of measurement results for the UWB LNA with BGB707L7ESD transistor

Parameter	Symbol	Value				Unit	Notes
Device		BGB707L7ESD					
Bias voltage	V_{CC}	3.3				V	
Bias current	I_{CC}	9.7				mA	
Frequency	f	6500	7000	7500	8000	MHz	
Gain	G	13.8	13.4	12.8	12.2	dB	
NF	NF	1.23	1.09	1.04	1.11	dB	PCB and SMA connector losses subtracted: 0.15 dB
Input return loss	RL_{in}	12.4	9	6.5	5.1	dB	
Output return loss	RL_{out}	11.6	15.4	18.3	15.4	dB	
Reverse isolation	ISO_{rev}	27	26.3	26.1	26.2	dB	
Output 1 dB compression point	OP_{1dB}	6.2	5.7	5.9	6.9	dBm	
Stability	K	More than 1					Measured from 10 MHz to 15 GHz

3.2 Schematic

The following figure shows the general schematic of the UWB LNA with low-noise MMIC BGB707L7ESD. In the circuit, the resistor R1 sets up the biasing current. The resistors R2 and R3 stabilize the circuit, whose stability is measured up to 15 GHz. The circuit input matching is achieved by the network of capacitors C1, C2 and the inductor L1. The network of L2, C3, C5, and C6 matches the transistor to the output port. The capacitors C2 and C4 serve as the RF bypass.

