Design guide for low-noise transistors for 6 GHz in space application

HiRel NPN Silicon RF Transistor

Scope and purpose

This application note provides application circuit design examples of Infineon's HiRel NPN Silicon RF Transistor for low-noise amplifiers (LNAs). In this document, the transistor-based LNA schematics, printed circuit board (PCB) layouts and measurement results are shown. This document is relevant to the following HiRel devices:

- BFY740B-02(ES)

Product features

- For L, S, C, X-frequency bands
- Ideal for low noise amplifiers
- Hermetically sealed microwave package

Intended audience

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

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1 Introduction

1.1 Radio front ends for space applications

Infineon's broad range of high-performance and high reliability silicon bipolar transistors are ideal for low noise and high-gain broadband amplifiers and are supplied in hermetically sealed microwave transistor packages as well as chips.

Using Infineon's radiation hard high reliability RF microwave technology, the diverse portfolio of microwave bipolar junction transistors is available in a range of frequencies and voltage classes and are qualified for use for applications in both space and aerospace industries.

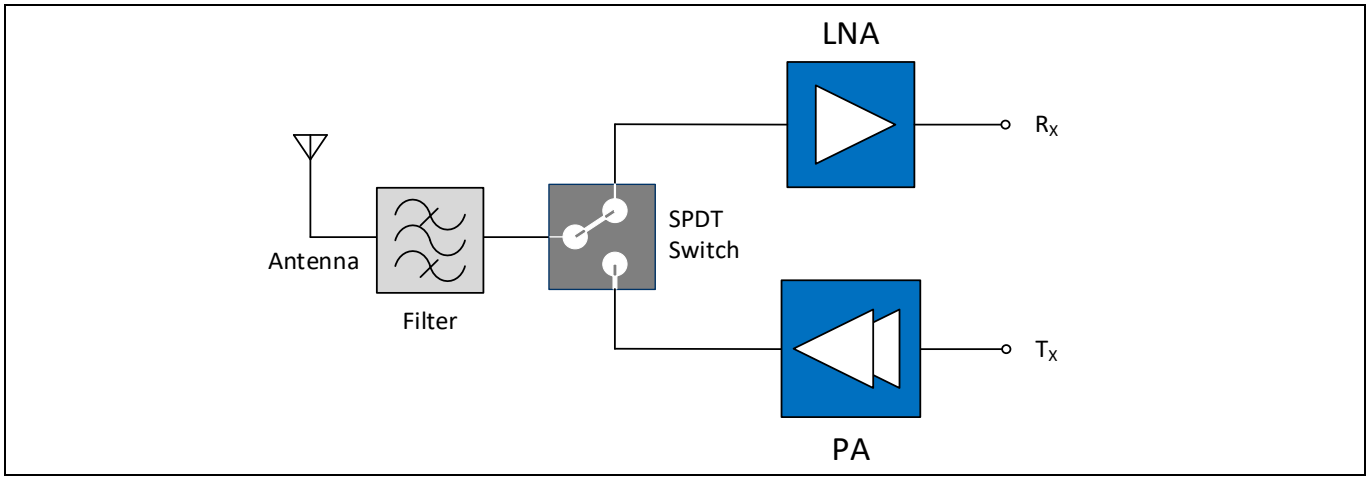

Figure 1 Example of radio front end block diagram

1.2 Infineon HiRel NPN Silicon RF Transistor

With nearly 50 years of space heritage, Infineon's radiation hard HiRel microwave transistors are offered in hermetically sealed ceramic packages and used in a wide range of space missions. Application examples are first and second stage LNA's, oscillators, and mixers.

Infineon's HiRel silicon bipolar transistor product range covers different generations of RF microwave transistor technology from bipolar Si to SiGe based devices. RF bipolar transistors with different voltage classes, frequency ranges, and output power, are available and based on Infineon's vast microwave bipolar transistor technical knowledge.

With different bipolar transistor types to choose from, Infineon's high reliability microwave bipolar junction transistor devices are available in different quality levels: Professional (P), which are designed for Engineering Modules and used for breadboards and circuit evaluation, and ESCC qualified (ES), which fulfills the requirements of the European Space Agency (ESA) for Flight Modules.

Their optimized inner transistor cell structure leads to best-in-class power gain and NF at high frequencies, including 6 GHz bands.

2 6 GHz band LNA application circuits

2.1 Performance overview

The following table shows the performance of the 6 GHz band low-noise transistors.

Table 1 Summary of measurement results for the 6 GHz band LNA

Parameter	Symbol	Value	Unit	Notes
Device		BFY740B-02(ES)		
Bias voltage	V_{CC}	3.3	V	
Bias current	I_{CC}	26.4	mA	
Frequency	f	6.0	GHz	
Gain	G	14.0	dB	
NF	NF	1.56	dB	PCB and SMA loss subtracted: 0.15 dB
Input return loss	RL_{in}	10.6	dB	
Output return loss	RL_{out}	12.8	dB	
Reverse isolation	ISO_{rev}	22.1	dB	
Output 1 dB compression point	OP_{1dB}	8.6	dBm	Measured at 6.0 GHz
Output third-order intercept point	OIP_3	15.3	dBm	Input power: -30 dBm Tone 1: 6000 MHz Tone 2: 6001 MHz
Stability	K	>1		Measured from 10 MHz to 15 GHz

2.2 Schematic

The following figure shows the schematic of the 6 GHz band LNAs with Infineon HiRel NPN Silicon RF Transistor BFY740B-02(ES). In the LNA circuit, resistors R1 and R2 stand for transistor voltage and current bias; meanwhile, they form a negative DC feedback mechanism to stabilize the transistor bias points in various conditions. Capacitors C3 and C4 serve as the RF bypass. Transistor input matching is achieved by C1, C2, and L1. The output matching network is formed by C5, L2, and R3. Resistor R3 also has the function of improving circuit stability.

