

# BFP840FESD

Low Noise Amplifier for 3.4GHz-  
3.8GHz (Band 42/ 43)

## Technical Report TR1129

Revision: Rev. 1.1  
2013-06-05

**Edition 2013-06-05**

**Published by  
Infineon Technologies AG  
81726 Munich, Germany**

**© 2013 Infineon Technologies AG  
All Rights Reserved.**

#### **Legal Disclaimer**

The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics. With respect to any examples or hints given herein, any typical values stated herein and/or any information regarding the application of the device, 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.

#### **Information**

For further information on technology, delivery terms and conditions and prices, please contact the nearest Infineon Technologies Office ([www.infineon.com](http://www.infineon.com)).

#### **Warnings**

Due to technical requirements, components may contain dangerous substances. For information on the types in question, please contact the nearest Infineon Technologies Office.

Infineon Technologies components may be used in life-support devices or systems only with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.

**Technical Report TR1129**

**Revision History: 2013-06-05**

**Previous Revision:**

Page	Subjects (major changes since last revision)
17 to 22	Figure 17 to Figure 28: Temperature measurement results are included

**Trademarks of Infineon Technologies AG**

AURIX™, C166™, CanPAK™, CIPOS™, CIPURSE™, EconoPACK™, CoolMOS™, CoolSET™, CORECONTROL™, CROSSAVE™, DAVE™, DI-POL™, EasyPIM™, EconoBRIDGE™, EconoDUAL™, EconoPIM™, EconoPACK™, EiceDRIVER™, eupec™, FCOS™, HITFET™, HybridPACK™, I<sup>2</sup>RF™, ISOFACE™, IsoPACK™, MIPAQ™, ModSTACK™, my-d™, NovalithIC™, OptiMOS™, ORIGA™, POWERCODE™, PRIMARION™, PrimePACK™, PrimeSTACK™, PRO-SIL™, PROFET™, RASIC™, ReverSave™, SatRIC™, SIEGET™, SINDRION™, SIPMOS™, SmartLEWIS™, SOLID FLASH™, TEMPFET™, thinQ!™, TRENCHSTOP™, TriCore™.

**Other Trademarks**

Advance Design System™ (ADS) of Agilent Technologies, AMBA™, ARM™, MULTI-ICE™, KEIL™, PRIMECELL™, REALVIEW™, THUMB™, µVision™ of ARM Limited, UK. AUTOSAR™ is licensed by AUTOSAR development partnership. Bluetooth™ of Bluetooth SIG Inc. CAT-iq™ of DECT Forum. COLOSSUS™, FirstGPS™ of Trimble Navigation Ltd. EMV™ of EMVCo, LLC (Visa Holdings Inc.). EPCOS™ of Epcos AG. FLEXGO™ of Microsoft Corporation. FlexRay™ is licensed by FlexRay Consortium. HYPERTERMINAL™ of Hilgraeve Incorporated. IEC™ of Commission Electrotechnique Internationale. IrDA™ of Infrared Data Association Corporation. ISO™ of INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. MATLAB™ of MathWorks, Inc. MAXIM™ of Maxim Integrated Products, Inc. MICROTEC™, NUCLEUS™ of Mentor Graphics Corporation. MIPI™ of MIPI Alliance, Inc. MIPS™ of MIPS Technologies, Inc., USA. muRata™ of MURATA MANUFACTURING CO., MICROWAVE OFFICE™ (MWO) of Applied Wave Research Inc., OmniVision™ of OmniVision Technologies, Inc. Openwave™ Openwave Systems Inc. RED HAT™ Red Hat, Inc. RFMD™ RF Micro Devices, Inc. SIRIUS™ of Sirius Satellite Radio Inc. SOLARIS™ of Sun Microsystems, Inc. SPANSION™ of Spansion LLC Ltd. Symbian™ of Symbian Software Limited. TAIYO YUDEN™ of Taiyo Yuden Co. TEAKLITE™ of CEVA, Inc. TEKTRONIX™ of Tektronix Inc. TOKO™ of TOKO KABUSHIKI KAISHA TA. UNIX™ of X/Open Company Limited. VERILOG™, PALLADIUM™ of Cadence Design Systems, Inc. VLYNQ™ of Texas Instruments Incorporated. VXWORKS™, WIND RIVER™ of WIND RIVER SYSTEMS, INC. ZETEX™ of Diodes Zetex Limited.

Last Trademarks Update 2011-11-11

## Table of Content

<b>1</b>	<b>Application Circuit and Performance Overview.....</b>	<b>5</b>
1.1	Summary of Measurement Results.....	5
1.2	High Gain Low Noise Amplifier using BFP840FESD for 3.4 – 3.8 GHz LTE Application .....	6
1.3	Schematics and Bill-of-Materials.....	8
<b>2</b>	<b>Measured Graphs .....</b>	<b>10</b>
<b>3</b>	<b>Evaluation Board and layout Information.....</b>	<b>23</b>
<b>4</b>	<b>Authors.....</b>	<b>25</b>

## List of Figures

Figure 1	Package and pin connections of BFP840FESD in Topview .....	6
Figure 2	Schematics of BFP840FESD Low Noise Amplifier for 3.4 – 3.8 GHz Application.....	8
Figure 3	Insertion Power Gain of the 3.4 – 3.8 GHz LNA with BFP840FESD .....	10
Figure 4	Wideband Insertion Power Gain of the 3.4 – 3.8 GHz LNA with BFP840FESD.....	10
Figure 5	Noise Figure of BFP840FESD LNA for 3400 - 2500 MHz .....	11
Figure 6	Reverse Isolation of the 3.4 – 3.8 GHz LNA with BFP840FESD.....	11
Figure 7	Input Matching of the 3.4 – 3.8 GHz LNA with BFP840FESD .....	12
Figure 8	Input Matching of the 3.4 – 3.8 GHz LNA with BFP840FESD (Smith Chart) .....	12
Figure 9	Output Matching of the 3.4 – 3.8 GHz LNA with BFP840FESD .....	13
Figure 10	Output Matching of the 3.4 – 3.8 GHz LNA with BFP840FESD (Smith Chart).....	13
Figure 11	Wideband Stability k Factor of the 3.4 – 3.8 GHz LNA with BFP840FESD.....	14
Figure 12	Wideband Stability Mu Factor of the 3.4 – 3.8 GHz LNA with BFP840FESD.....	14
Figure 13	1dB Compression Point of the BFP840FESD Circuit at 3600 MHz.....	15
Figure 14	Output 3 <sup>rd</sup> Order Intercept Point of BFP840FESD at 3600 MHz.....	15
Figure 15	OFF-Mode (Vcc = 0V, Icc = 0mA) S21 of the 3.4 – 3.8 GHz LNA with BFP840FESD.....	16
Figure 16	OFF-Mode (Vcc = 0V, Icc = 0mA) S21 of the 3.4 – 3.8 GHz LNA with BFP840FESD.....	16
Figure 17	Bias current in the Temperature Range from -40°C to 85°C (Vcc=3.0 V).....	17
Figure 18	Noise Figure of BFP840FESD LNA in the Temperature Range from -40°C to 85°C (Vcc=3.0V)....	17
Figure 19	BFP840FESD LNA Insertion Power Gain in the Temperature Range from -40°C to 85°C (Vcc=3.0 V).....	18
Figure 20	BFP840FESD LNA Reverse Isolation in the Temperature Range from -40°C to 85°C (Vcc=3.0V) 18	18
Figure 21	BFP840FESD LNA Input Matching in the Temperature Range from -40°C to 85°C (Vcc=3.0 V) ....	19
Figure 22	BFP840FESD LNA Input Matching in the Temperature Range from -40°C to 85°C (Smith Chart) (Vcc=3.0 V) .....	19
Figure 23	BFP840FESD LNA Output Matching in the Temperature Range from -40°C to 85°C (Vcc=3.0V)...	20
Figure 24	BFP840FESD LNA Output Matching in the temperature range from -40 °C to 85 °C (Smith Chart) (Vcc=3.0 V) .....	20
Figure 25	1dB Compression Point of the BFP840FESD LNA at 3.6 GHz in the Temperature Range from -40°C to 85°C (Vcc=3.0 V).....	21
Figure 26	K Factor of the BFP840FESD LNA in the Temperature Range from -40°C to 85°C (Vcc=3.0 V) ....	21
Figure 27	μ1 Factor of the BFP840FESD LNA in the Temperature Range from -40°C to 85°C (Vcc=3.0 V)...	22
Figure 28	μ2 Factor of the BFP840FESD LNA in the Temperature Range from -40°C to 85°C (Vcc=3.0 V)...	22
Figure 29	Photo Picture of Evaluation Board .....	23
Figure 30	Zoom-In Picture of the BFP840FESD 3.4 – 3.8 GHz LNA Evaluation Board.....	23
Figure 31	Layout Proposal for RF Grounding of the 3.4 – 3.8 GHz LNA with BFP840FESD.....	24
Figure 32	PCB Layer Information.....	24

## List of Tables

Table 1	Summary of Measurement Results.....	5
Table 2	Bill-of-Materials.....	9

## 1 Application Circuit and Performance Overview

**Device:** BFP840FESD

**Application:** Low Noise Amplifier for 3.4GHz- 3.8GHz (Band 42/ 43)

**PCB Marking:** M13031106 0.6mmEDG TSFP-4-1 BFP840FESD

### 1.1 Summary of Measurement Results

**Table 1 Summary of Measurement Results**

Parameter	Symbol	Value			Unit	Note/Test Condition
DC Voltage	Vcc	3.0			V	
DC Current	Icc	14.5			mA	
Frequency Range	Freq	3400	3600	3800	MHz	
Gain	G	18.2	17.7	17.2	dB	
Noise Figure	NF	1.11	1.06	1.11	dB	SMA and PCB losses (~0.05 dB) are subtracted
Input Return Loss	RLin	11.6	12.2	13.3	dB	
Output Return Loss	RLout	23.8	23.7	15.0	dB	
Reverse Isolation	IRev	29.6	29.2	29.0	dB	
Input P1dB	IP1dB	-12.6			dBm	Measured @ 3600MHz
Output P1dB	OP1dB	4.1			dBm	
Input IP3	IIP3	-3			dBm	Measured @ 3600MHz, Δf =1 MHz, Pin= - 30 dBm
Output IP3	OIP3	14.7			dBm	
Stability	k	> 1.0			--	Measured up to 15 GHz

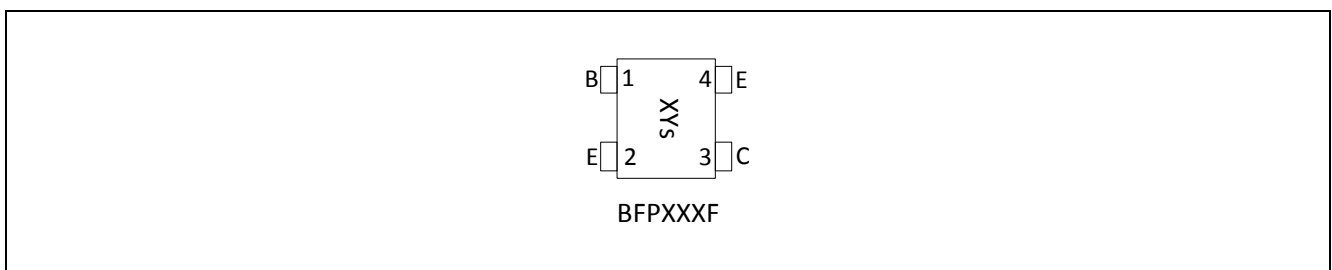
## 1.2 High Gain Low Noise Amplifier using BFP840FESD for 3.4 – 3.8 GHz LTE Application

The BFP840FESD is a discrete hetero-junction bipolar transistor (HBT) specifically designed for high performance 3.4 – 3.8 GHz low noise amplifier (LNA) solutions for LTE connectivity applications. It combines the 80 GHz fT silicon-germanium:carbide (SiGe:C) B9HFM process with special device geometry engineering to reduce the parasitic capacitance between substrate and transistor that degrades high-frequency characteristics, resulting in an inherent input matching and a major improvement in power gain Band 42/43 together with a low noise figure performance that is industry's best.

The BFP840FESD has an integrated 1.5kV HBM ESD protection which makes the device robust against electrostatic discharge and extreme RF input power. The device offers its high performance at low current and voltage and is especially well-suited for portable battery powered applications in which energy efficiency is a key requirement.

The BFP840FESD is housed in flat-leads TSFP-4-1 package. Further variants are available in industry standard visible-leads SOT343 package (BFP840ESD) and in the low-height 0.31mm TSLP-3-9 package (BFR840L3RHESD) specially fitting into modules.

**Figure 1** shows the pin assignment of package of BFP840FESD in the top view:



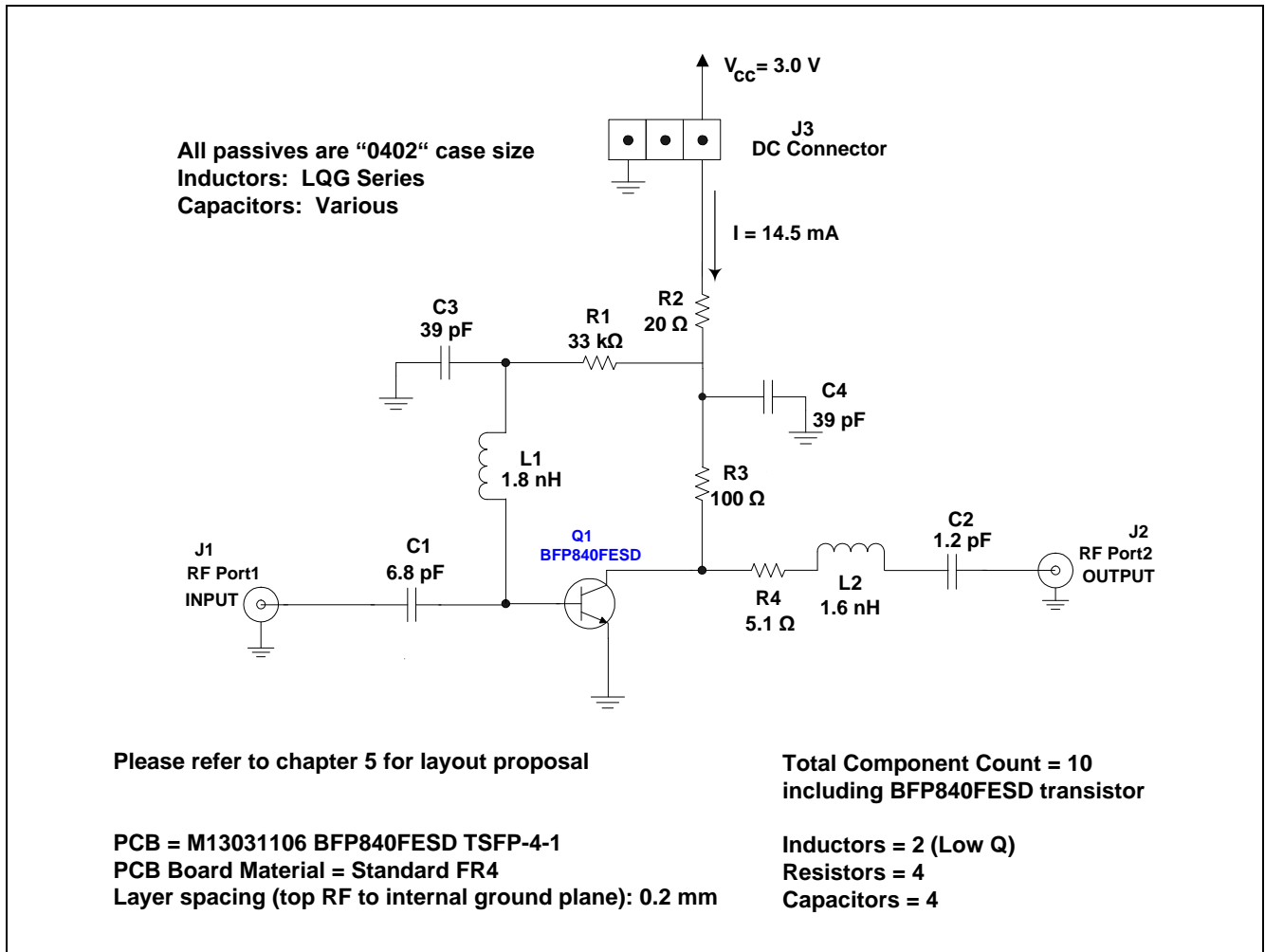
**Figure 1** Package and pin connections of BFP840FESD in Topview

This application note presents the measurement results of the Low Noise Amplifier using BFP840FESD for 3400 MHz to 3800 MHz LTE applications. It requires 10 passive 0402 SMD components and can provide 17.7 dB gain at 3600 MHz. The noise figure varies from 1.03 dB to 1.08 dB (SMA and PCB losses are subtracted) over the frequency band.