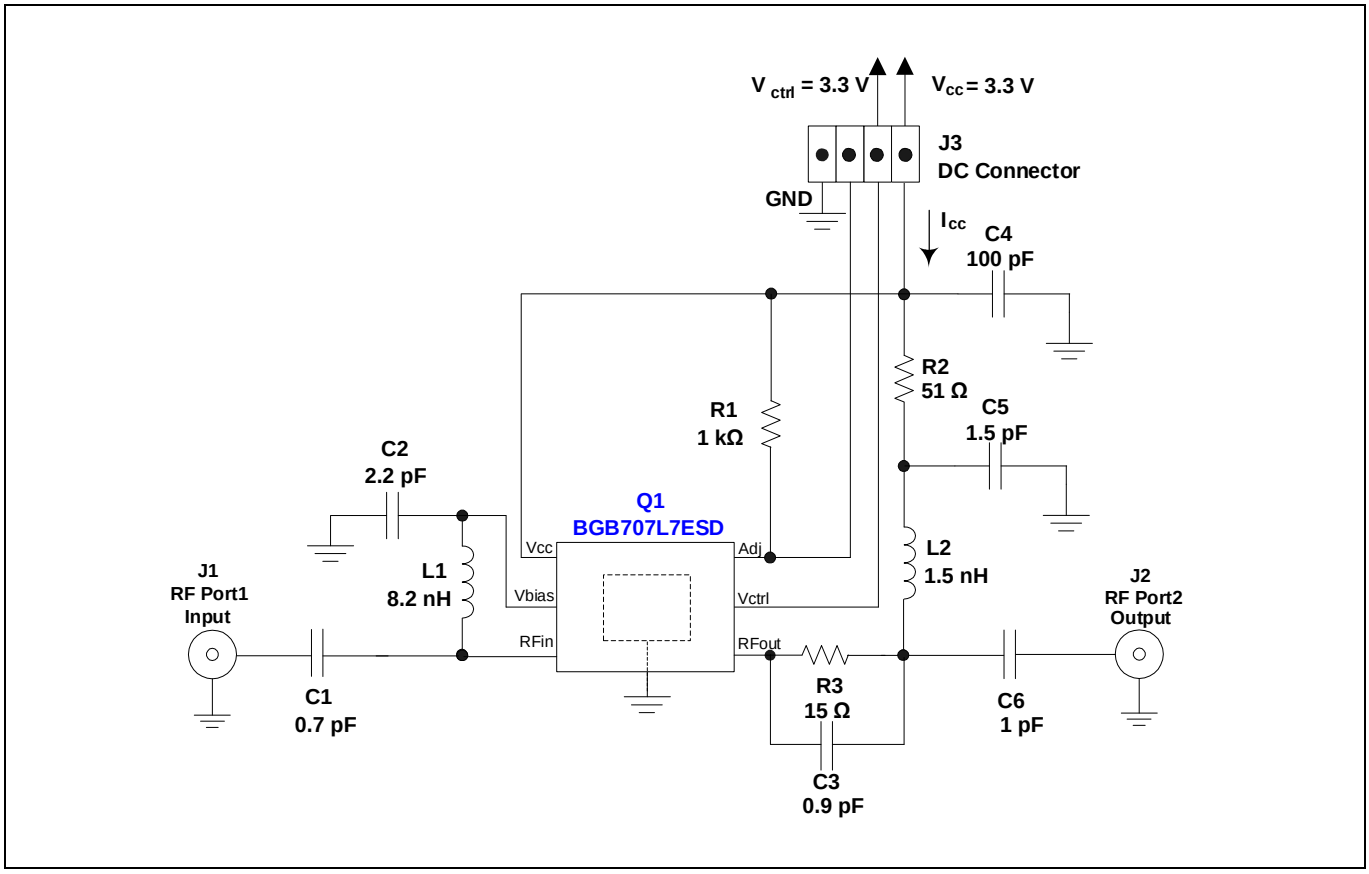

Figure 12 Schematic of the UWB LNA with BGB707L7ESD transistor

3.3 Bill of materials

Table 4 Bill of materials of the UWB LNA with BGB707L7ESD transistor

Symbol	Value	Unit	Package	Manufacturer	Comment
Q1	BGB707L7ESD		TSLP-7-1	Infineon Technologies	SiGe:C MMIC LNA
C1	0.7	pF	0402	Various	Input matching and DC block
C2	2.2	pF	0402	Various	RF bypass
C3	0.9	pF	0402	Various	Output matching
C4	100	pF	0402	Various	RF bypass
C5	1.5	pF	0402	Various	Low-frequency stability improvement
C6	1	pF	0402	Various	Output matching and DC block
L1	8.2	nH	0402	Murata LQW	DC feed and input matching
L2	1.5	nH	0402	Murata LQG	DC feed and output matching
R1	1	kΩ	0402	Various	Base bias
R2	51	Ω	0402	Various	Low-frequency stability improvement
R3	15	Ω	0201	Various	High-frequency stability improvement

3.4 Evaluation board and layout information

The UWB LNA evaluation board with BGB707L7ESD transistor:

- PCB material: Rogers RO4003C
- PCB marking: BGB7 family V5.2 M170302

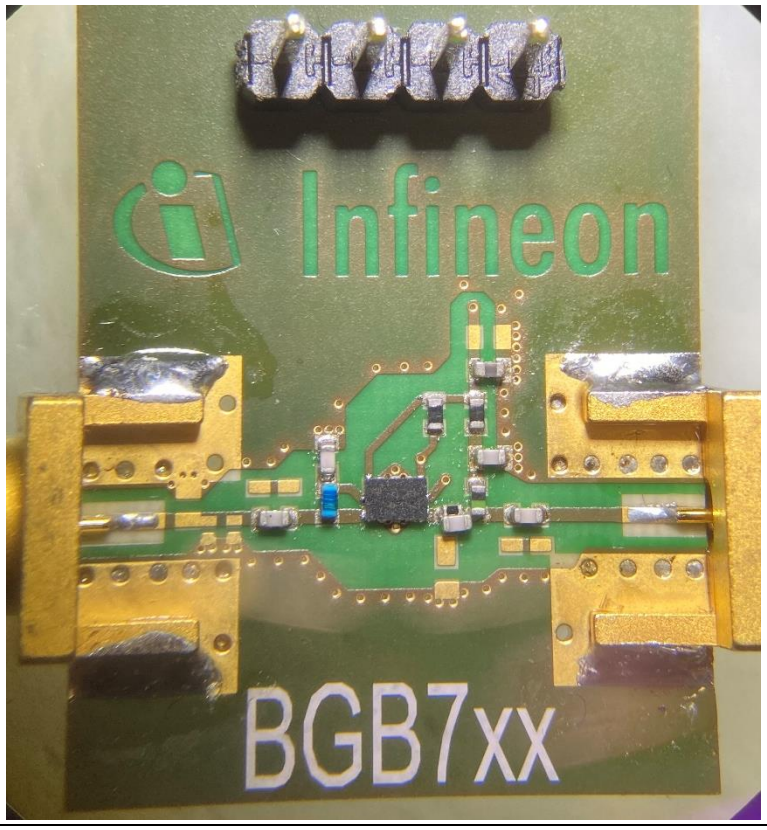

Figure 13 PCB layout and photo of the BGB707L7ESD UWB LNA evaluation board

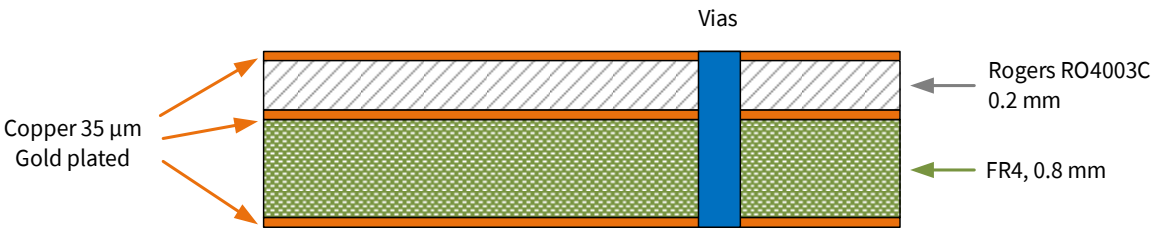

Figure 14 PCB stack information for the evaluation board

3.5 Measurement results of the UWB LNA with BGB707L7ESD transistor