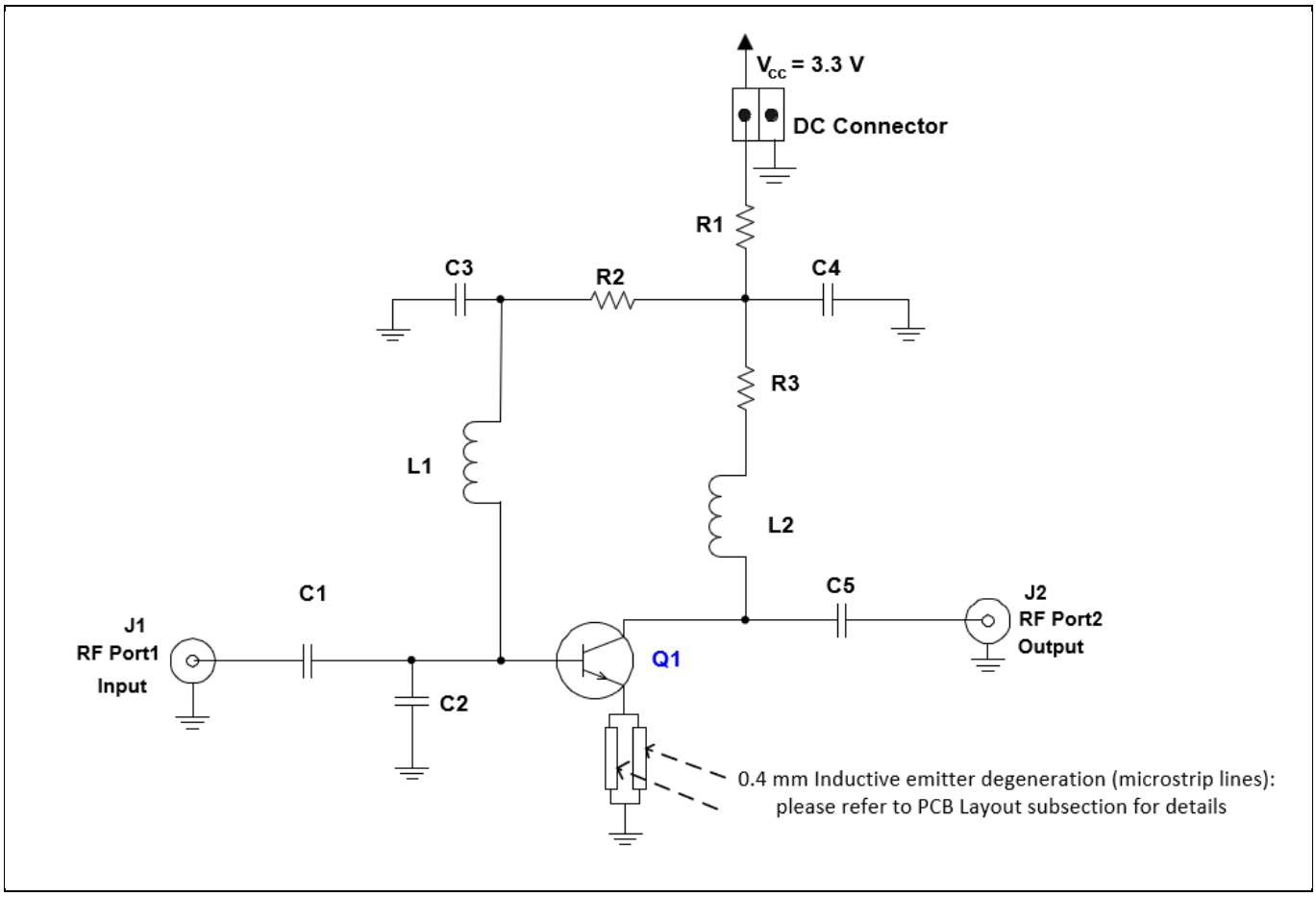

Figure 2 6 GHz band LNA schematic

2.3 Bill of materials

Table 2 BOM of the 6 GHz band LNAs

Symbol	Value	Package/size	Manufacturer	Notes
Q1	BFY740B-02(ES)	Micro-X	Infineon	SiGe:C bipolar low-noise transistor
C1	6.8 pF	0402	Murata	Input matching and DC blocking
C2	0.3 pF	0402	Murata	Input matching
C3	47 nF	0402	Murata	RF decoupling
C4	47 nF	0402	Murata	RF decoupling
C5	4.7 pF	0402	Murata	Output matching and DC blocking
R1	22 ohm	0402	Various	DC bias and DC negative feedback
R2	15 kohm	0402	Various	DC biasing for transistor base
R3	39 ohm	0402	Various	Low-frequency stability improvement
L1	6.8 nH	0402	LQW Murata	RF choke and input matching
L2	4.7 nH	0402	LQW Murata	RF choke and output matching

2.4 Evaluation boards and layout information

The evaluation boards for the 6 GHz band LNAs:

- PCB material: FR4
- PCB marking:
  - BFY740 Micro-X

The detailed description of the PCB stack and photos of the 6 GHz band LNAs' evaluation boards are shown in the following figures.