The circuit achieves an input return loss of 12 dB and output return loss 24 dB. Furthermore, the circuit is unconditionally stable from 10 MHz to 15 GHz. However, Proper RF grounding on PCB has to be ensured in order to achieve stability  $k\text{-factor} > 1$  (Figure 3111).

At 3600 MHz, using two tones spacing of 1 MHz, the output third order intercept point OIP3 reaches 14.7 dBm. Besides, we obtain input 1dB input compression point IP1dB of -12.6 dBm at 3600 MHz.

### 1.3 Schematics and Bill-of-Materials



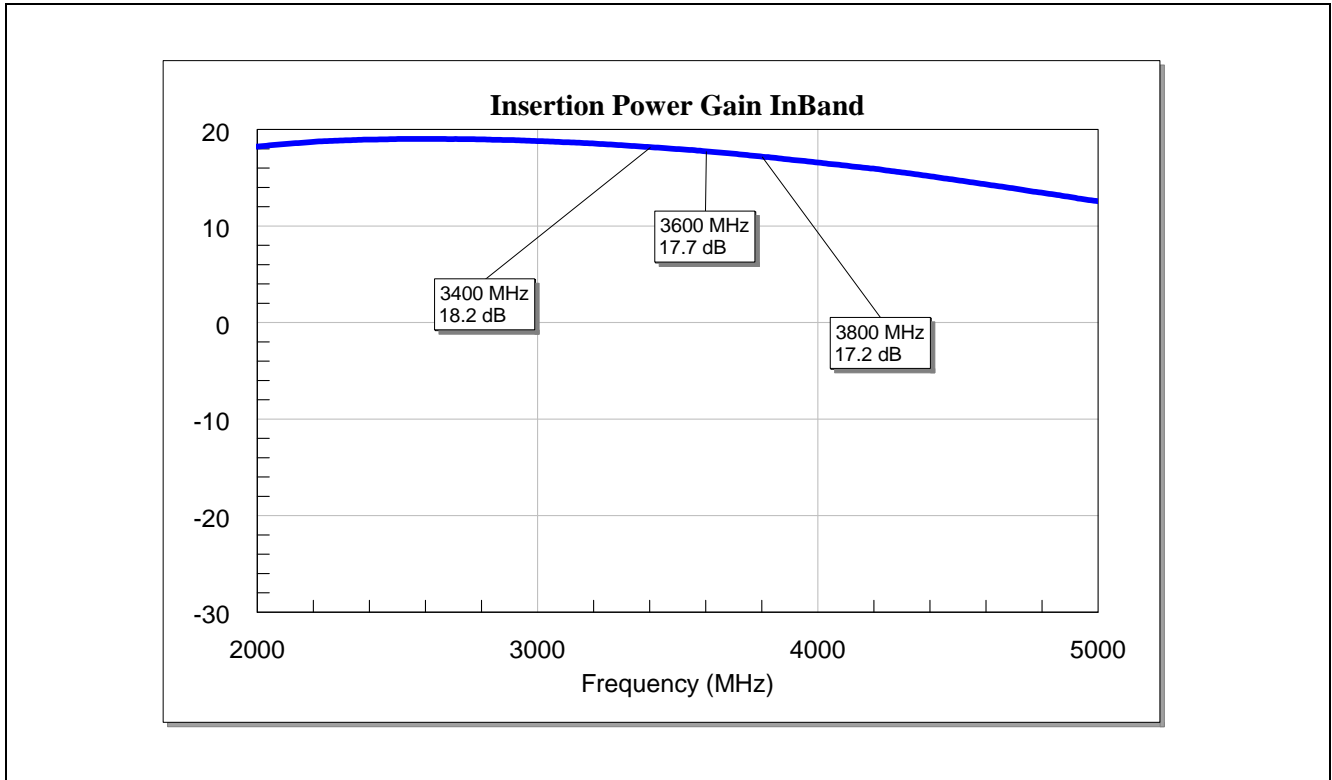
**Figure 2 Schematics of BFP840FESD Low Noise Amplifier for 3.4 – 3.8 GHz Application**



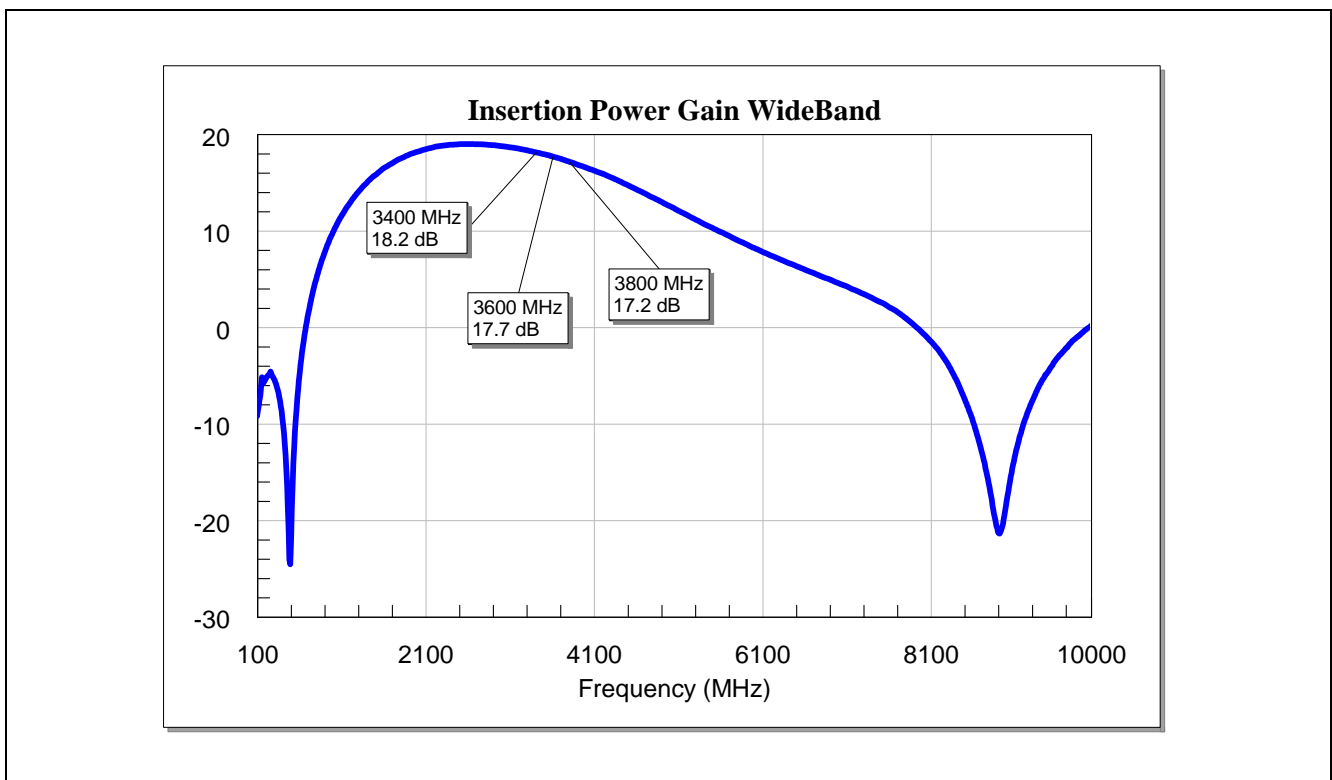
**Table 2 Bill-of-Materials**

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	6.8	pF	0402	Various	DC block & input matching
C2	1.2	pF	0402	Various	DC block & output matching
C3	39	pF	0402	Various	RF decoupling
C4	39	pF	0402	Various	RF decoupling
L1	1.8	nH	0402	LQG	Input matching
L2	1.6	nH	0402	LQG	Output matching and high frequency stability improvement
R1	33	k $\Omega$	0402	Various	DC biasing
R2	20	$\Omega$	0402	Various	DC biasing (provides DC negative feedback to stabilize DC operating point over temperature variation, transistor h <sub>FE</sub> variation, etc.)
R3	100	$\Omega$	0402	Various	Stability and input/output matching
R4	5.1	$\Omega$	0402	Various	Output matching and stability improvement
Q1			TSLP-4-1	Infineon Technologies	BFP840FESD SiGe: C Heterojunction Bipolar RF Transistor