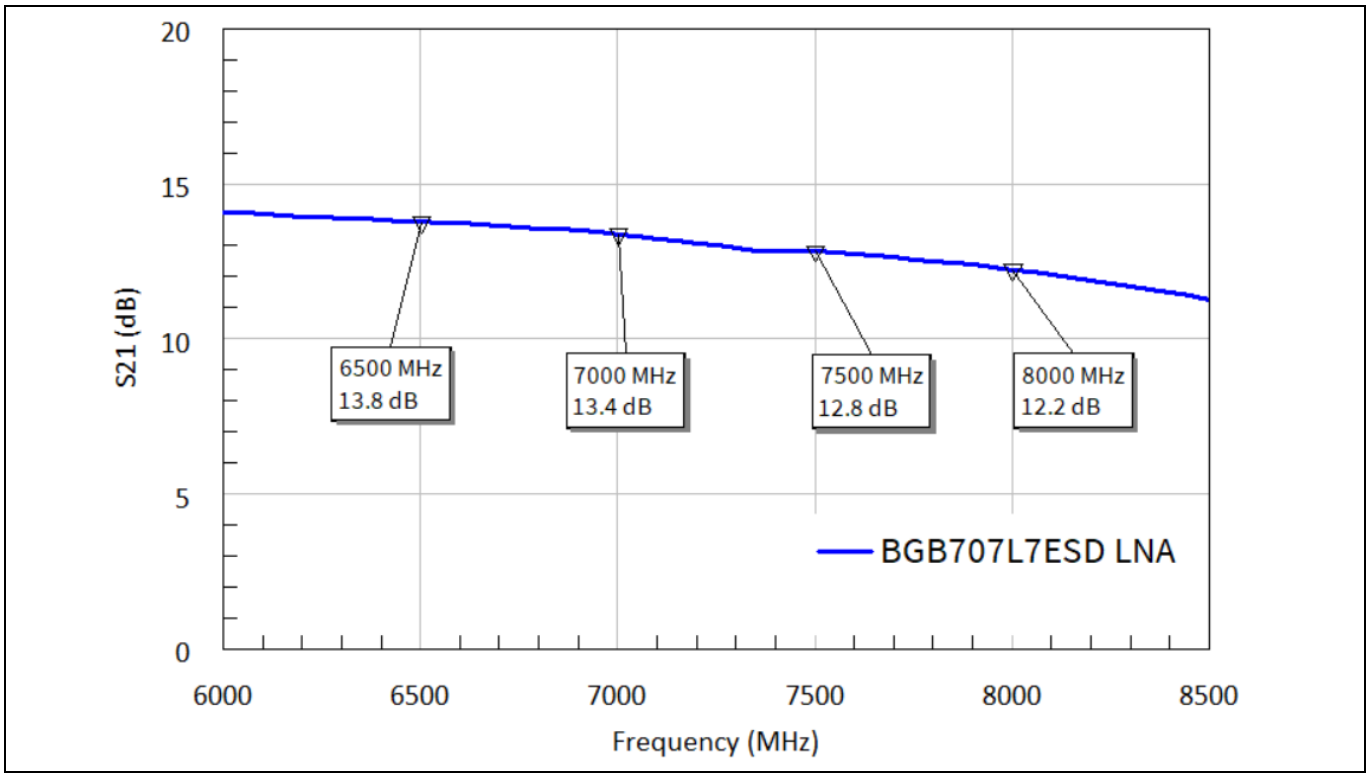

Figure 15 Small-signal gain of the UWB LNA with BGB707L7ESD transistor

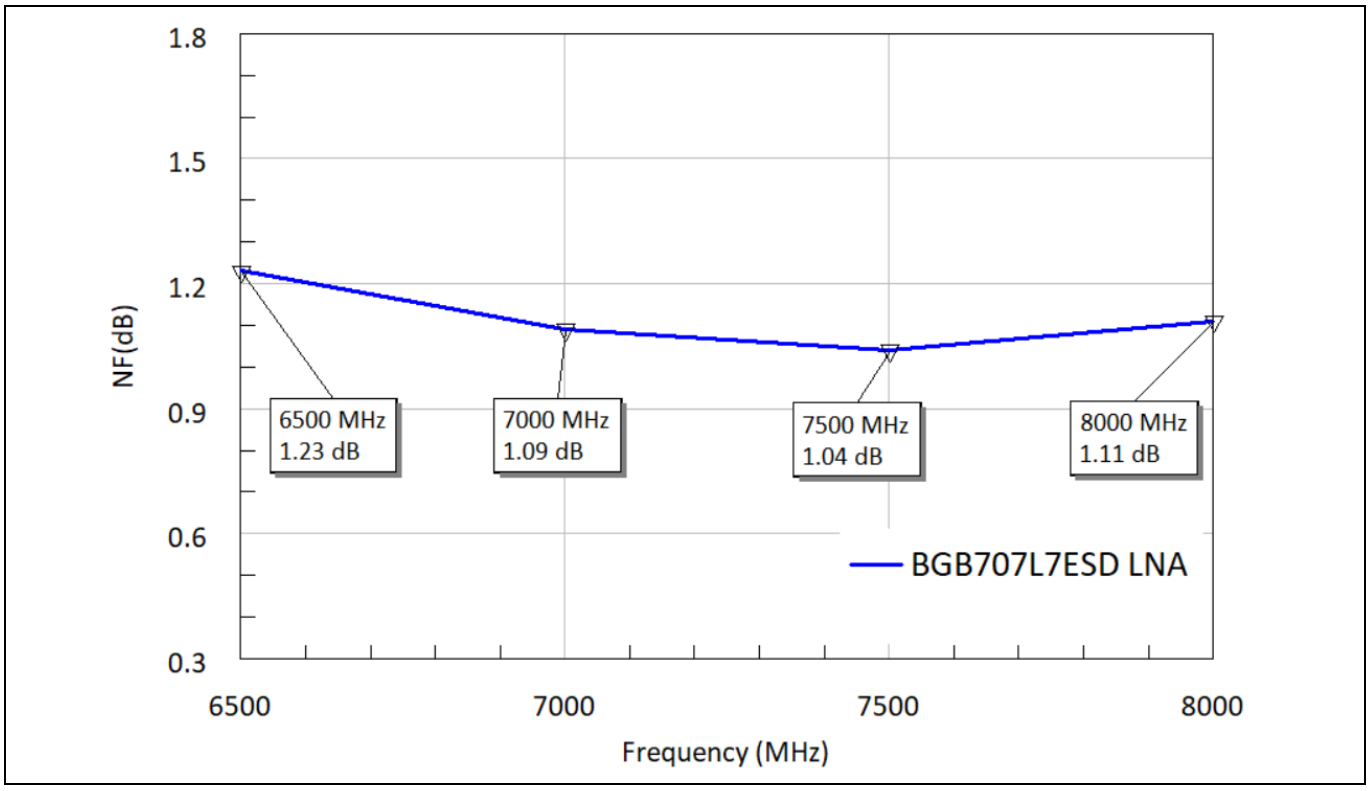

Figure 16 NF measurement of the UWB LNA with BGB707L7ESD transistor

Note: The graphs are generated with the AWR EDA software Microwave Office®.