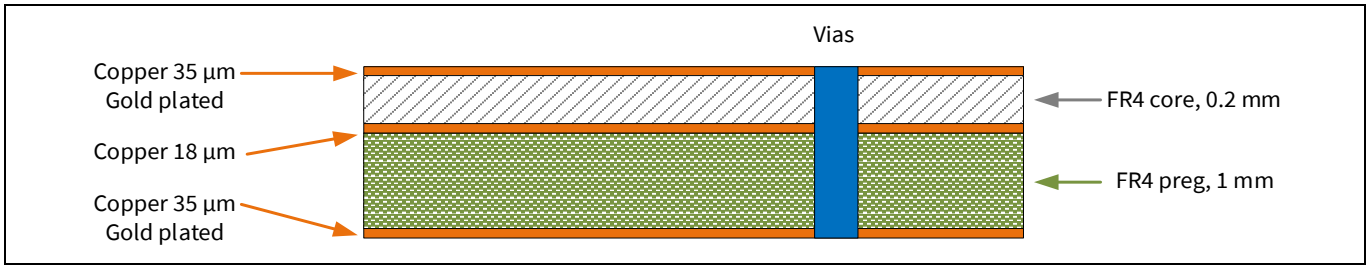

Figure 3 PCB stack information for the evaluation board

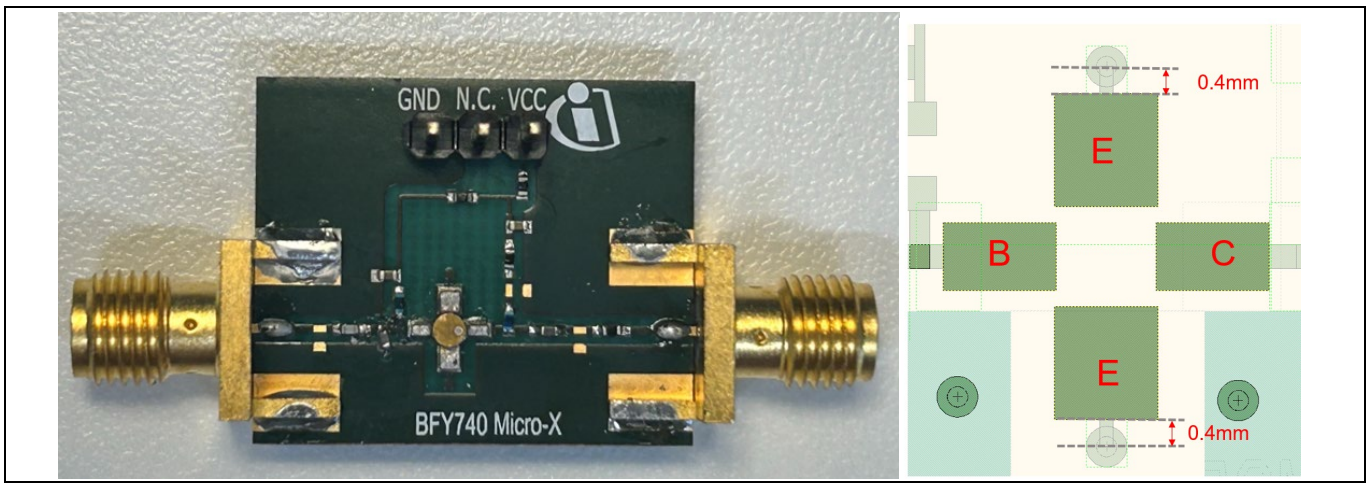

Figure 4 Photo of the evaluation board with marking Micro-X 6Hz LNA