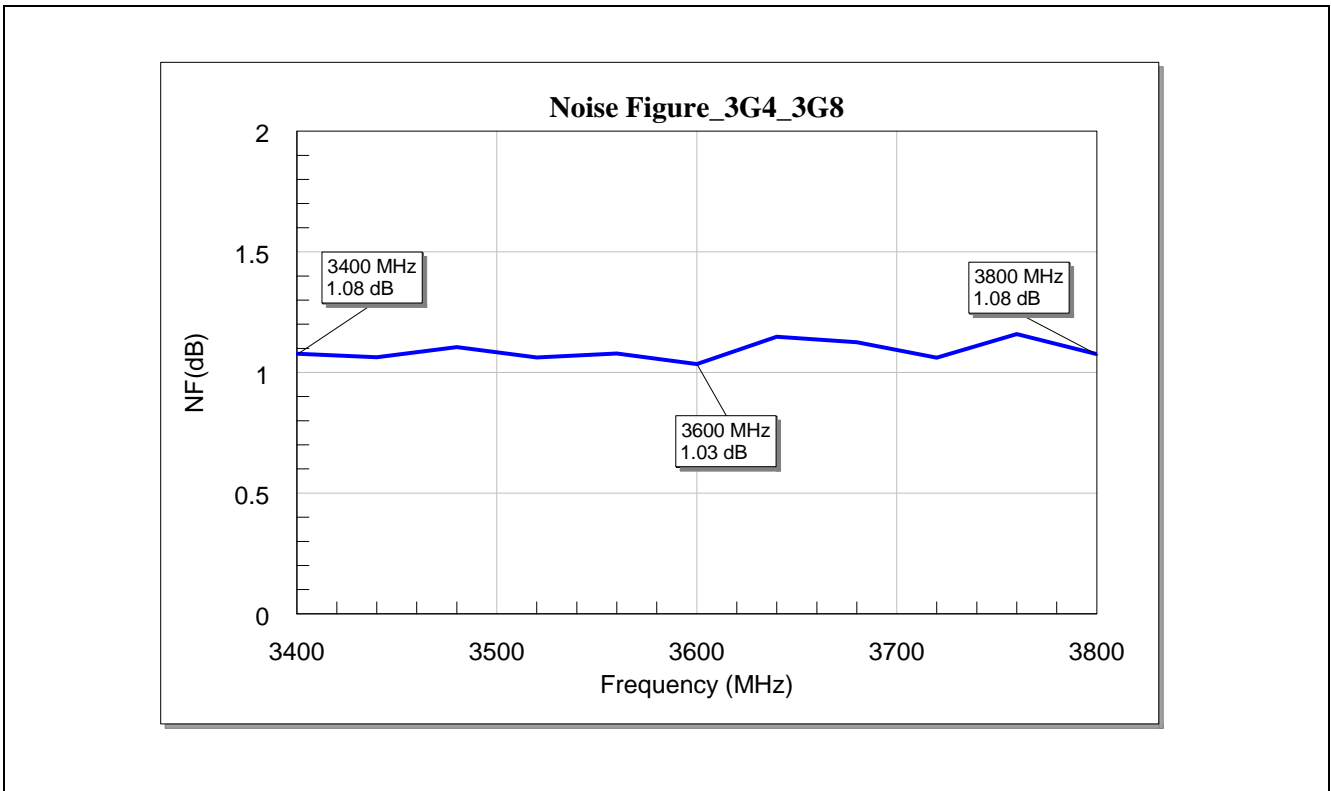
## 2 Measured Graphs



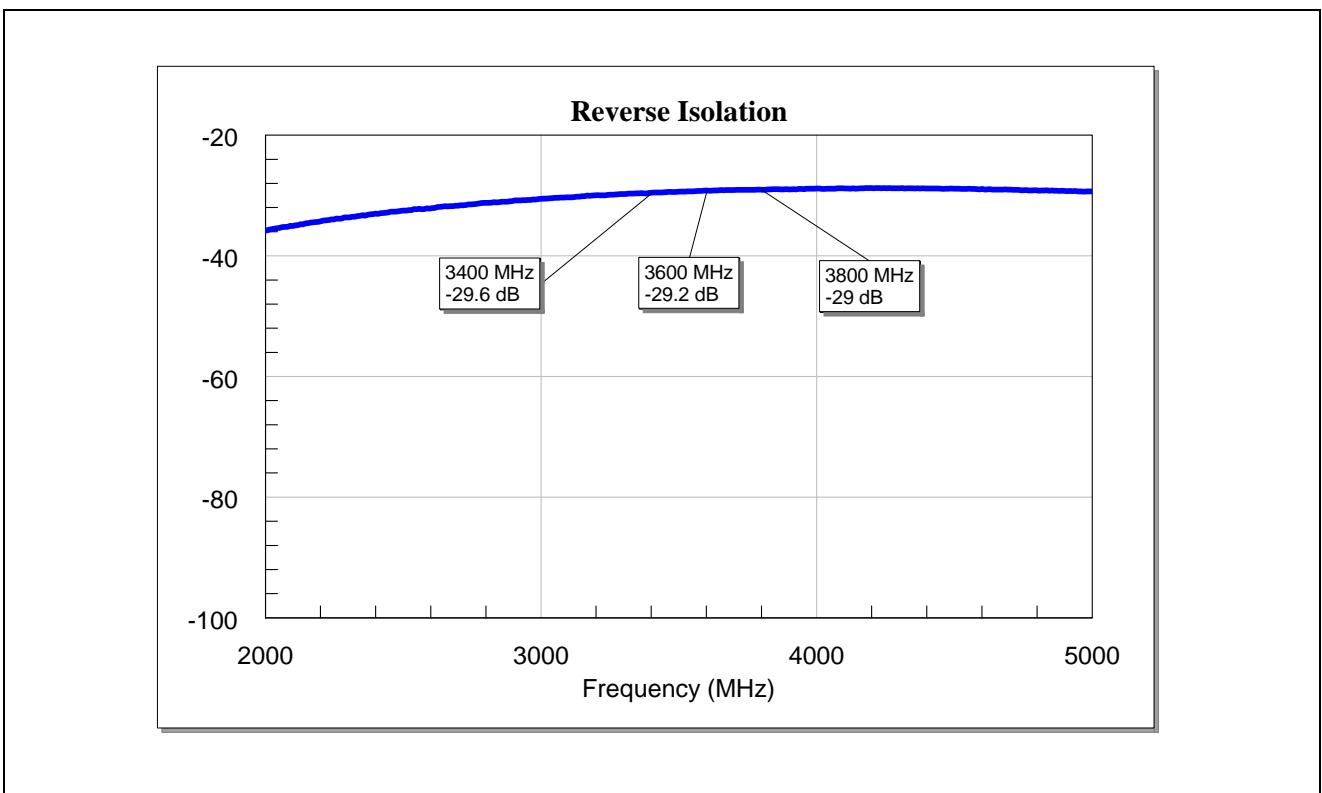
**Figure 3 Insertion Power Gain of the 3.4 – 3.8 GHz LNA with BFP840FESD**



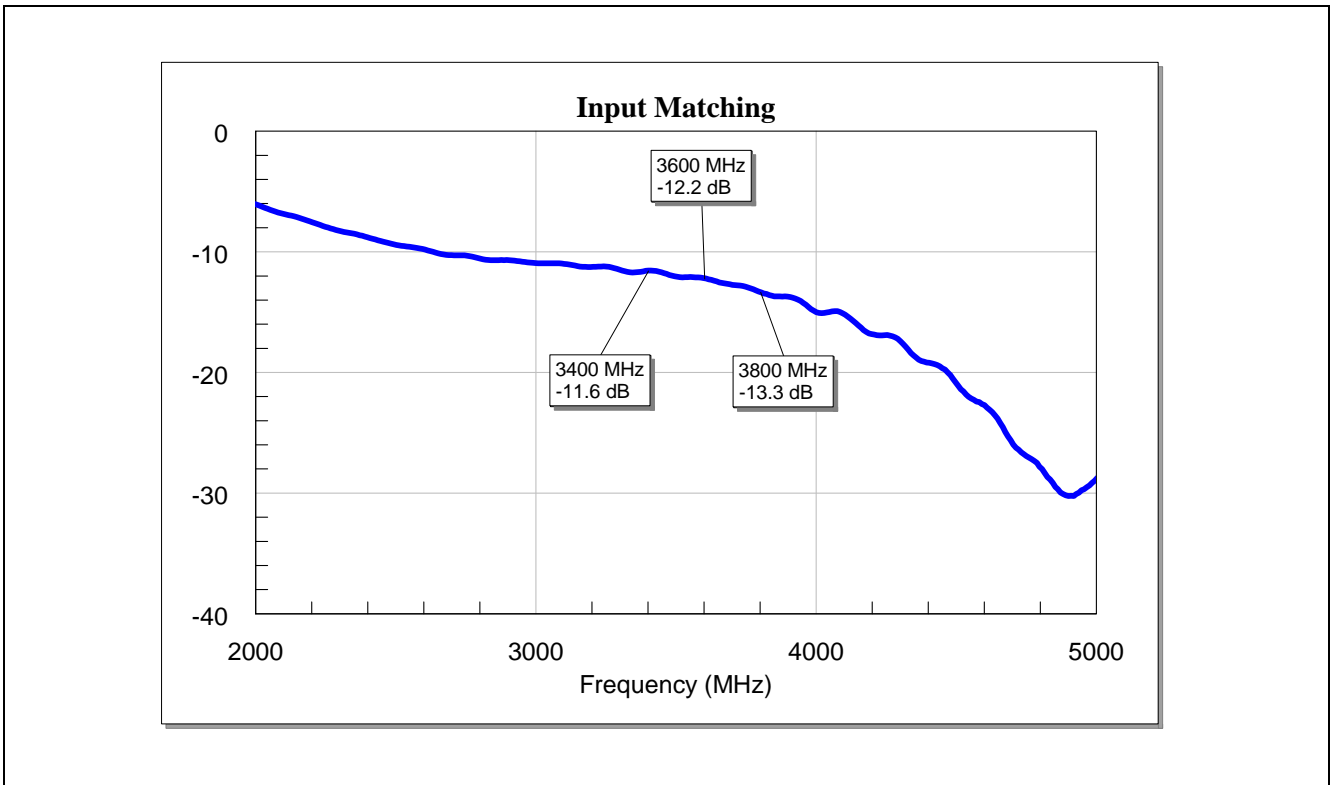
**Figure 4 Wideband Insertion Power Gain of the 3.4 – 3.8 GHz LNA with BFP840FESD**



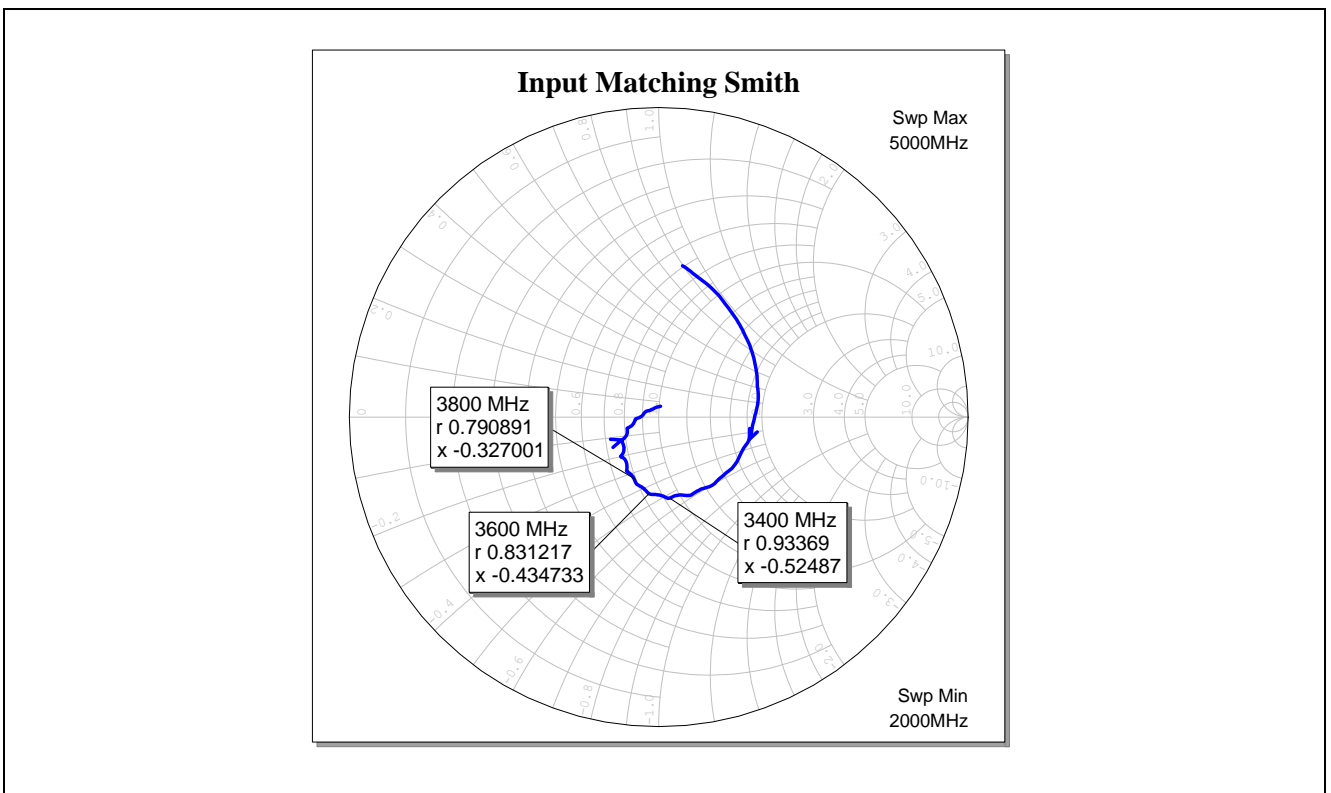
**Figure 5 Noise Figure of BFP840FESD LNA for 3400 - 2500 MHz**



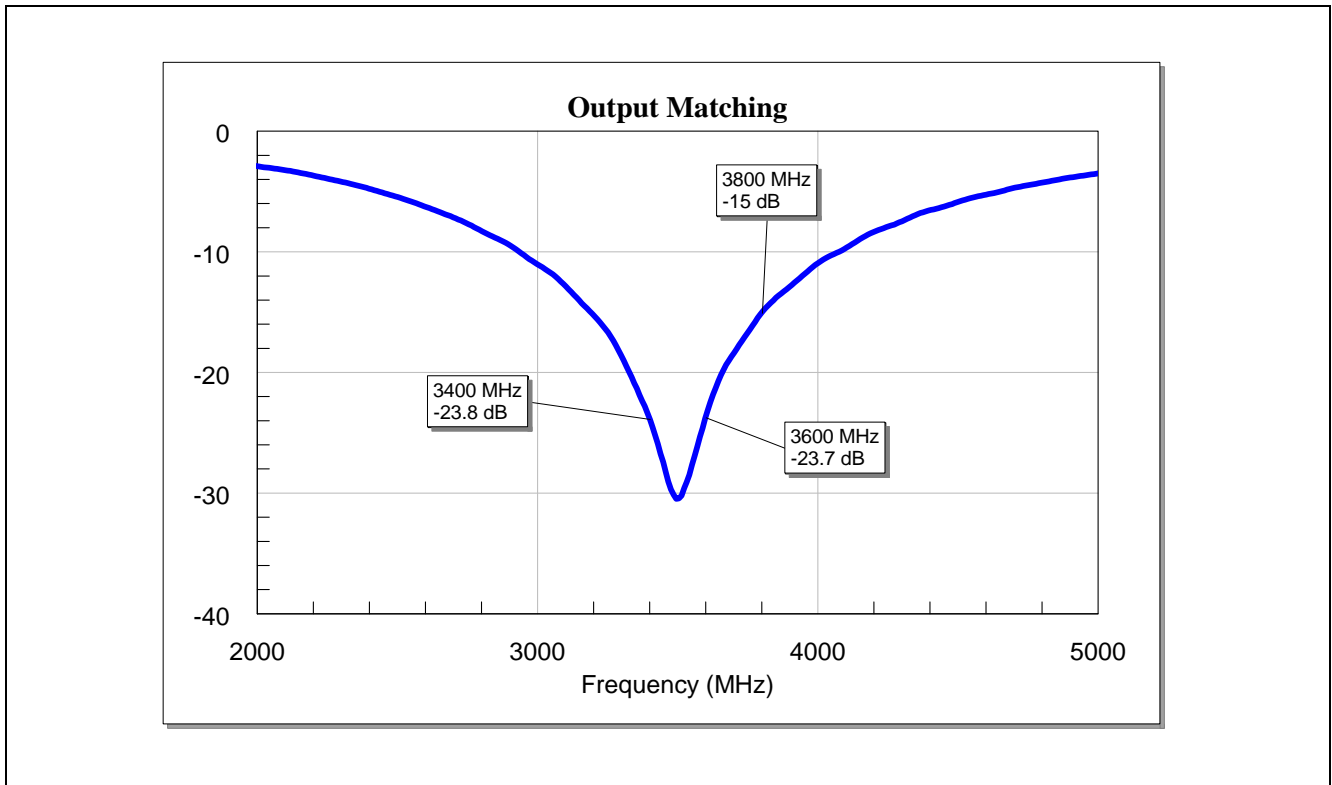
**Figure 6 Reverse Isolation of the 3.4 – 3.8 GHz LNA with BFP840FESD**



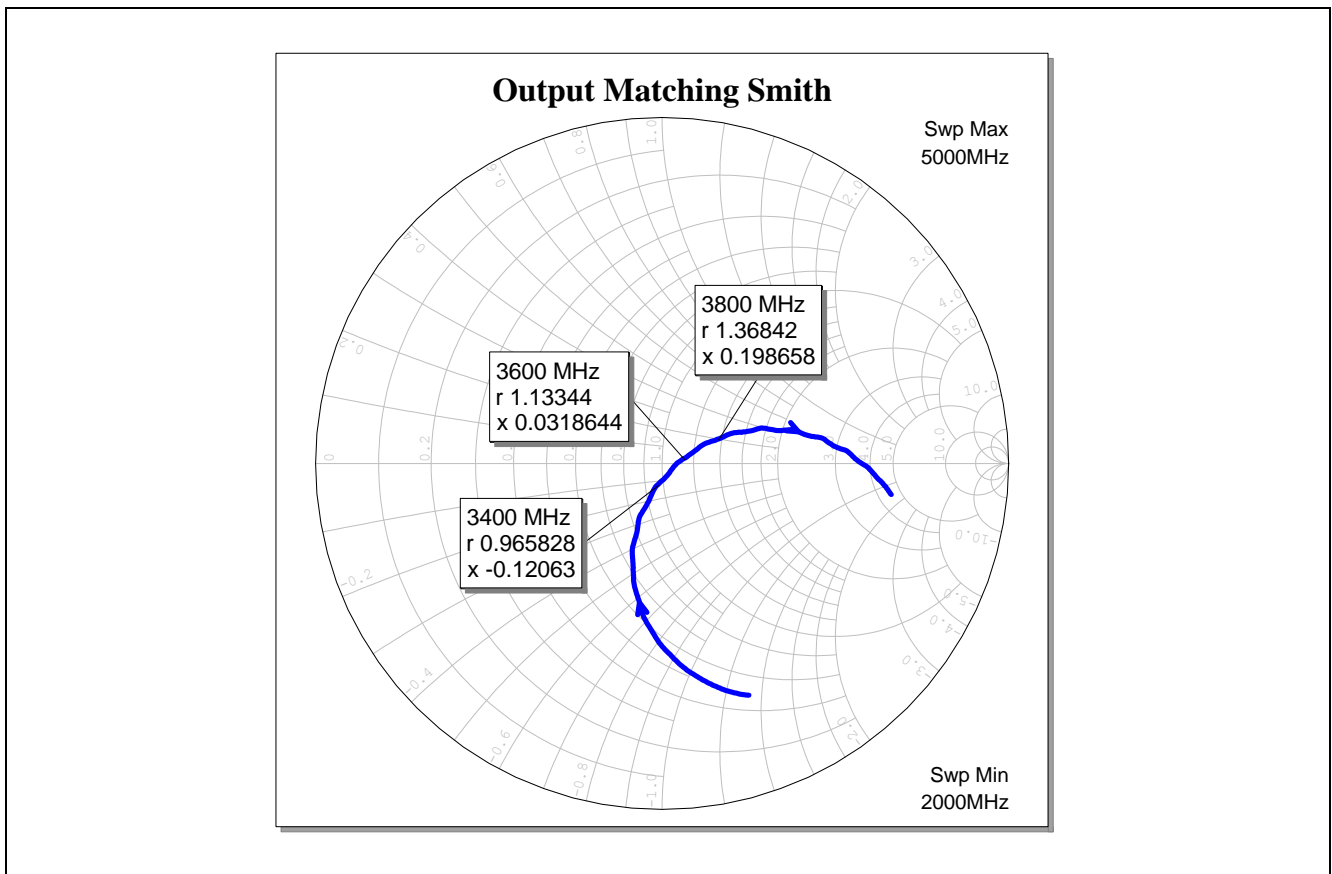
**Figure 7** Input Matching of the 3.4 – 3.8 GHz LNA with BFP840FESD