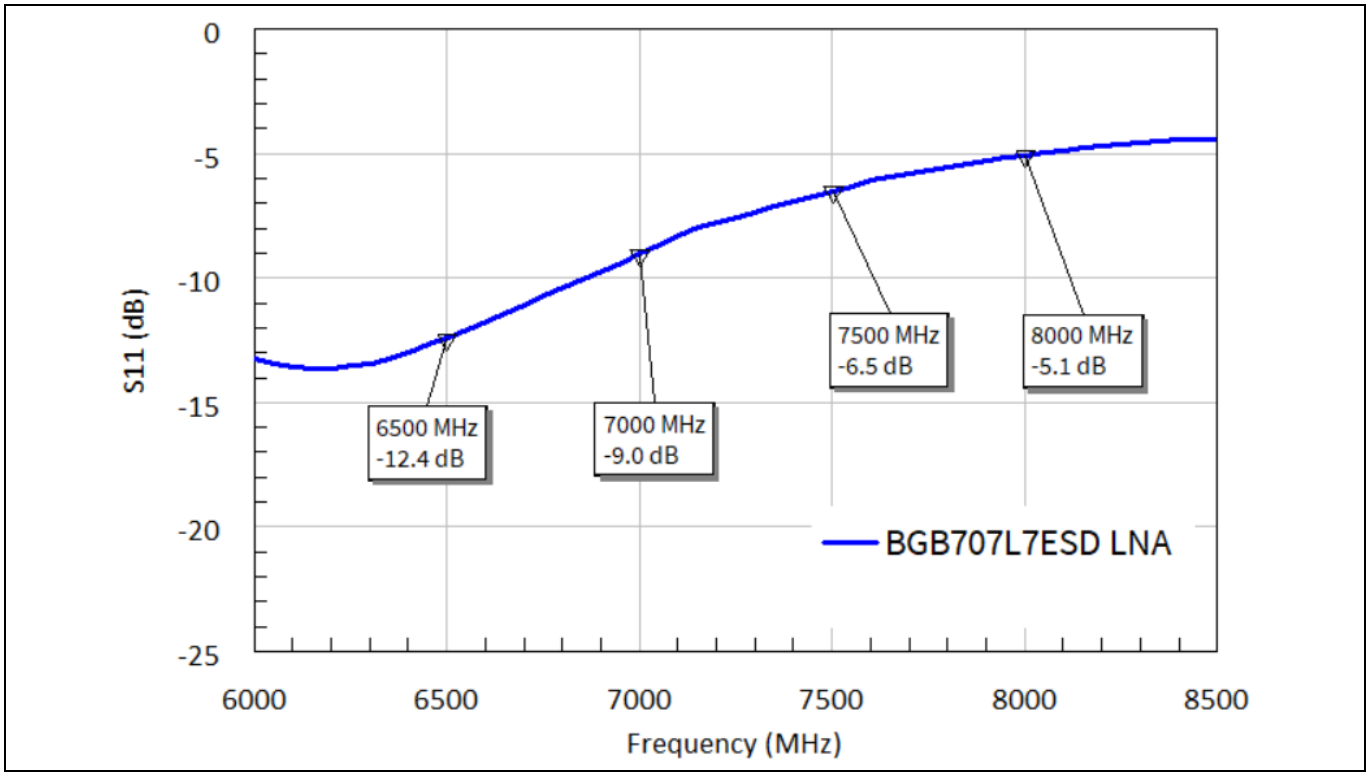

Figure 17 Input return loss of the UWB LNA with BGB707L7ESD transistor

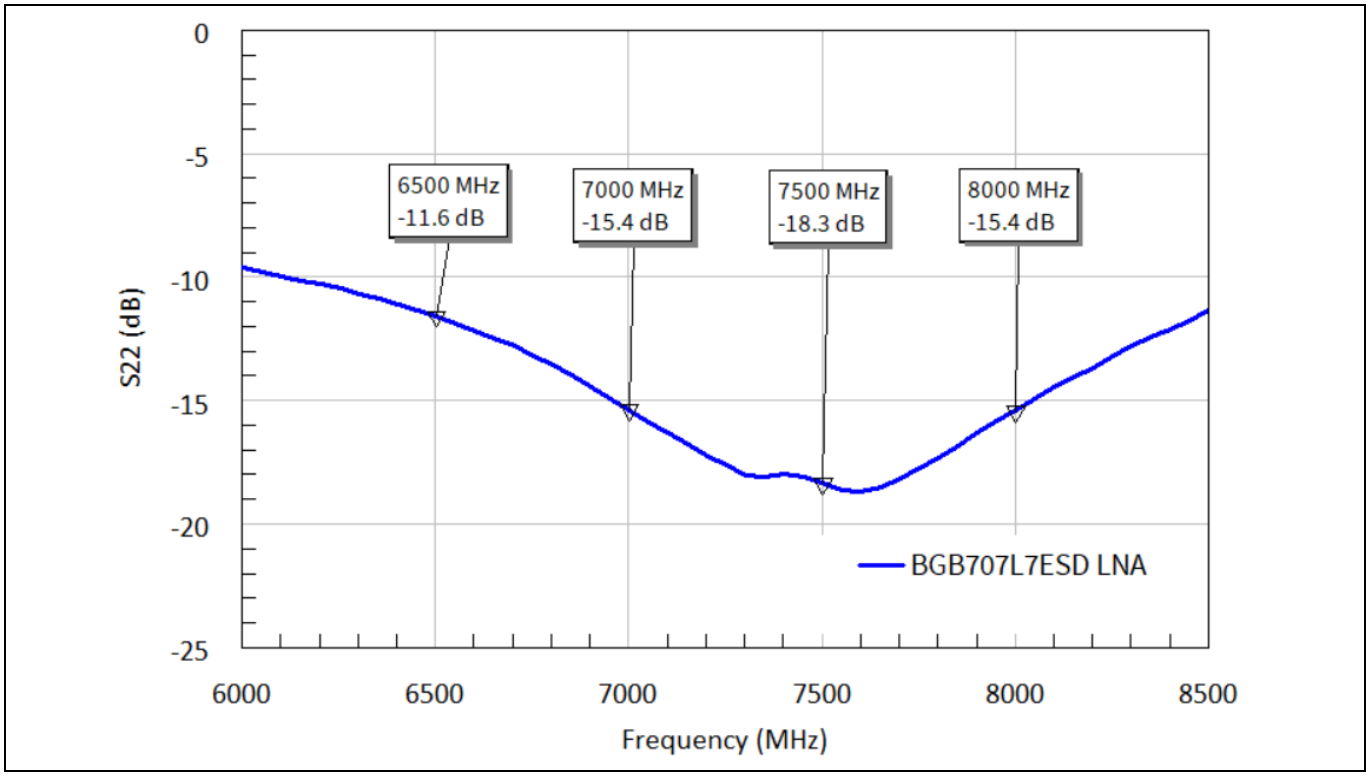