2.5 Measurement results of the 6 GHz band LNAs

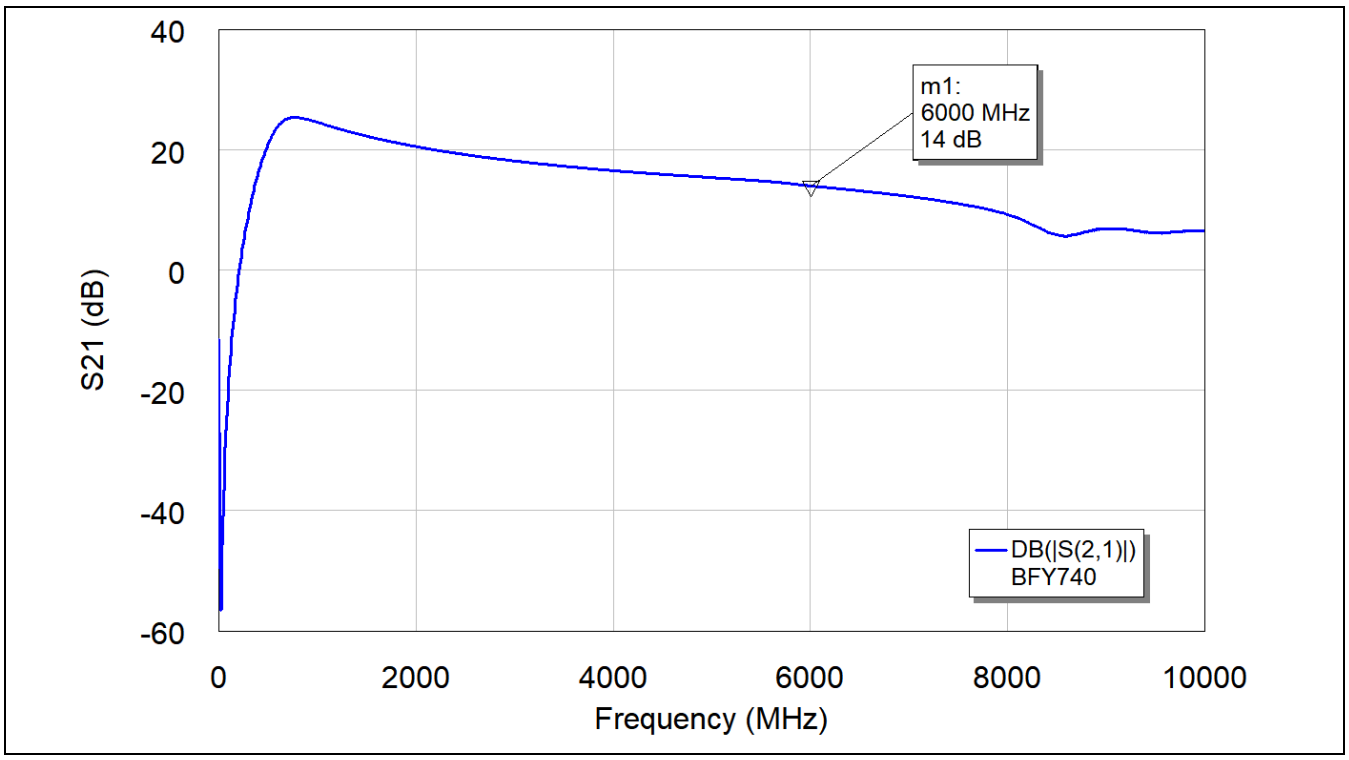

Figure 5 Small-signal gain of the 6 GHz band LNA

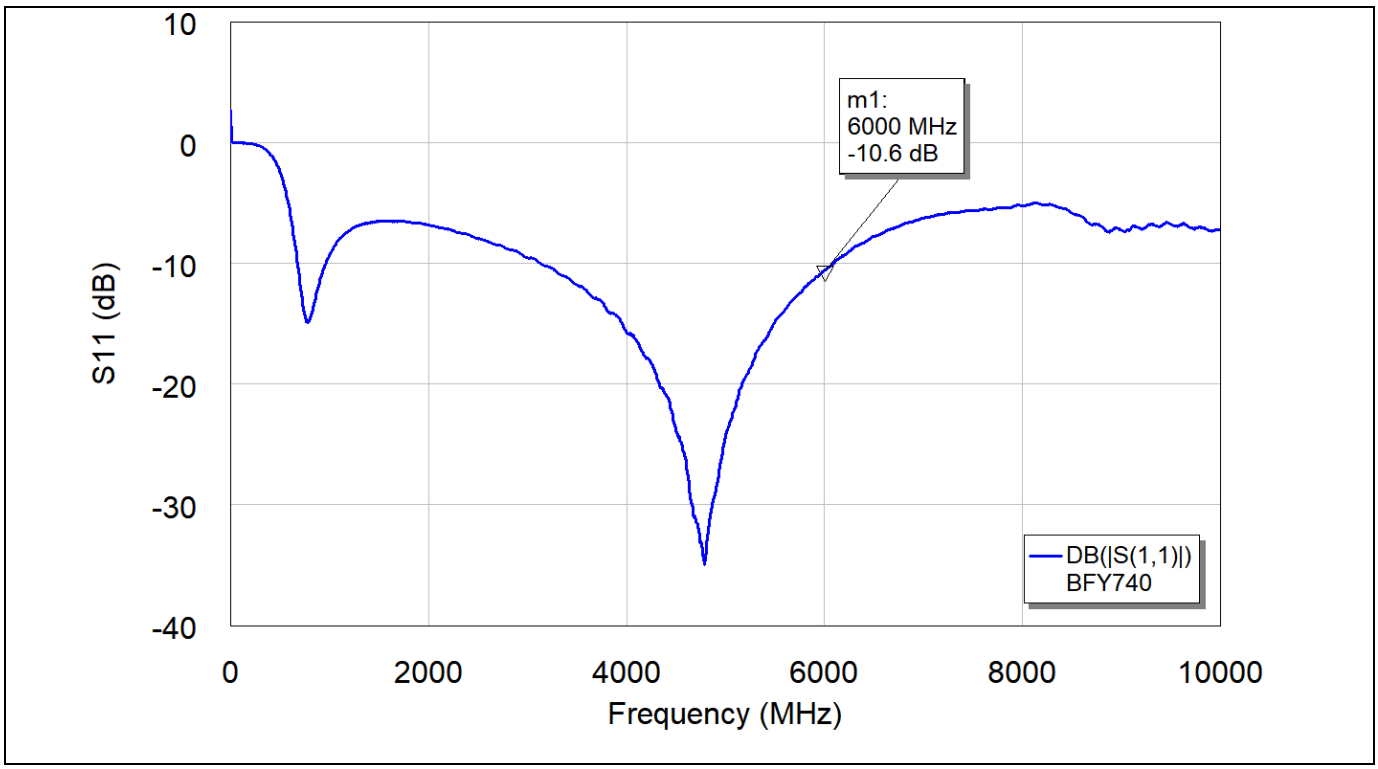