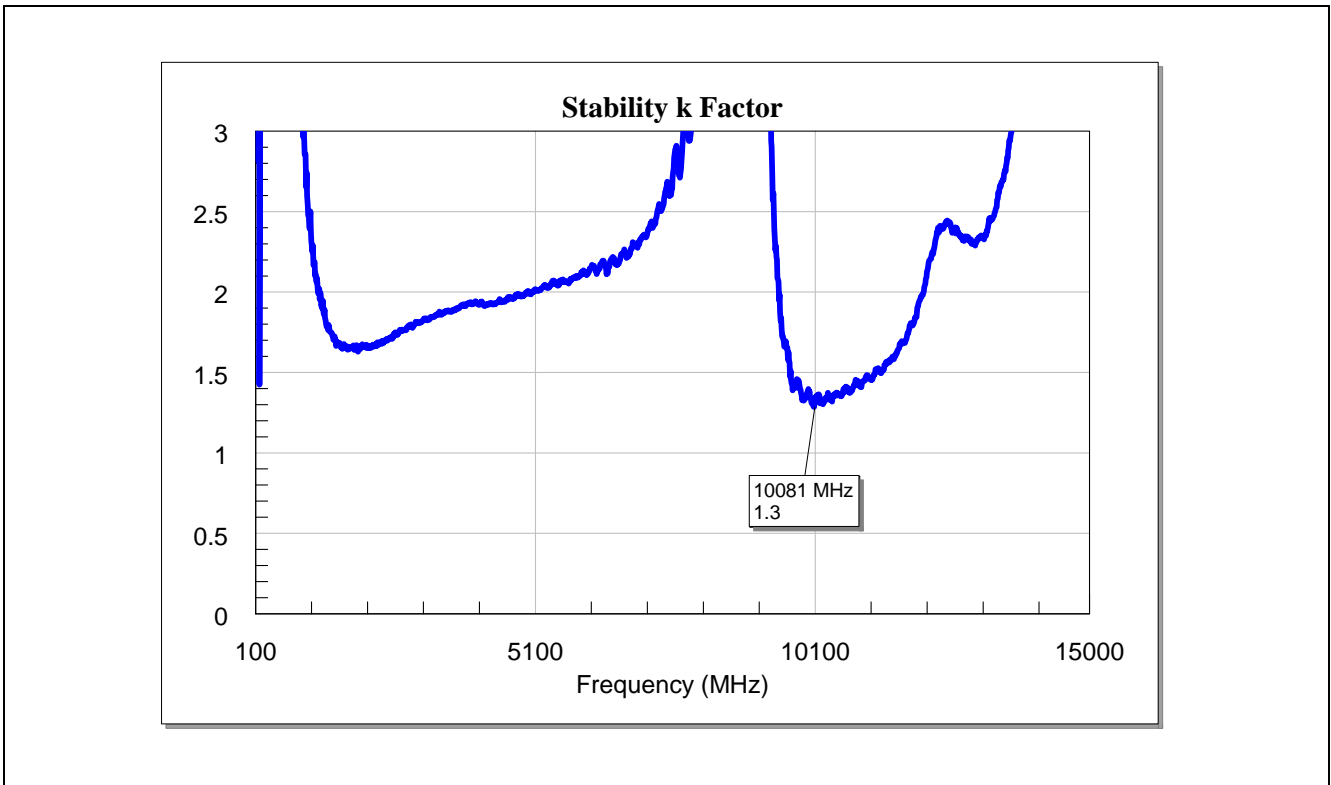
**Figure 8** Input Matching of the 3.4 – 3.8 GHz LNA with BFP840FESD (Smith Chart)



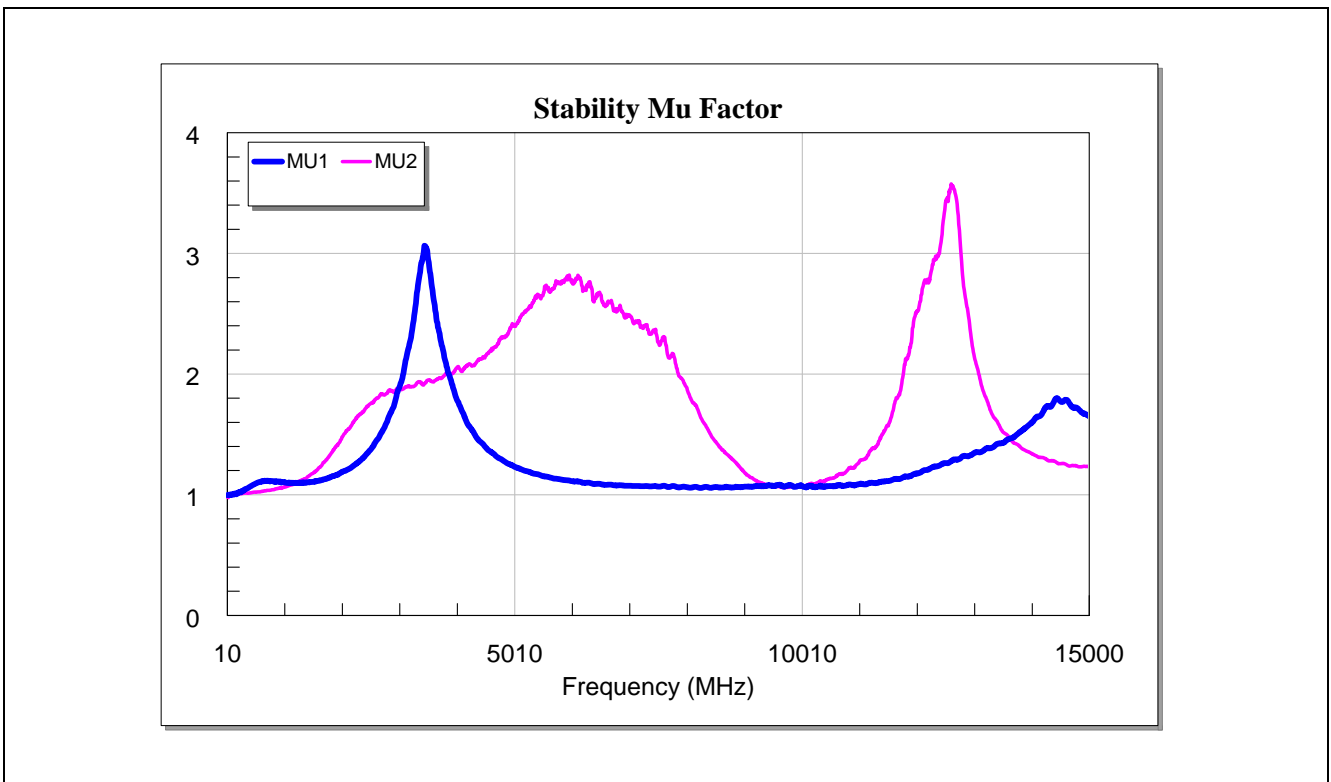
**Figure 9** Output Matching of the 3.4 – 3.8 GHz LNA with BFP840FESD



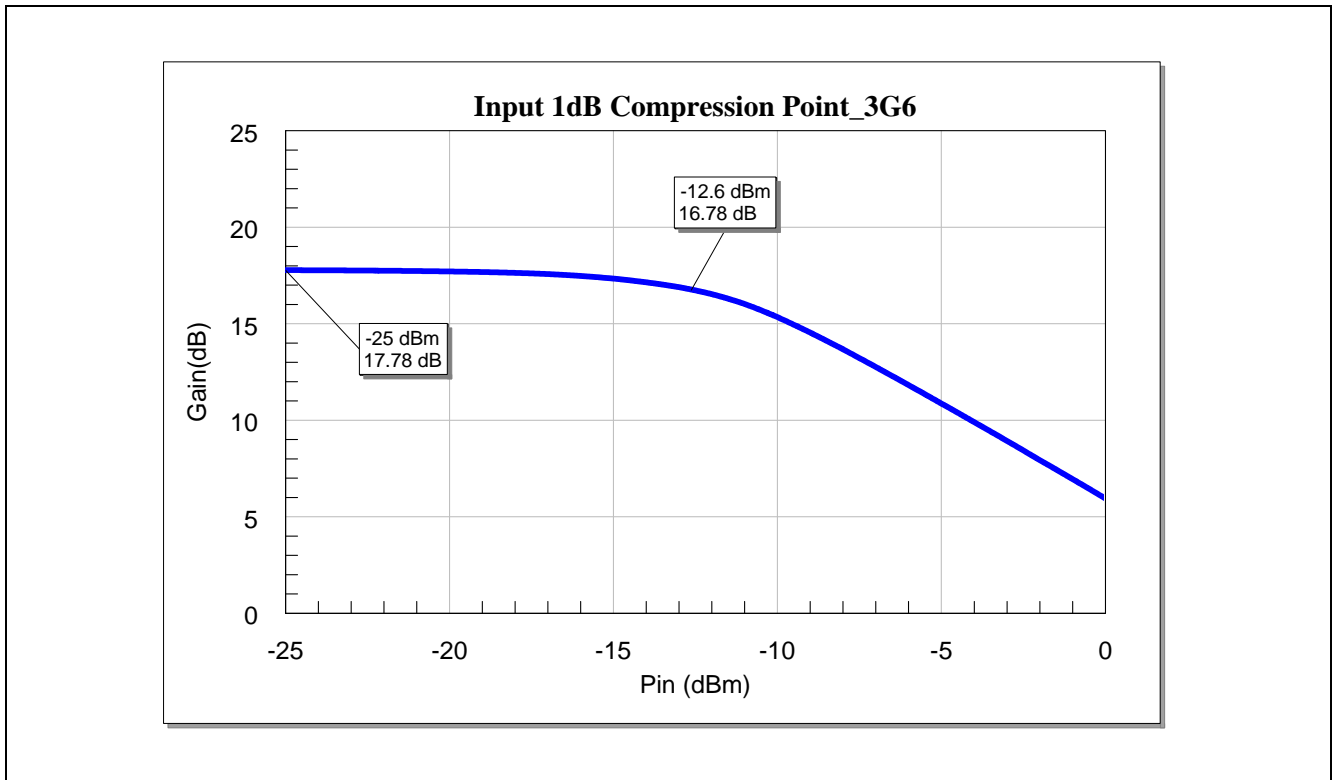
**Figure 10** Output Matching of the 3.4 – 3.8 GHz LNA with BFP840FESD (Smith Chart)



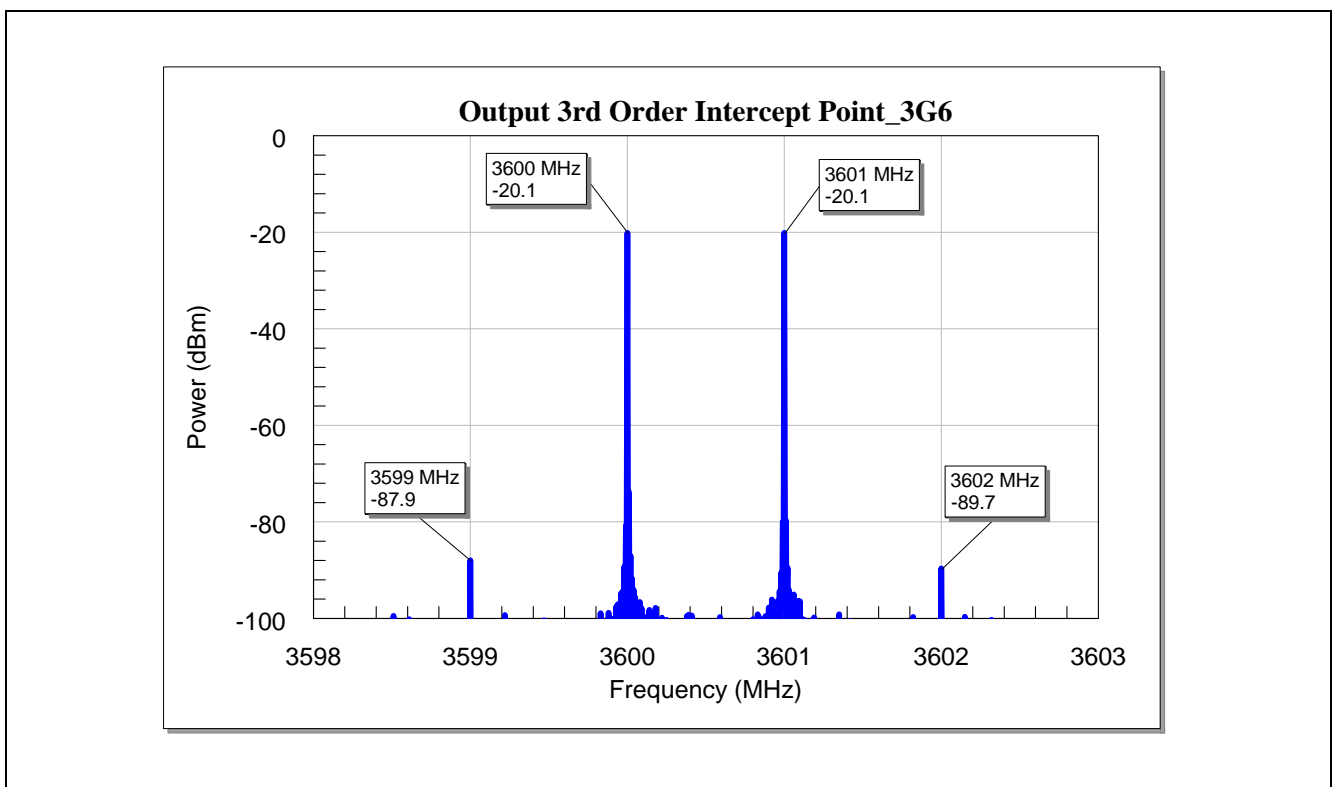
**Figure 11 Wideband Stability k Factor of the 3.4 – 3.8 GHz LNA with BFP840FESD**