Figure 18 Output return loss of the UWB LNA with BGB707L7ESD transistor

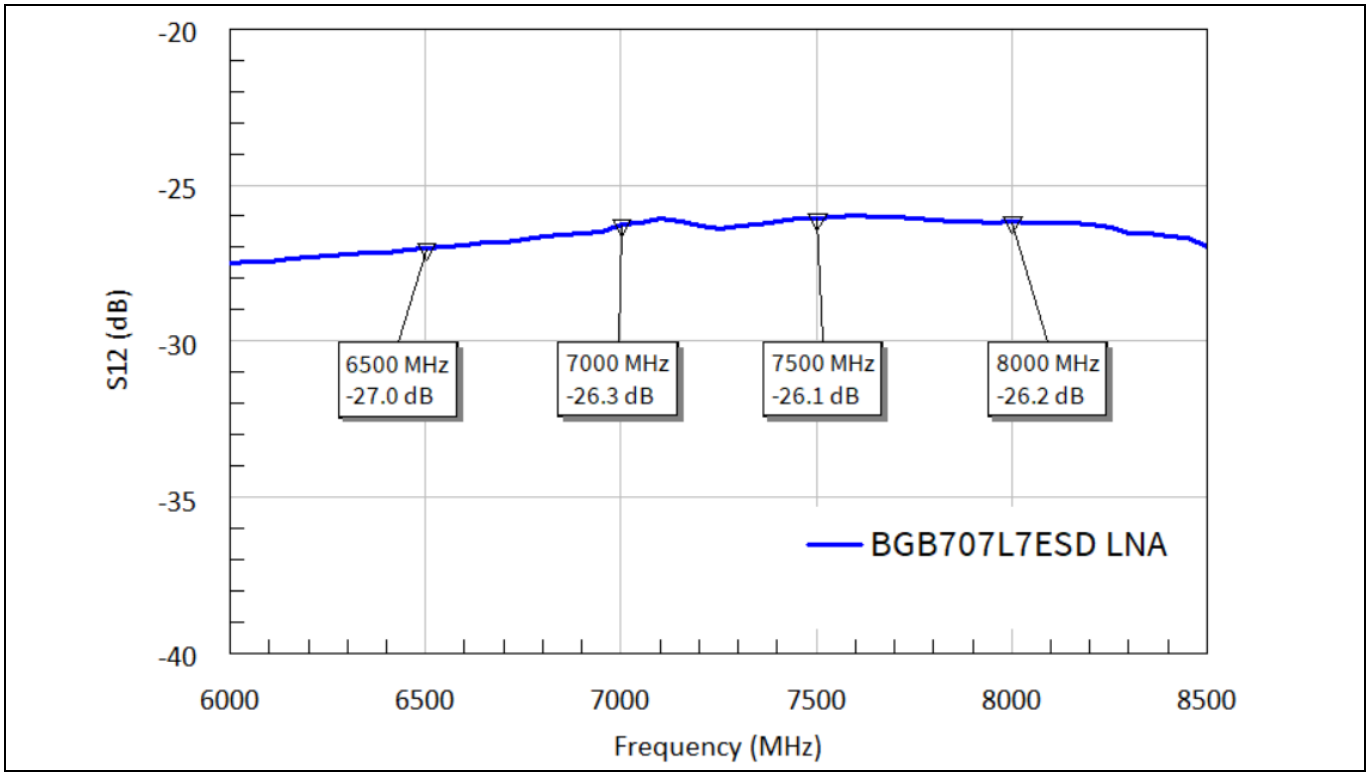

Figure 19 Reverse isolation of the UWB LNA with