Figure 6 Input return loss measurement of 6 GHz band LNA

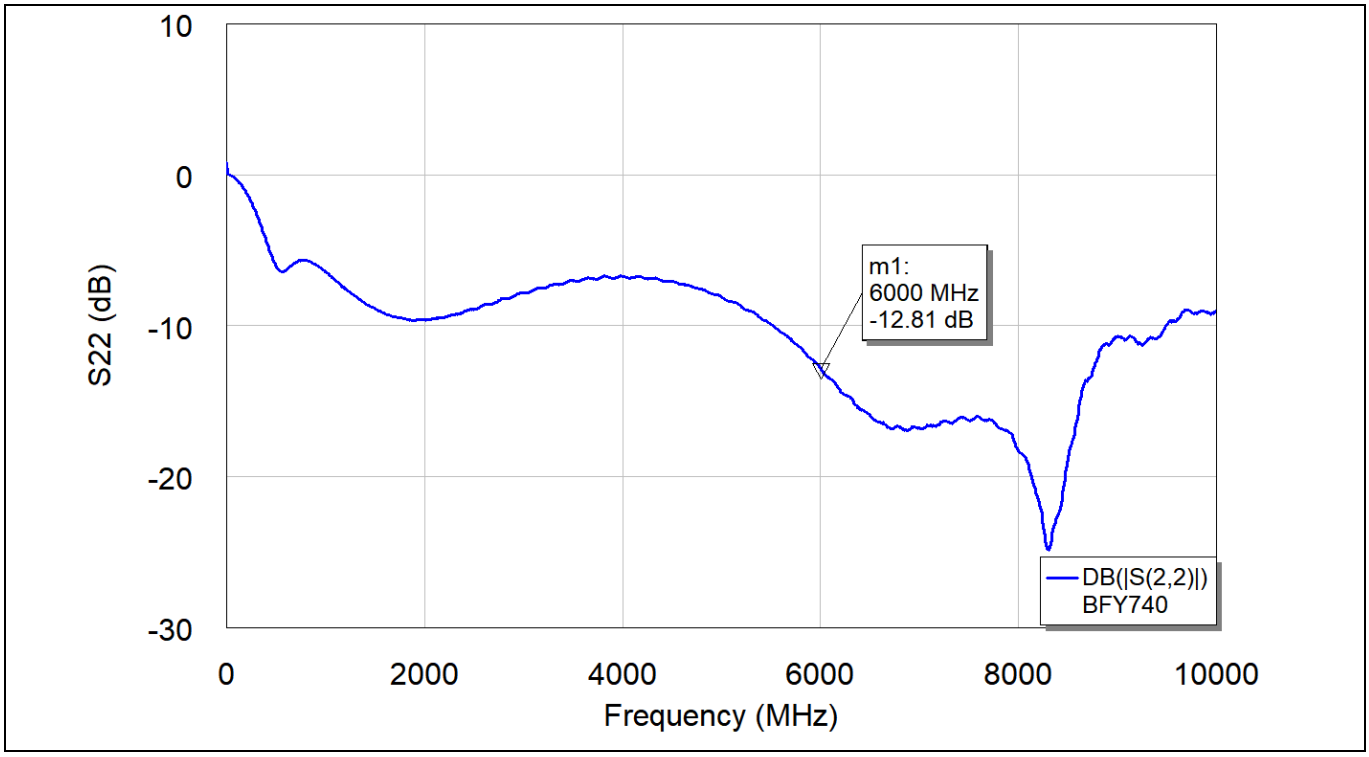

Figure 7 Output return loss measurement of the 6 GHz band LNA

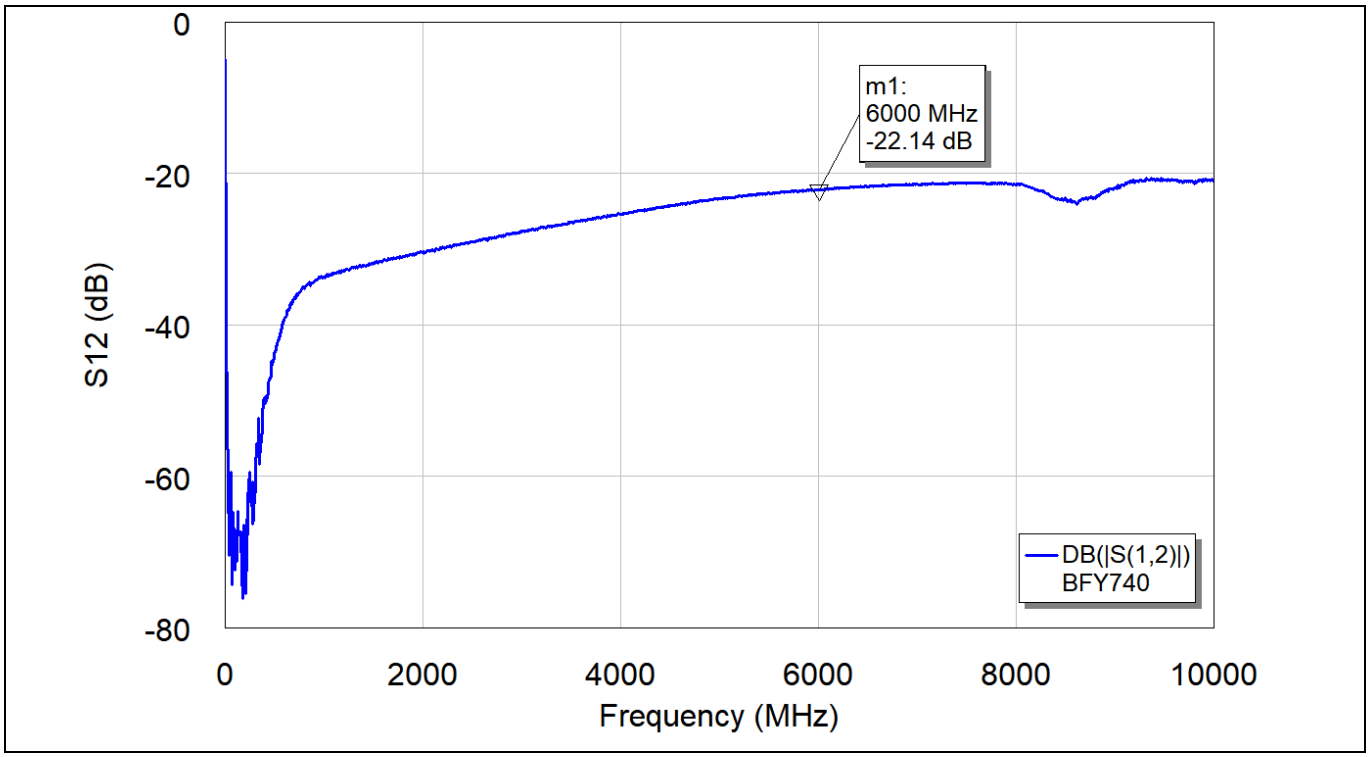

Figure 8 Reverse isolation measurement of the 6 GHz band LNA

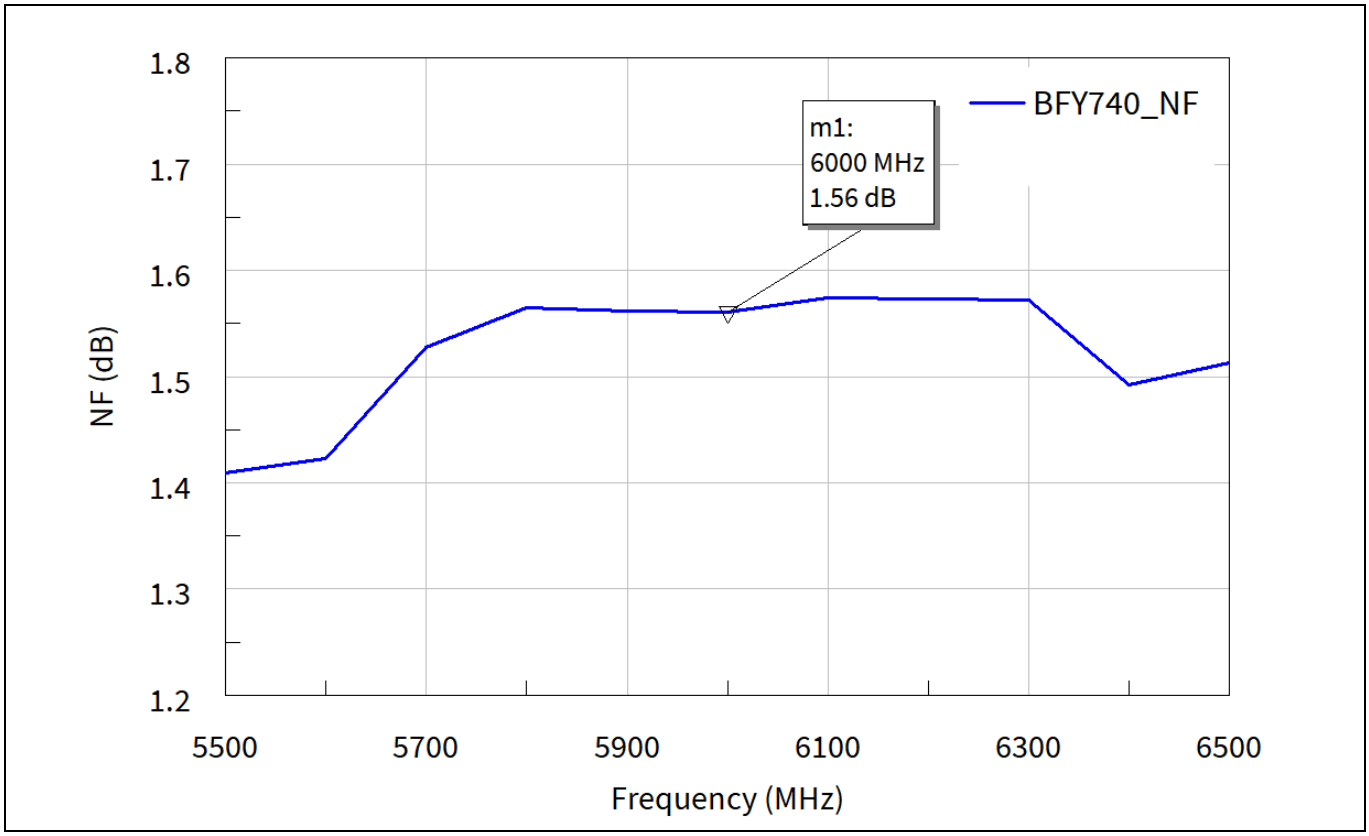

Figure 9 NF measurement of the 6 GHz band LNA

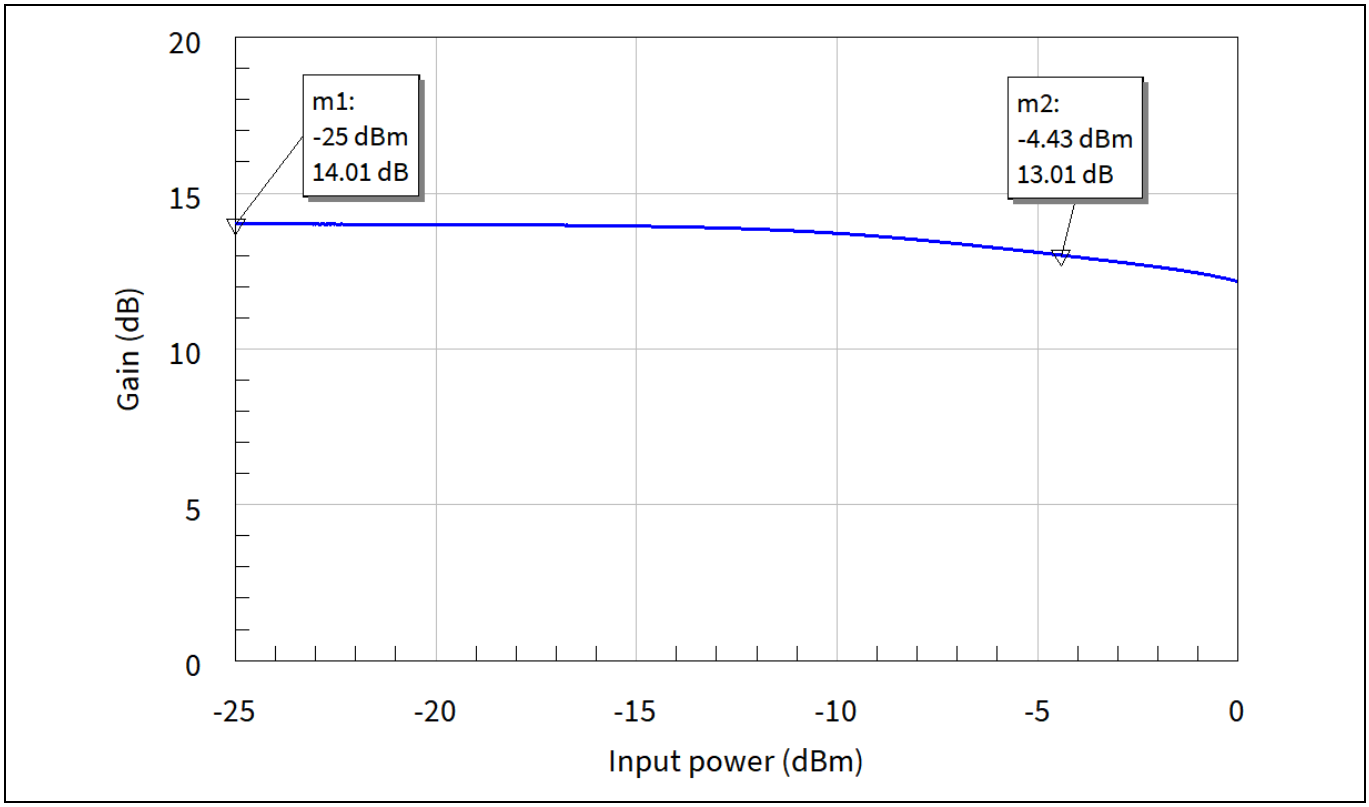

Figure 10 Input 1 dB compression point measurement at 6 GHz

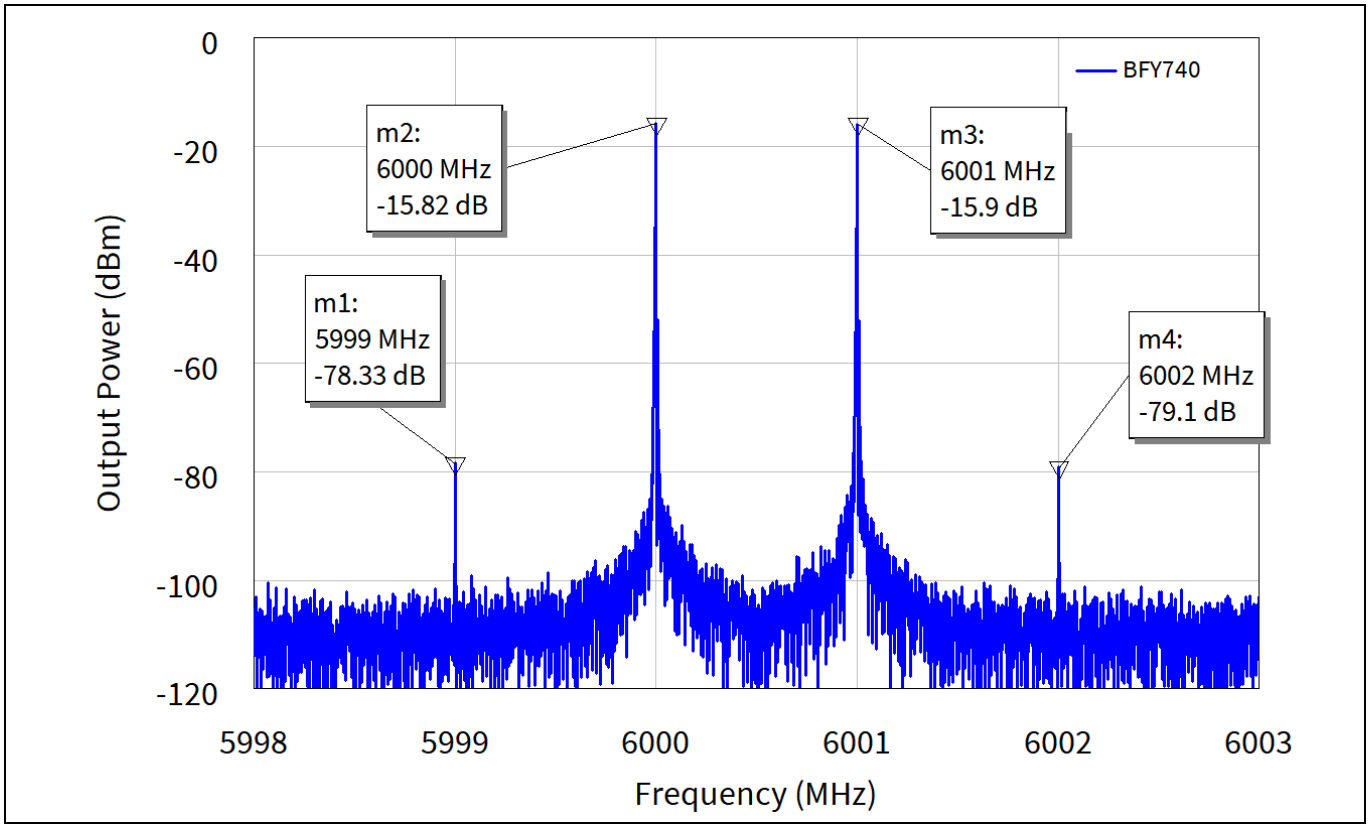

Figure 11 Output IMD$_3$ measurement of the 6 GHz band LNA

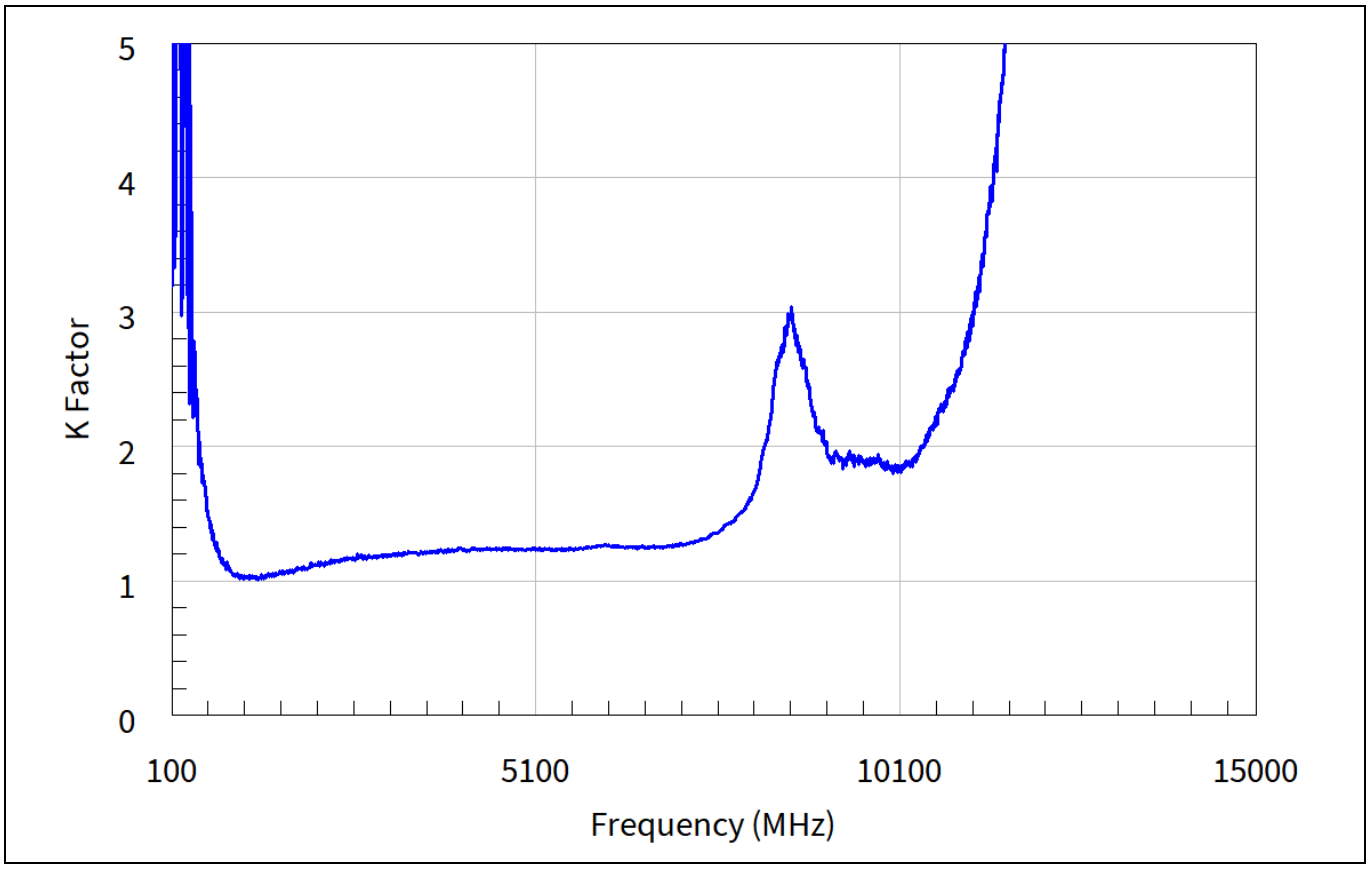

Figure 12 Stability K-factor plots of the 6 GHz band LNAs

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Revision history

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