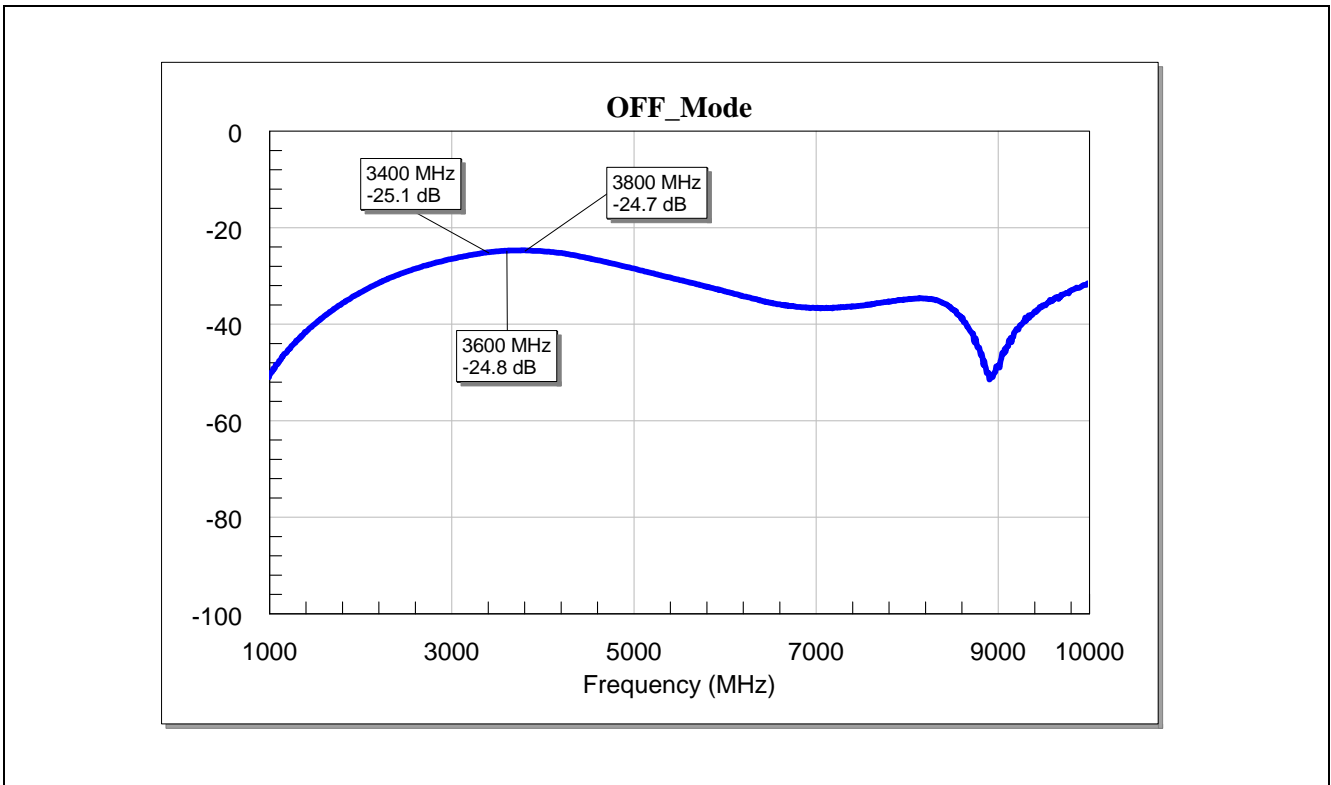
**Figure 12 Wideband Stability Mu Factor of the 3.4 – 3.8 GHz LNA with BFP840FESD**



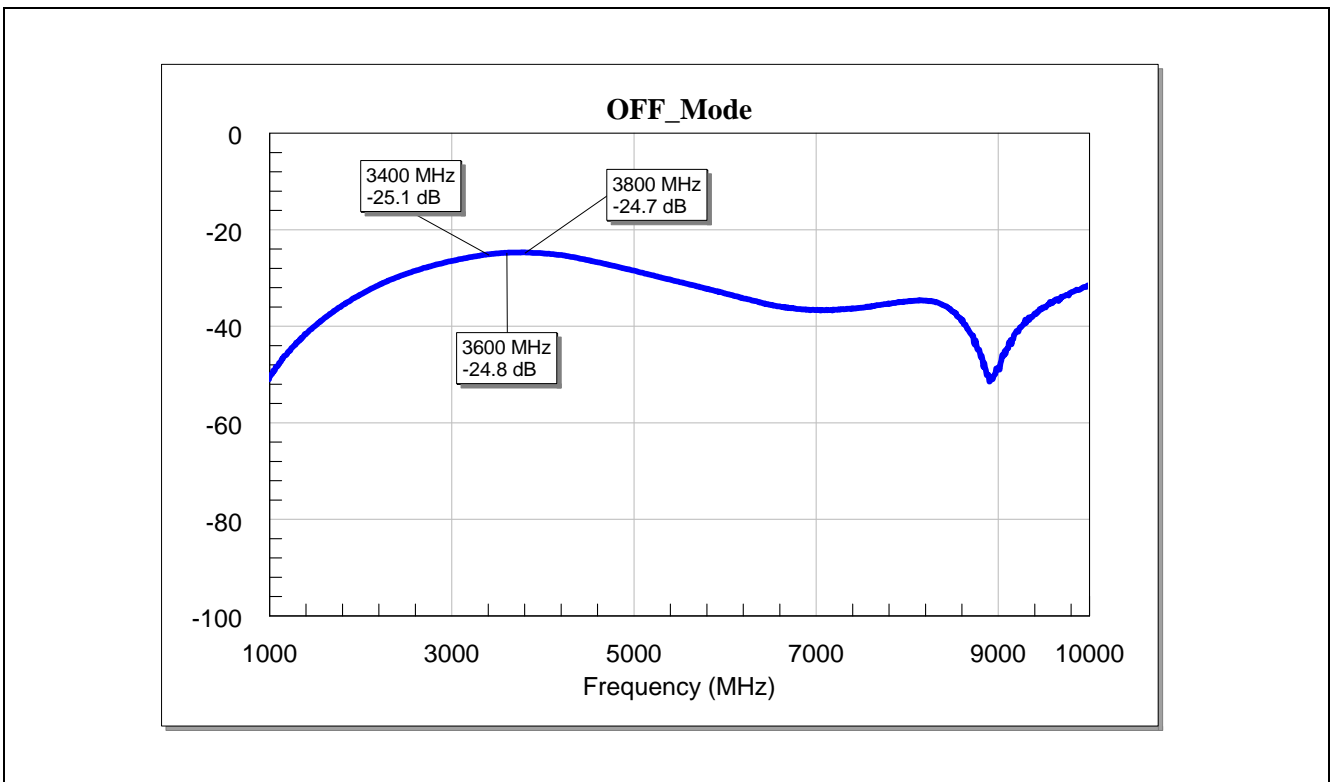
**Figure 13** 1dB Compression Point of the BFP840FESD Circuit at 3600 MHz



**Figure 14** Output 3<sup>rd</sup> Order Intercept Point of BFP840FESD at 3600 MHz

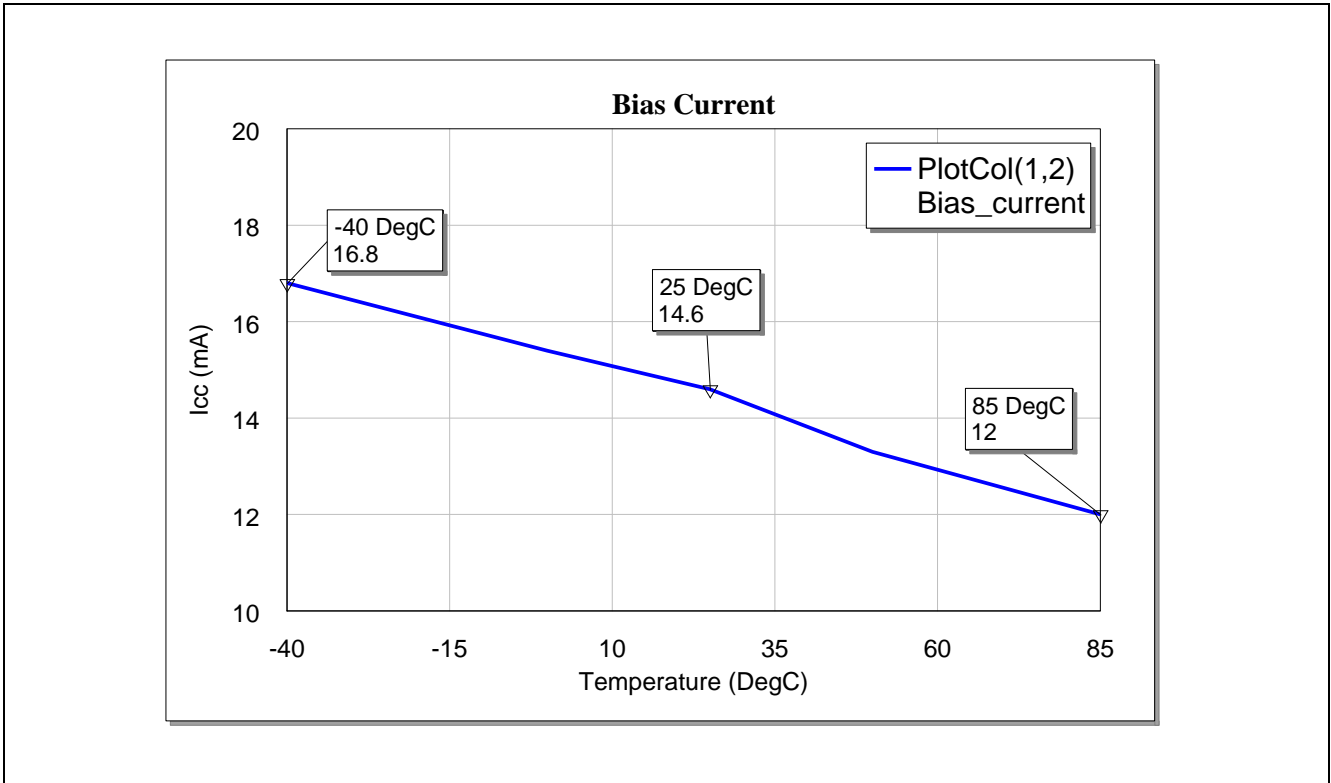


**Figure 15 OFF-Mode ( $V_{cc} = 0V$ ,  $I_{cc} = 0mA$ ) S21 of the 3.4 – 3.8 GHz LNA with BFP840FESD**

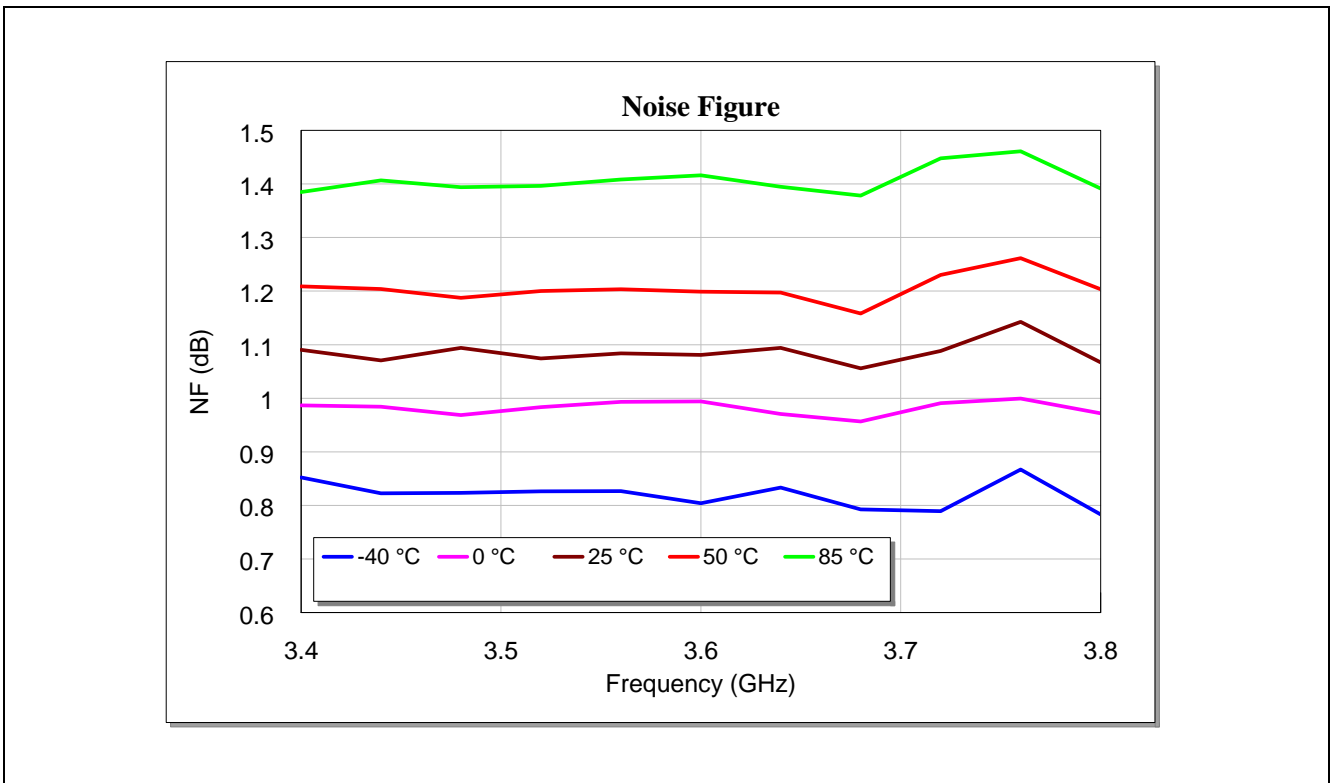


**Figure 16 OFF-Mode ( $V_{cc} = 0V$ ,  $I_{cc} = 0mA$ ) S21 of the 3.4 – 3.8 GHz LNA with BFP840FESD**

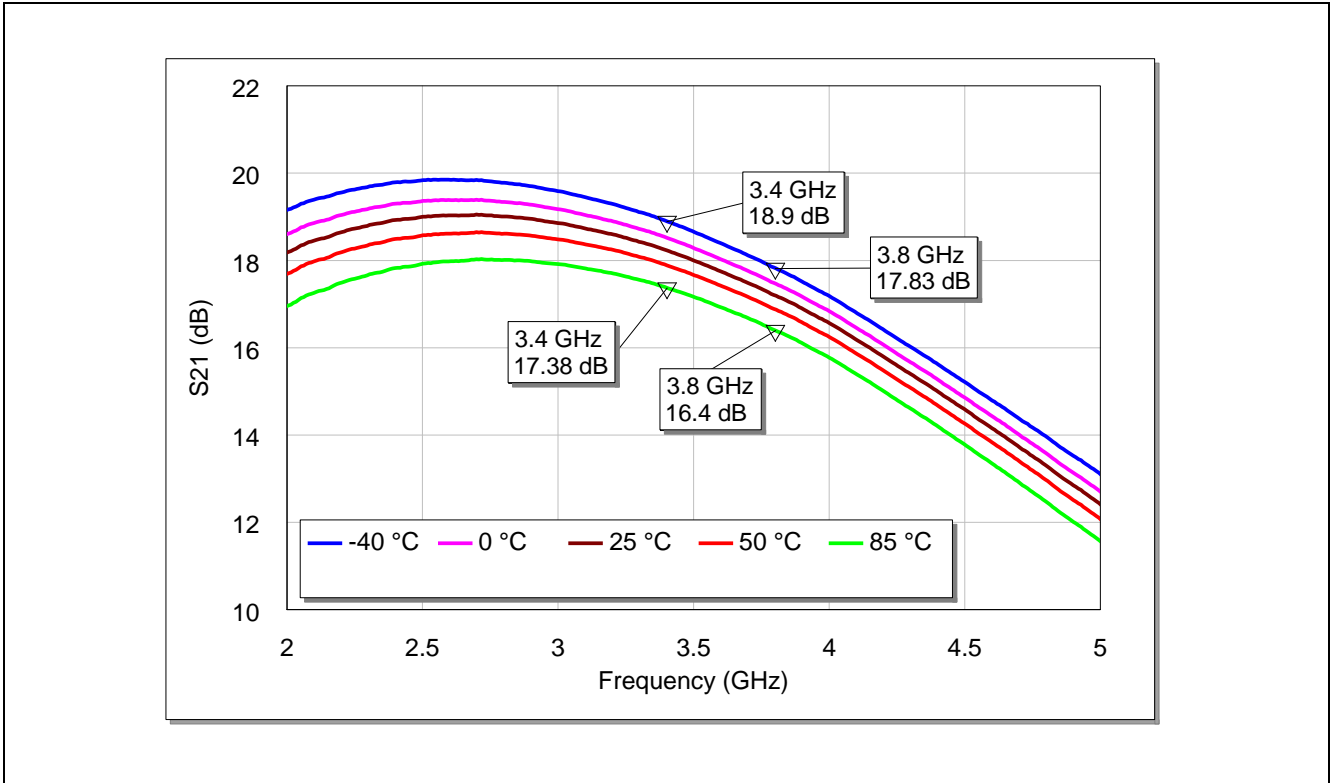




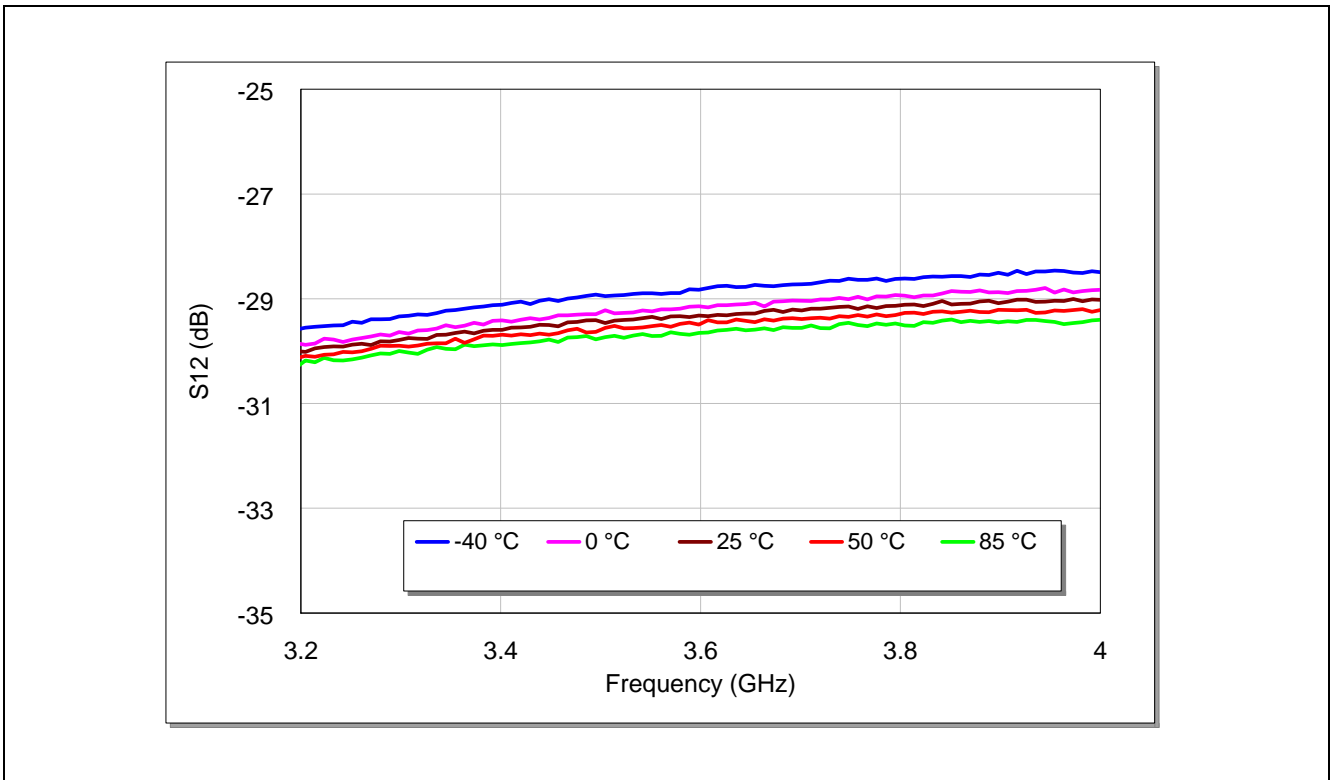
**Figure 17 Bias current in the Temperature Range from -40°C to 85°C (Vcc=3.0 V)**



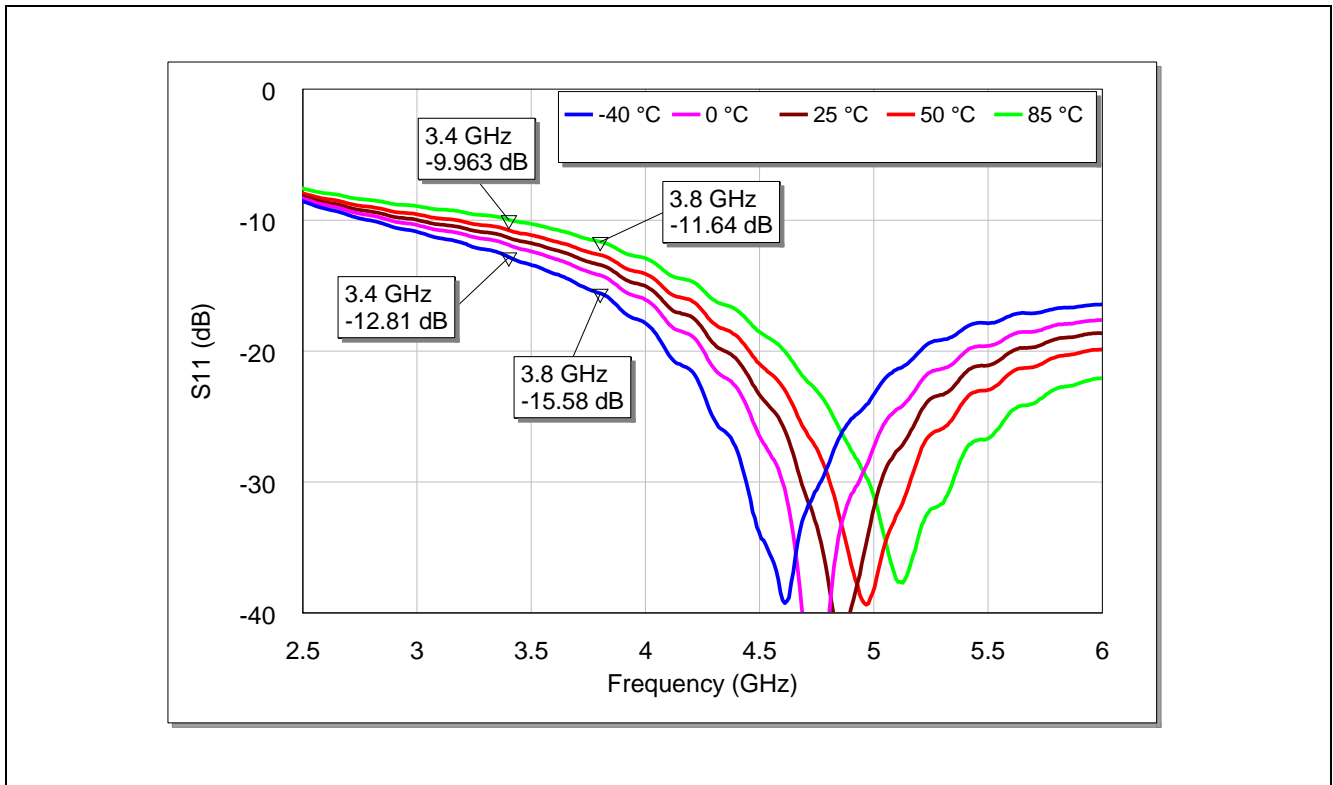
**Figure 18 Noise Figure of BFP840FESD LNA in the Temperature Range from -40°C to 85°C (Vcc=3.0V)**



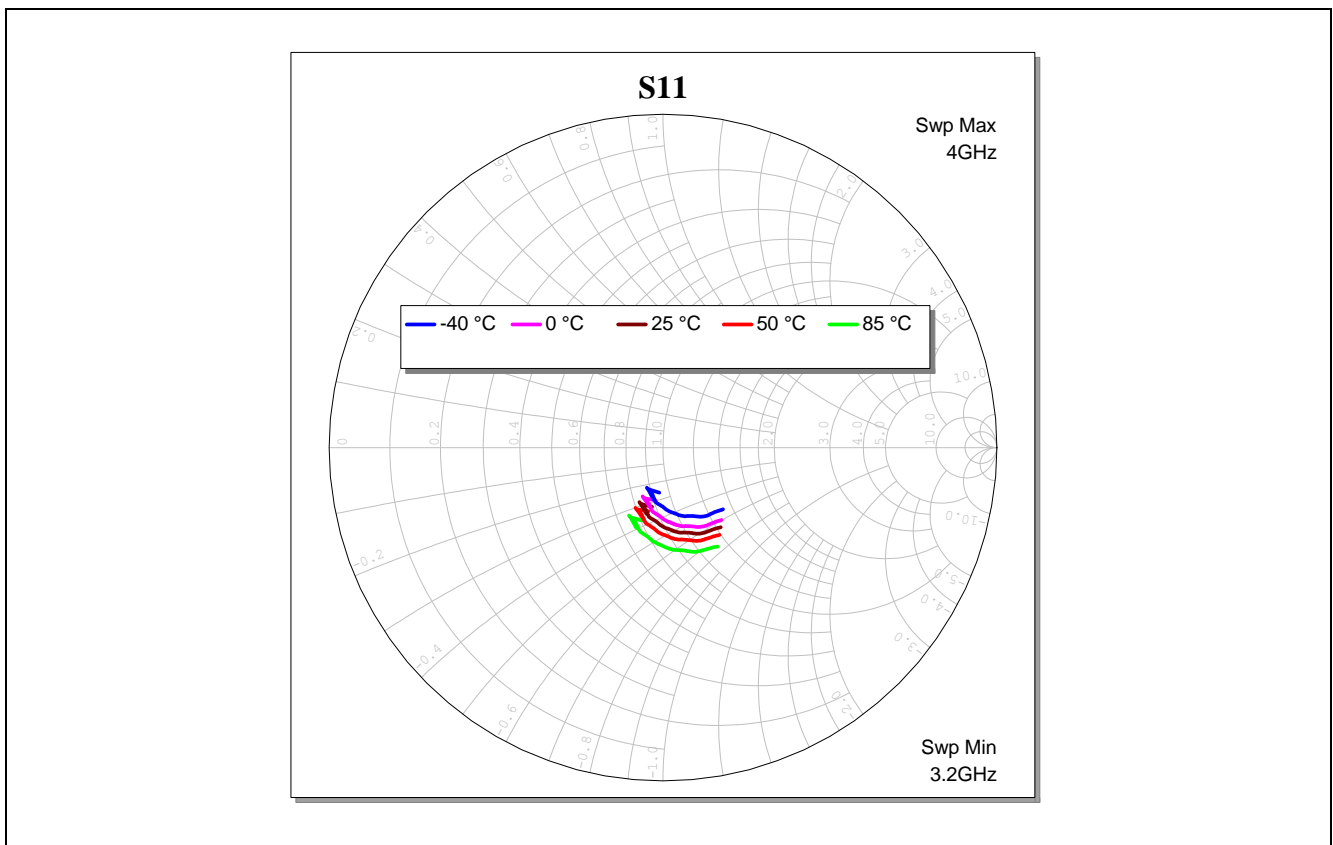
**Figure 19 BFP840FESD LNA Insertion Power Gain in the Temperature Range from -40°C to 85°C (Vcc=3.0 V)**



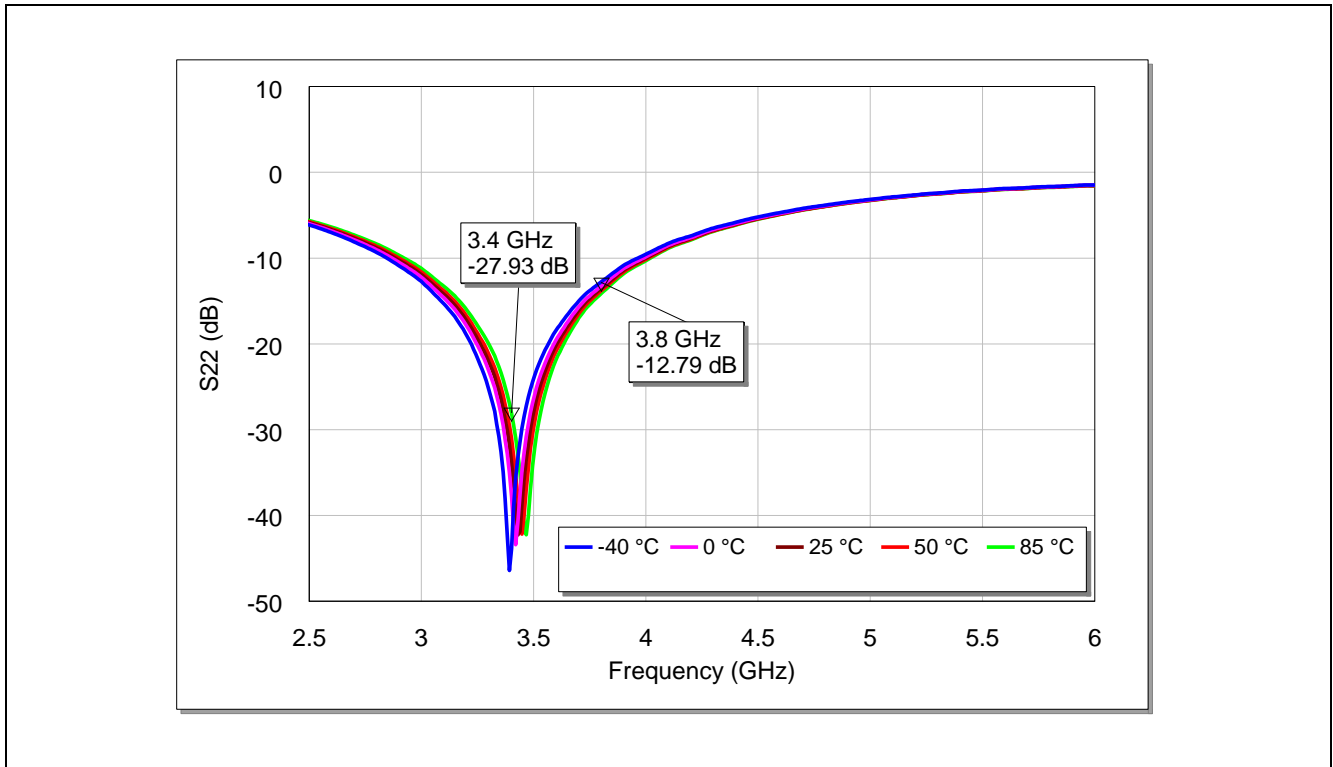
**Figure 20 BFP840FESD LNA Reverse Isolation in the Temperature Range from -40°C to 85°C (Vcc=3.0V)**



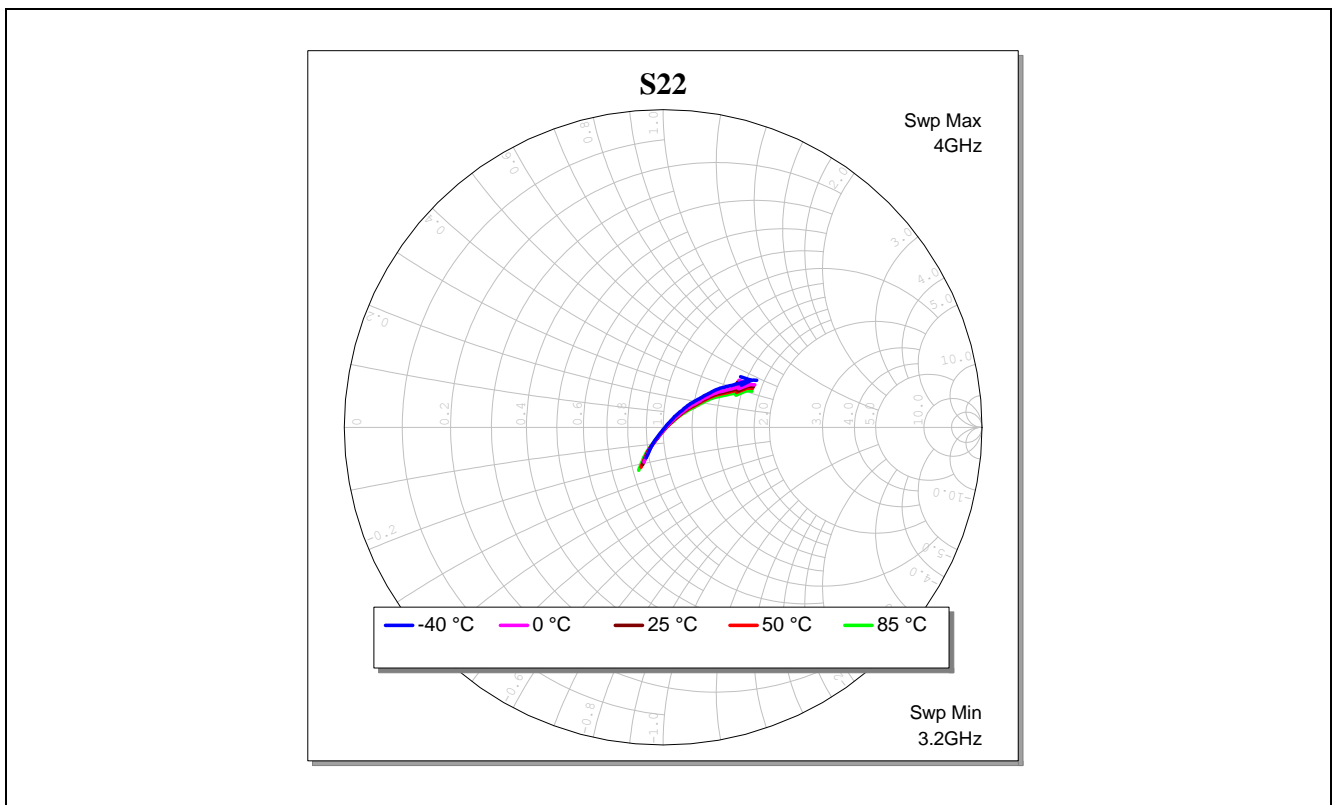
**Figure 21 BFP840FESD LNA Input Matching in the Temperature Range from -40°C to 85°C (Vcc=3.0 V)**



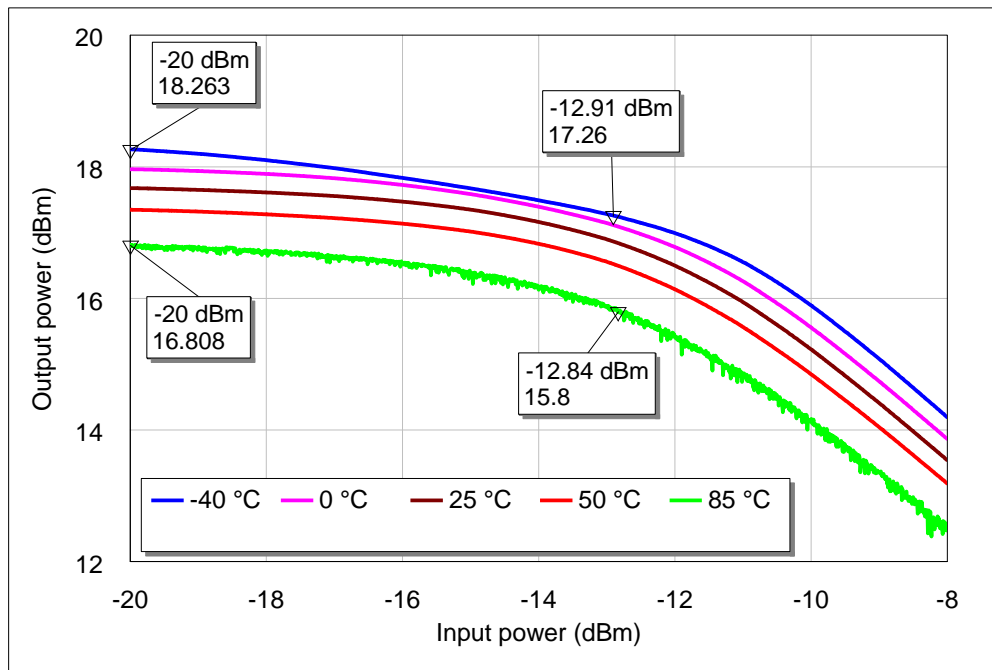
**Figure 22 BFP840FESD LNA Input Matching in the Temperature Range from -40°C to 85°C (Smith Chart) (Vcc=3.0 V)**



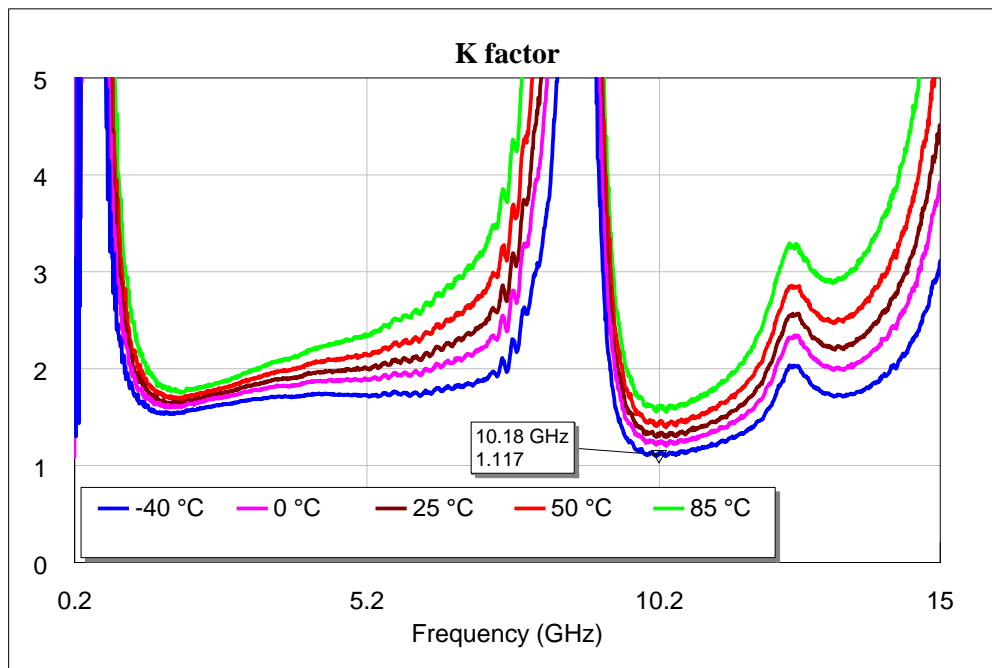
**Figure 23 BFP840FESD LNA Output Matching in the Temperature Range from -40°C to 85°C (Vcc=3.0V)**



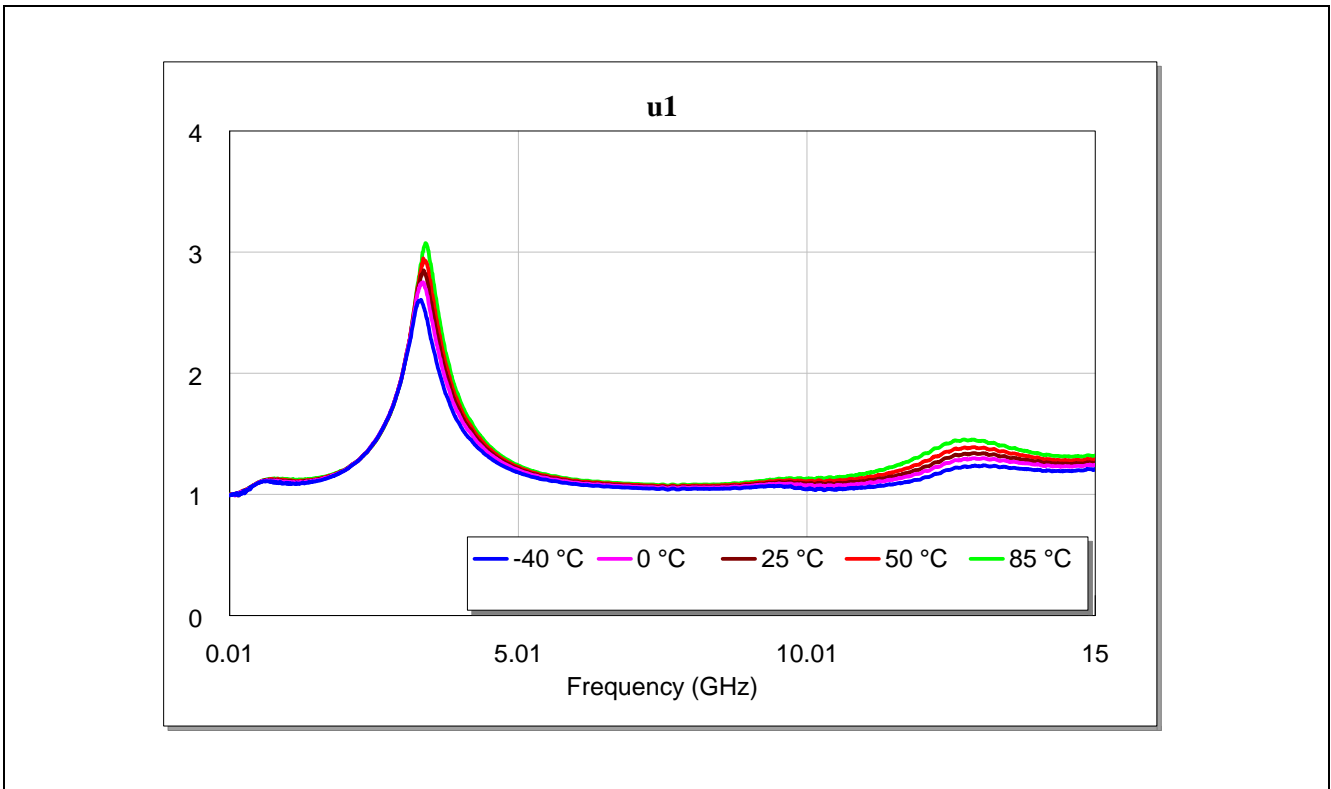
**Figure 24 BFP840FESD LNA Output Matching in the temperature range from -40 °C to 85 °C (Smith Chart) (Vcc=3.0 V)**



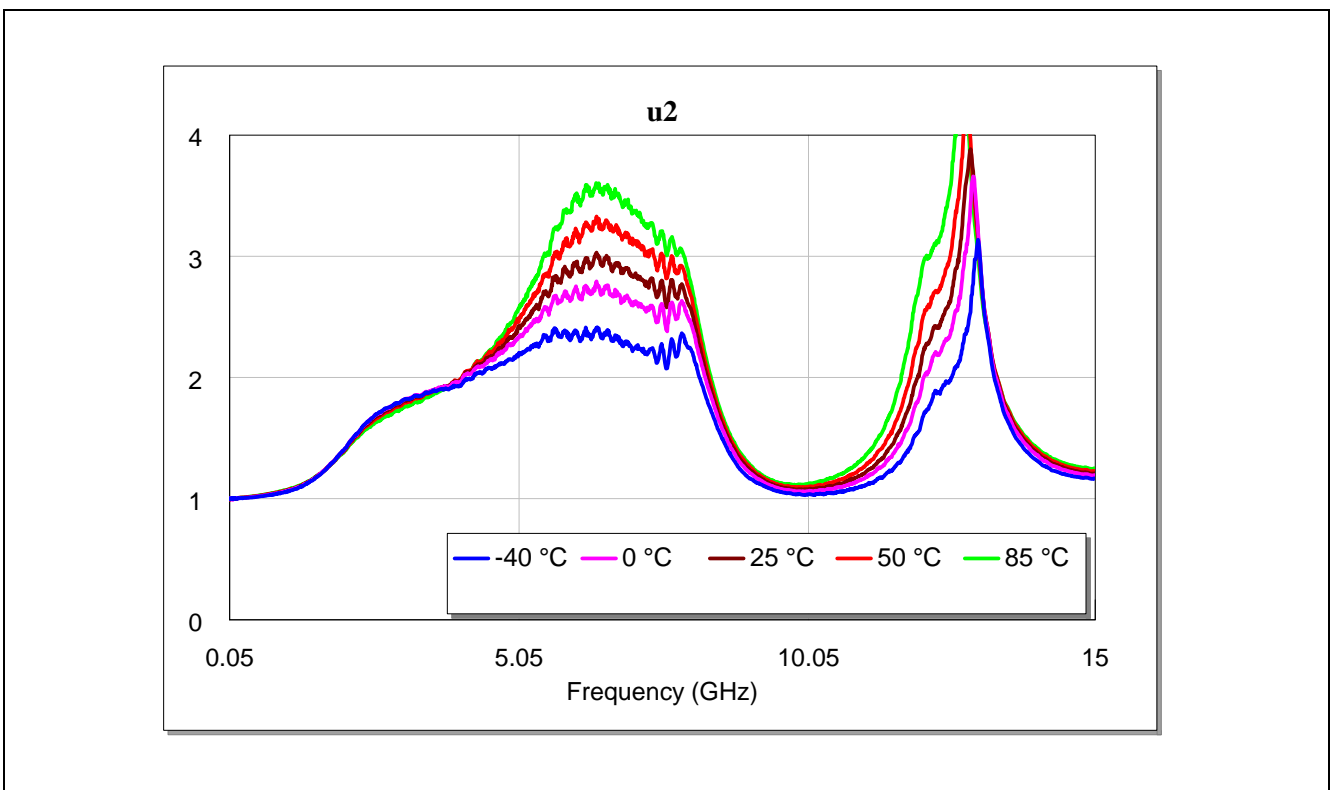
**Figure 25** 1dB Compression Point of the BFP840FESD LNA at 3.6 GHz in the Temperature Range from -40°C to 85°C (Vcc=3.0 V)



**Figure 26** K Factor of the BFP840FESD LNA in the Temperature Range from -40°C to 85°C (Vcc=3.0 V)



**Figure 27**  $\mu_1$  Factor of the BFP840FESD LNA in the Temperature Range from -40°C to 85°C ( $V_{cc}=3.0$  V)



**Figure 28**  $\mu_2$  Factor of the BFP840FESD LNA in the Temperature Range from -40°C to 85°C ( $V_{cc}=3.0$  V)

### 3 Evaluation Board and layout Information

In this Technical Report, the following PCB is used:

PCB Marking: M13031106 0.6mmEDG TSFP-4-1 BFP840FESD

PCB Board Material: Standard FR4

$\epsilon_r$  of PCB Material: 4.3 (FR4)

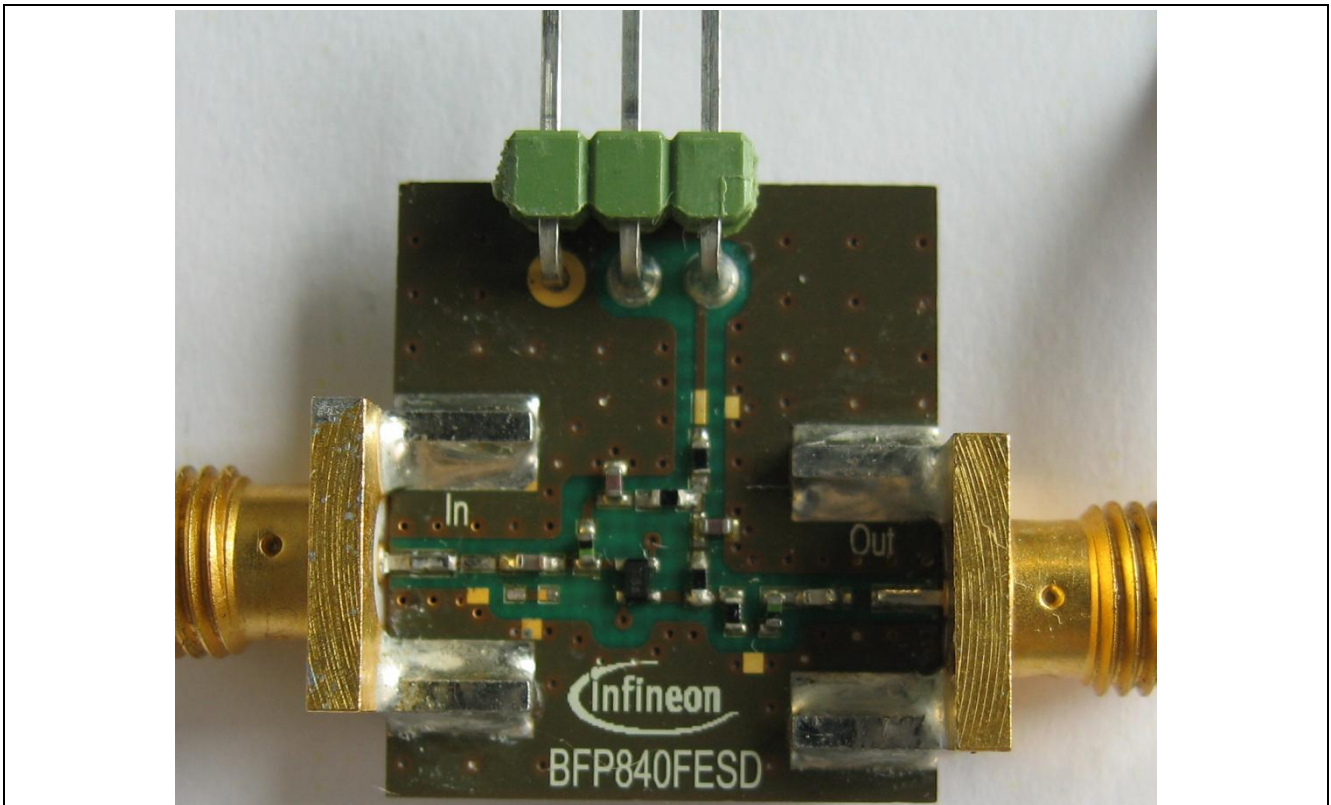


Figure 29 Photo Picture of Evaluation Board

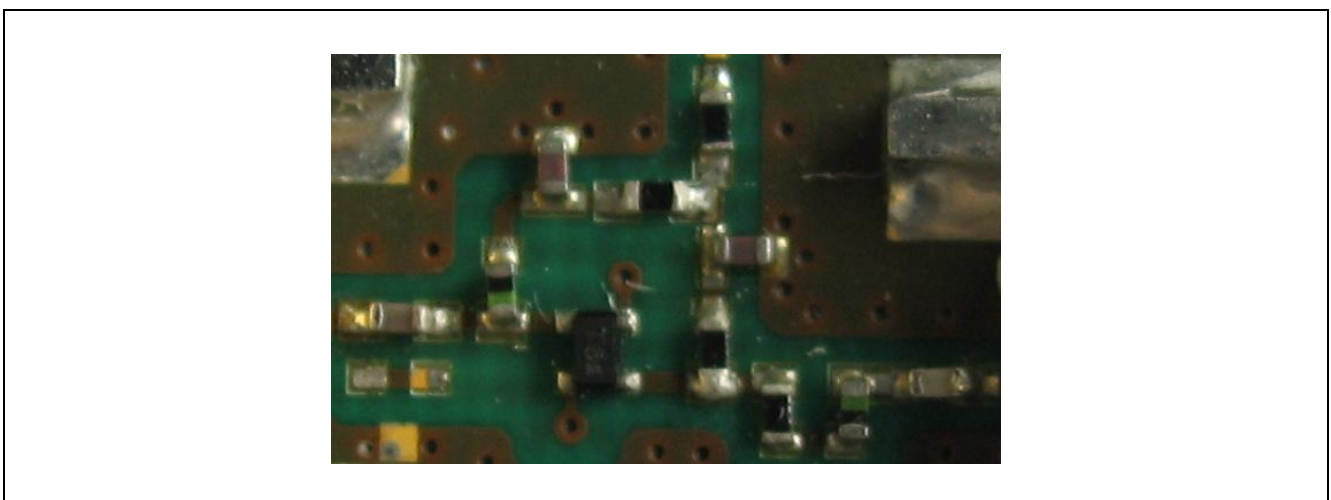
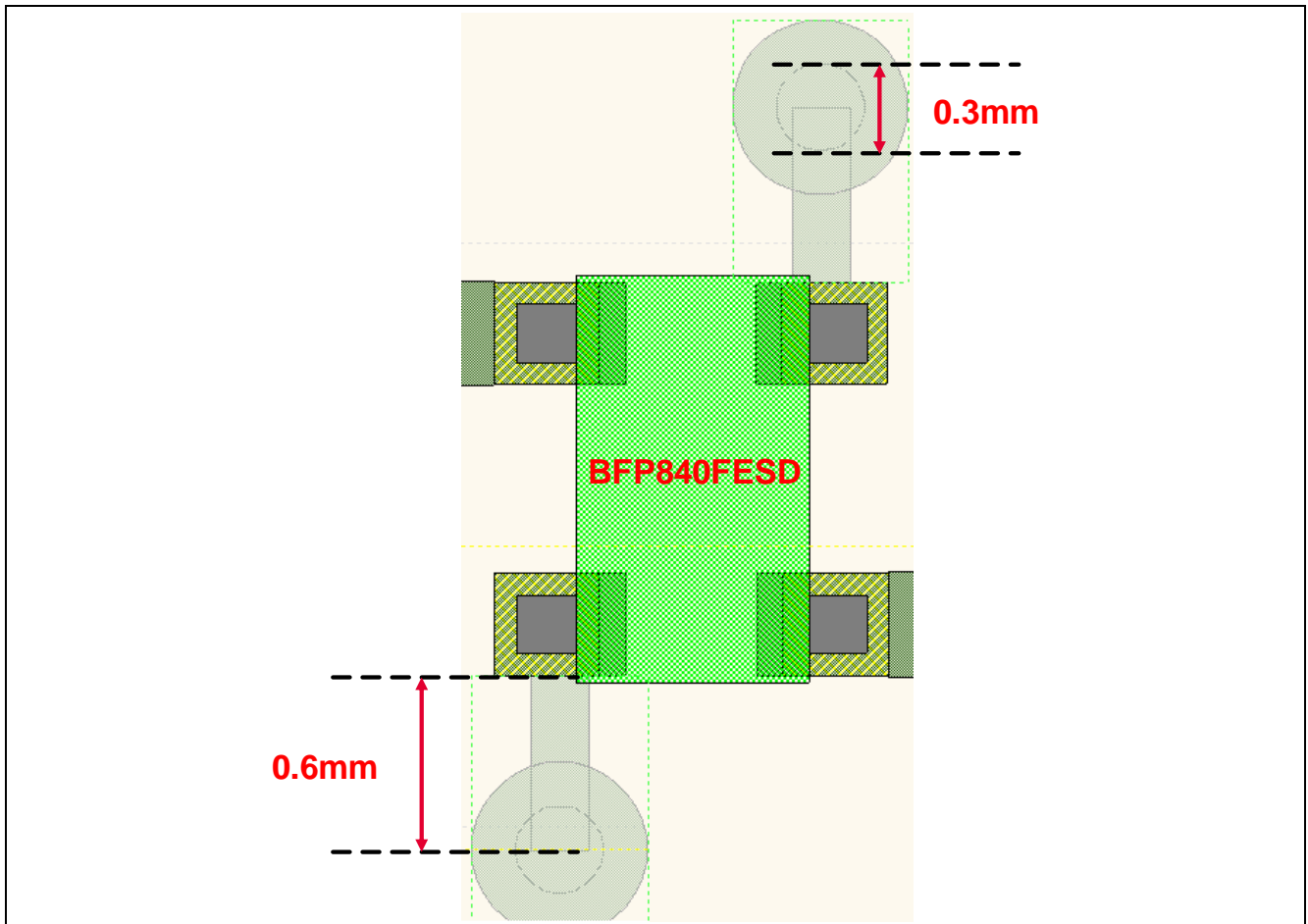
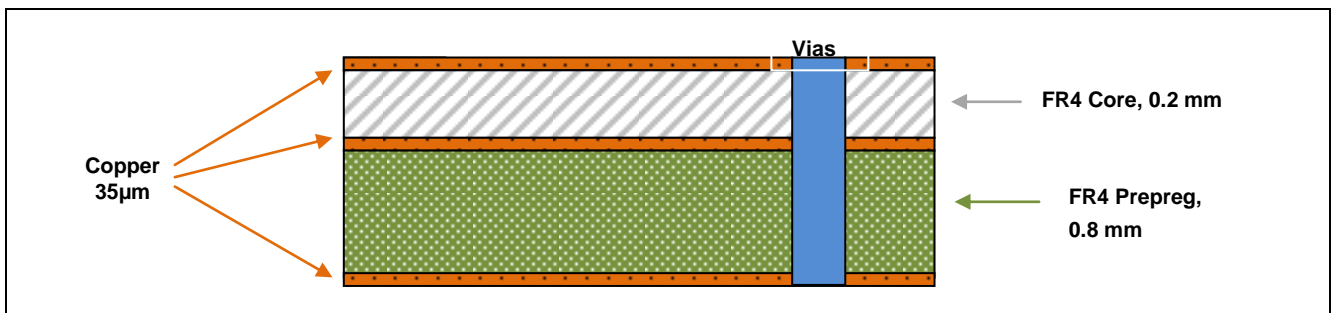


Figure 30 Zoom-In Picture of the BFP840FESD 3.4 – 3.8 GHz LNA Evaluation Board



**Figure 31** Layout Proposal for RF Grounding of the 3.4 – 3.8 GHz LNA with BFP840FESD



**Figure 32** PCB Layer Information



## **4 Authors**

Shamsuddin Ahmed, Application Engineer of Business Unit “RF and Protection Devices”

Fang Jie, Application Engineer of Business Unit “RF and Protection Devices”

[www.infineon.com](http://www.infineon.com)