BGB707L7ESD transistor

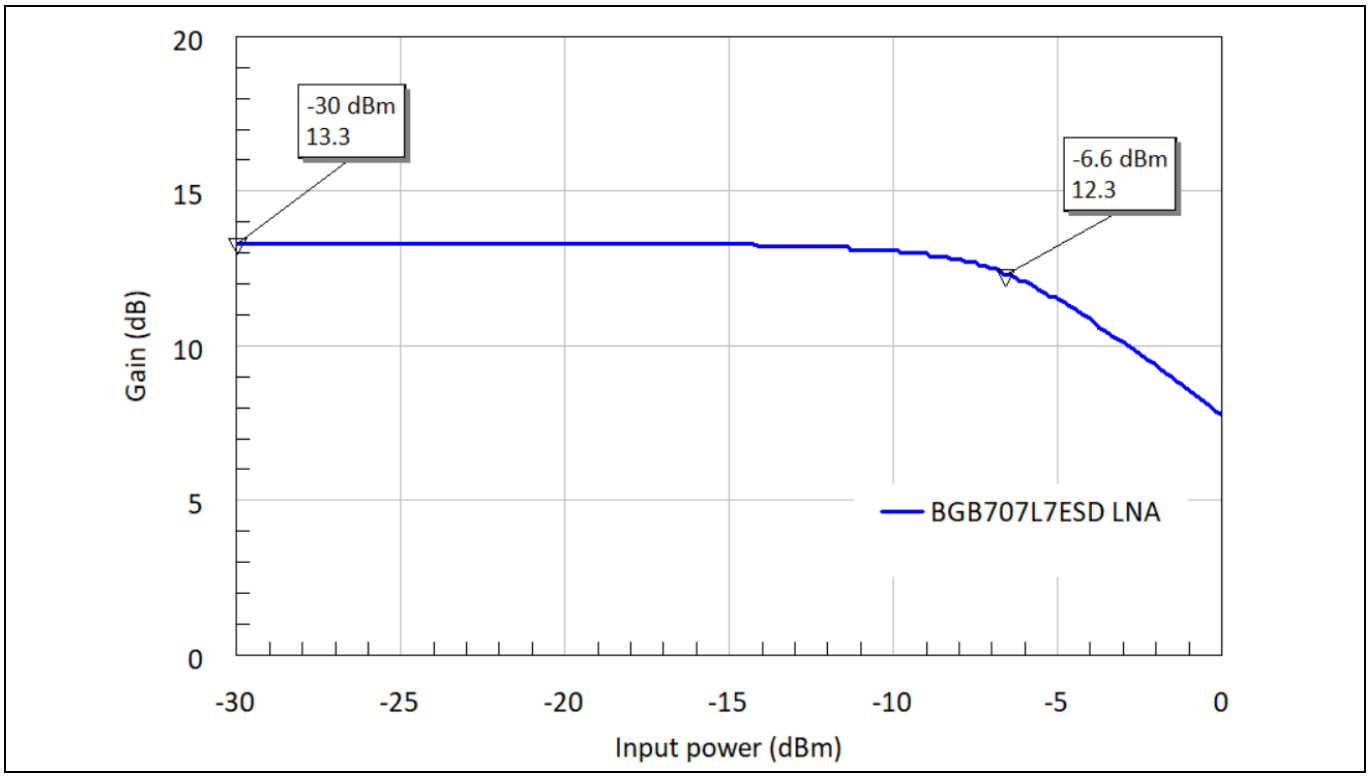

Figure 20 Input 1 dB compression point of the UWB LNA with BGB707L7ESD transistor at 7 GHz

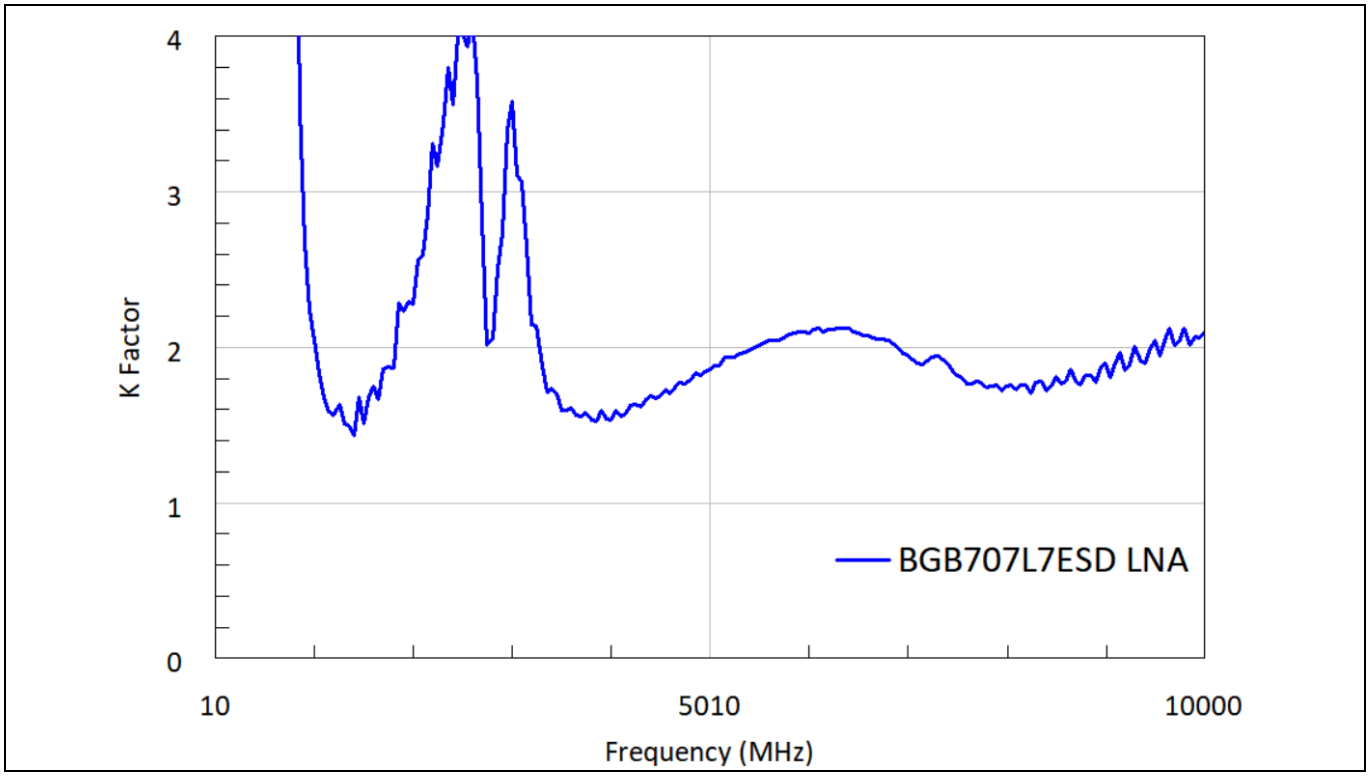

Figure 21 K-factor measurement of the UWB LNA with BGB707L7ESD transistor

4 Authors

Mamun Md Abdullah Al, RF application engineer of business unit RF and sensors

Mohammad Talha, RF application engineer of business unit RF and sensors

Atif Mehmood, RF application engineer of business unit RF and sensors

Revision history

Document version	Date of release	Description of changes
V1.0	2022-06-17	Application note release
V1.1	2022-11-02	Evaluation board pictures updated

Trademarks
All referenced product or service names and trademarks are the property of their respective owners.

Edition 2022-11-02

Published by

Infineon Technologies AG

81726 Munich, Germany

© 2022 Infineon Technologies AG. All Rights Reserved.

Do you have a question about this document?

Email: erratum@infineon.com

Document reference
AN_2205_PL55_2206_160457

IMPORTANT NOTICE

The information contained in this application note is given as a hint for the implementation of the product only and shall in no event be regarded as a description or warranty of a certain functionality, condition or quality of the product. Before implementation of the product, the recipient of this application note must verify any function and other technical information given herein in the real application. Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind (including without limitation warranties of non-infringement of intellectual property rights of any third party) with respect to any and all information given in this application note.

The data contained in this document is exclusively intended for technically trained staff. It is the responsibility of customer's technical departments to evaluate the suitability of the product for the intended application and the completeness of the product information given in this document with respect to such application.

For further information on the product, technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies office (**www.infineon.com**).

WARNINGS

Due to technical requirements products may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies office.

Except as otherwise explicitly approved by Infineon Technologies in a written document signed by authorized representatives of Infineon Technologies, Infineon Technologies' products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury.