# Low noise amplifier for remote keyless entry (RKE) applications

## RF low power transistor

## About this document

### Scope and purpose

This application note provides application circuit design example with Infineon's radio frequency (RF) low power silicon (Si) transistor BFP460 as low noise amplifier (LNA) for RKE automotive applications. In this document, the BFP460 LNA schematic, PCB layout and measurement results are shown.

### Intended audience

This document is intended for engineers who need to design RF LNA for RKE applications.

## Table of contents

# 1 Introduction

## 1.1 RKE for automotive applications

The term RKE refers to a lock that uses an electronic remote control as a key which is activated by a handheld device. Widely used in automobiles, an RKE performs the functions of a standard car key without physical contact. When within a few meters of the car, pressing a button on the remote can lock or unlock the doors, and may perform other functions.

An RKE system consists of an RF transmitter in the keyfob (or key) that sends a signal to the onboard receiver in the vehicle as shown in Figure 1. In automotive systems, the onboard RKE receiver antenna is usually placed in locations often dictated by cost and practical considerations, and may result in increasing path loss and reducing the RKE system range. Furthermore, the antennas used in the RKE receiver typically have poor efficiency. Adding an external LNA between the receiver antenna and the RKE IC is the most cost-effective option to increase the range of the RKE system with minimal increase in power consumption. The wireless carrier frequency used for the RKE systems is 315 MHz in the US/Japan and 433.92 MHz (ISM band) in Europe.

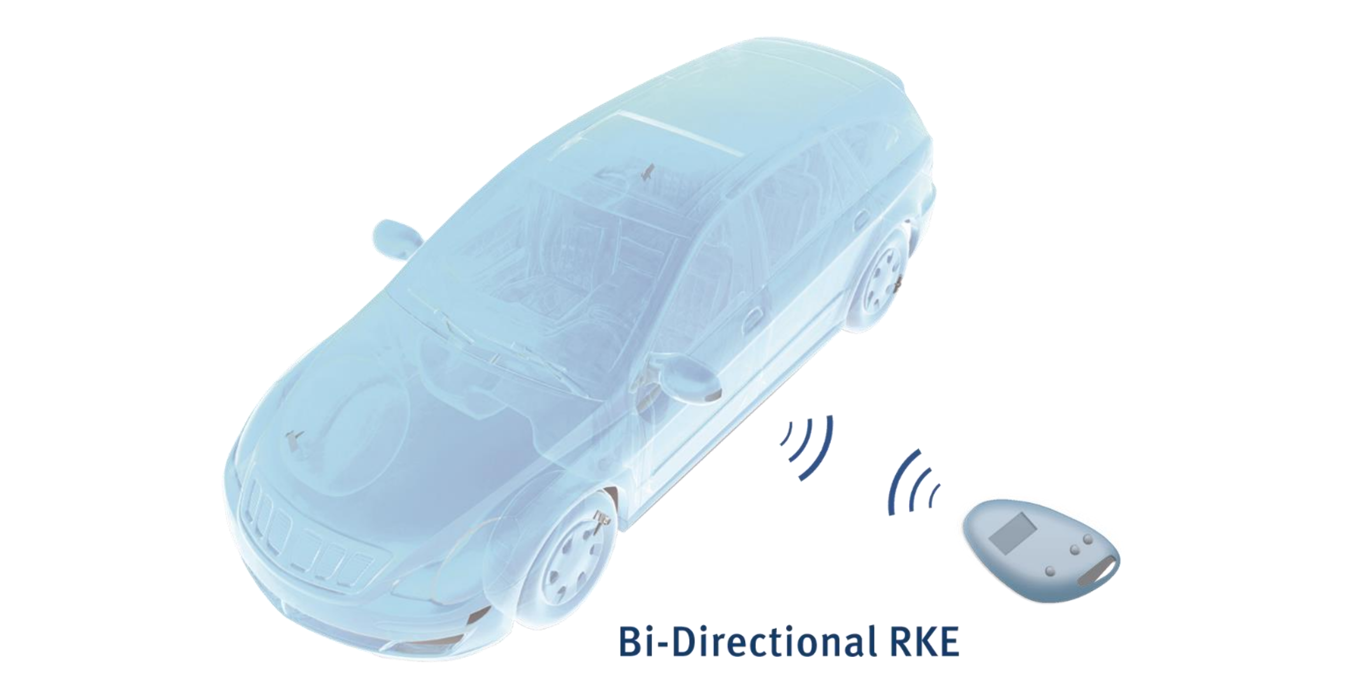


**Figure 1 The RKE application in automobiles**

## 1.2 Infineon low noise Si transistors

Infineon Technologies provides high performance RF transistors. Infineon’s reliable high-volume RF transistors offer exceptionally low noise figure, high gain and high linearity at low power consumption levels for RF applications. The high performance low-noise wideband amplifiers are based on Silicon bipolar technology. Their optimized inner transistor cell structure leads to best-in-class power gains and noise figures. The transistors maximize the design flexibility to customer requirements.

# 2 BFP460 LNA for RKE applications

## 2.1 Performance overview

The following table shows the RF LNA performance with RF low power transistor BFP460 for RKE applications. The measurements are performed with network analyzer source power of -40 dBm.

**Table 1 Summary of measurement results of BFP460 LNA for RKE applications**

| Parameter | Symbol | Value | | | Unit | Notes |
|---|---|---|---|---|---|---|
| Bias voltage | $V_{CC}$ | 5.0 | | | V | |
| Bias current | $I_{CC}$ | 5.3 | | | mA | |
| Frequency range | f | 315 | 434 | 900 | MHz | |
| Gain | G | 16.3 | 16 | 14.3 | dB | |
| Input return loss | $RL_{in}$ | 16.4 | 14.2 | 10.3 | dB | |
| Output return loss | $RL_{out}$ | 24.2 | 24.6 | 20.2 | dB | |
| Reverse isolation | $ISO_{rev}$ | 21.1 | 21 | 20.6 | dB | |
| Noise figure | NF | 1.6 | 1.7 | 1.7 | dB | PCB and SMA connector losses not extracted |
| Input 1-dB compression point | $IP_{1dB}$ | -20.9[1)] | -20.2[2)] | | dBm | 1) Measured at 315 MHz<br>2) Measured at 434 MHz |
| Output 1-dB compression point | $OP_{1dB}$ | -5.6[3)] | -5.2[4)] | | dBm | 3) Measured at 315 MHz<br>4) Measured at 434 MHz |
| Output 3rd order intercept point | $OIP_3$ | 6.7[5)] | 7.0[6)] | | dBm | 5) Input power: -33 dBm per tone, $f_1$=314.5 MHz, $f_2$=315.5 MHz.<br>6) Input power: -33 dBm per tone, $f_1$=433.5 MHz, $f_2$=434.5 MHz. |
| Stability | K | >1 | | | | Measured from 10 MHz upto 10 GHz |

## 2.2 Schematic

The following figure presents the schematic of BFP460 LNA for RKE applications. In the schematic, resistors R1, R2 and R3 stand for transistor voltage and current bias, meanwhile, R1 and R3 form a negative DC feedback mechanism to stabilize the transistor bias points in various conditions. R2 and C2 serve as the negative feedback to improve input and output impedance matching. Capacitor C3 and C4 serve as RF bypass. The transistor input matching is achieved by C1 and the output matching network is formed by C5 and R4.

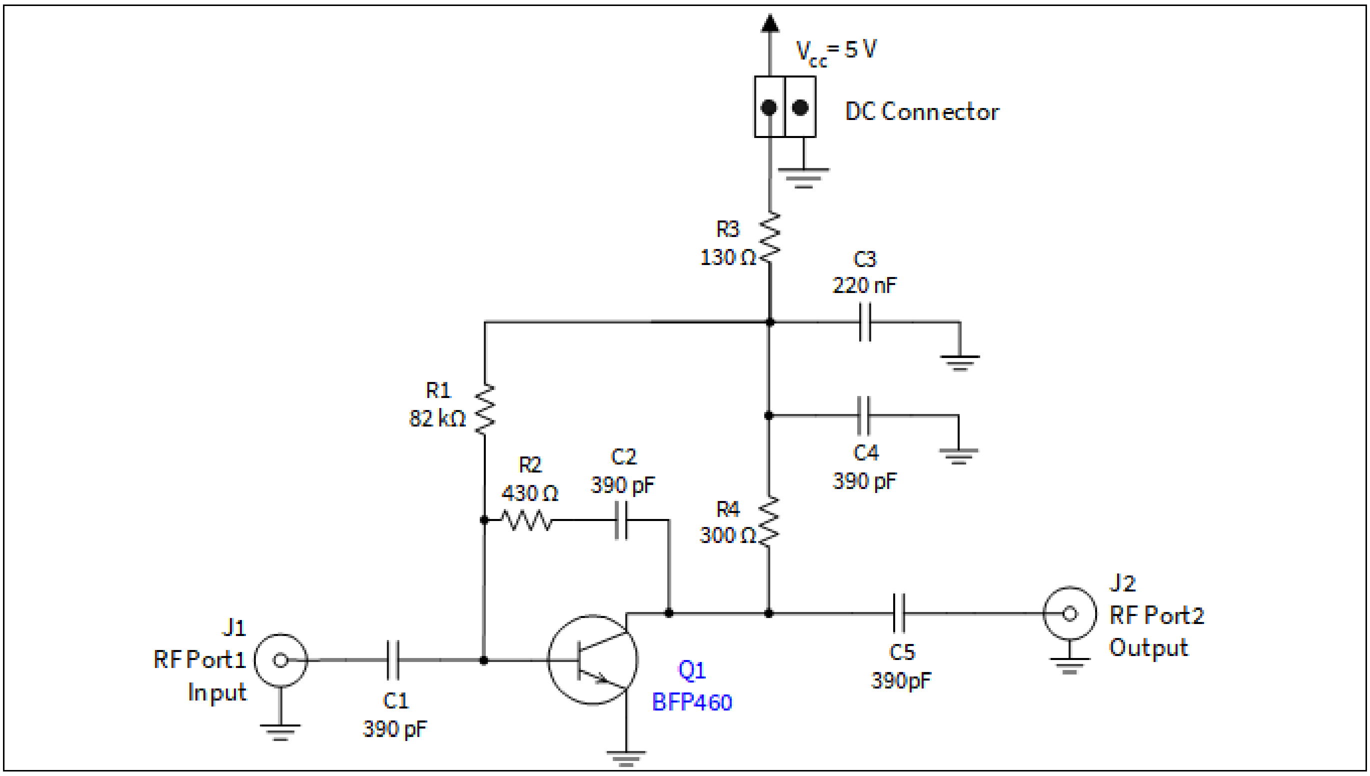


**Figure 2** BFP460 LNA schematic for RKE applications

## 2.3 Bill of materials (BOM)

**Table 2** BOM of BFP460 LNA for RKE applications

| Symbol | Value | Unit | Package | Manufacture | Comment |
|---|---|---|---|---|---|
| Q1 | BFP460 | | SOT343 | Infineon | Low power Si transistor |
| C1 | 390 | pF | 0402 | Various | DC block and input matching |
| C2 | 390 | pF | 0402 | Various | DC block for feedback network |
| C3 | 220 | nF | 0402 | Various | RF bypass |
| C4 | 390 | pF | 0402 | Various | RF bypass |
| C5 | 390 | pF | 0402 | Various | DC block and output matching |
| R1 | 82 | kΩ | 0402 | Various | Base DC bias |
| R2 | 430 | Ω | 0402 | Various | Feedback resistor |
| R3 | 130 | Ω | 0402 | Various | DC bias and DC negative feedback |
| R4 | 300 | Ω | 0402 | Various | Collector DC bias and output matching |

## 2.4 Evaluation board and layout information

The evaluation board for BFP460 LNA for RKE applications:

- PCB material: FR4
- PCB marking: BFP460 V2.0

The photo of the evaluation board and the PCB stack information are presented in the following figures.

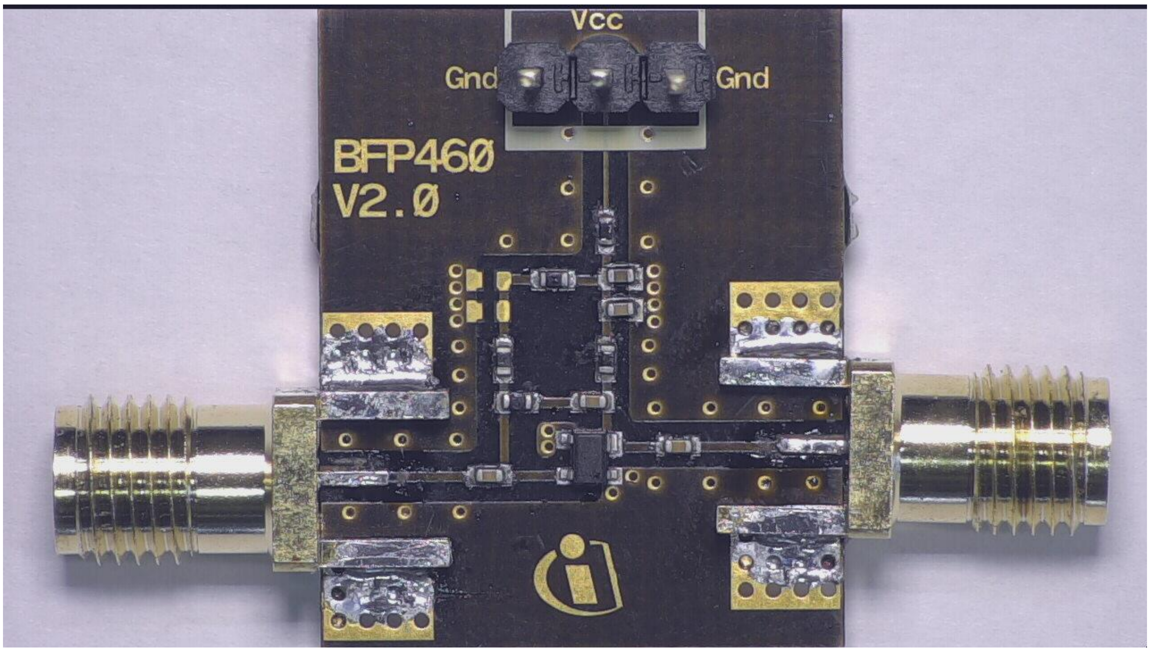


**Figure 3 The photo of BFP460 LNA for RKE applications**

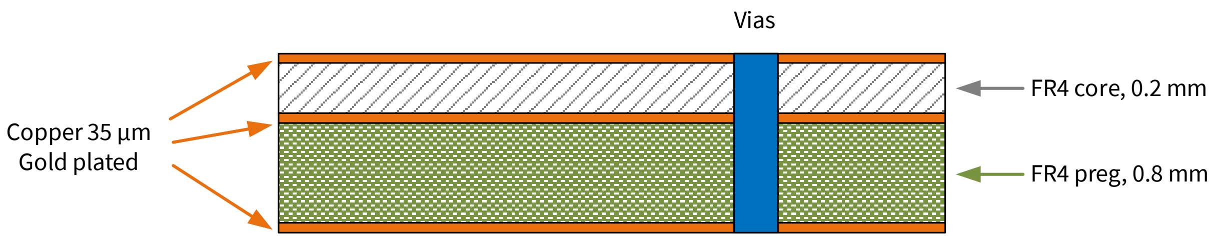


**Figure 4 PCB stack information for the evaluation board**

# 3 Measurement results of BFP460 LNA for RKE applications

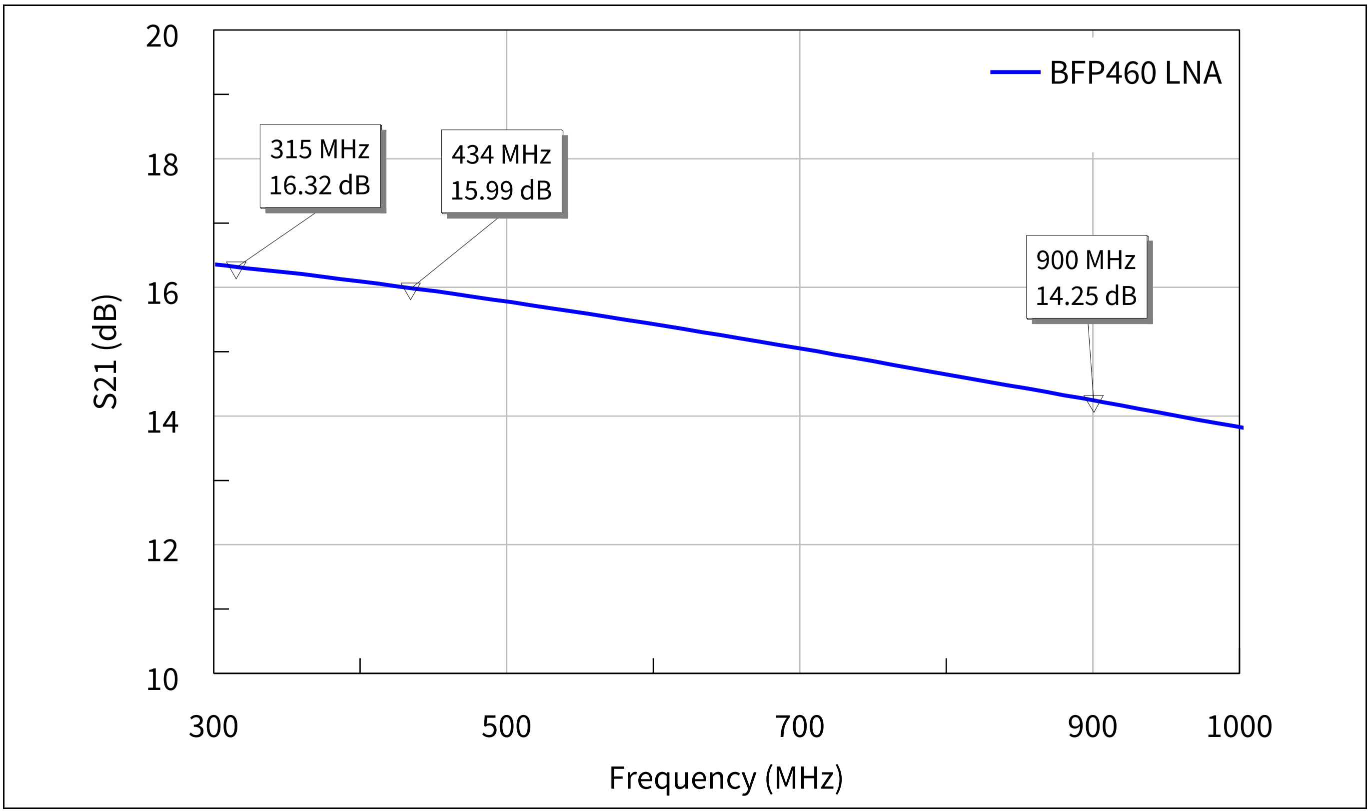


**Figure 5 Small signal gain of BFP460 LNA for RKE applications**

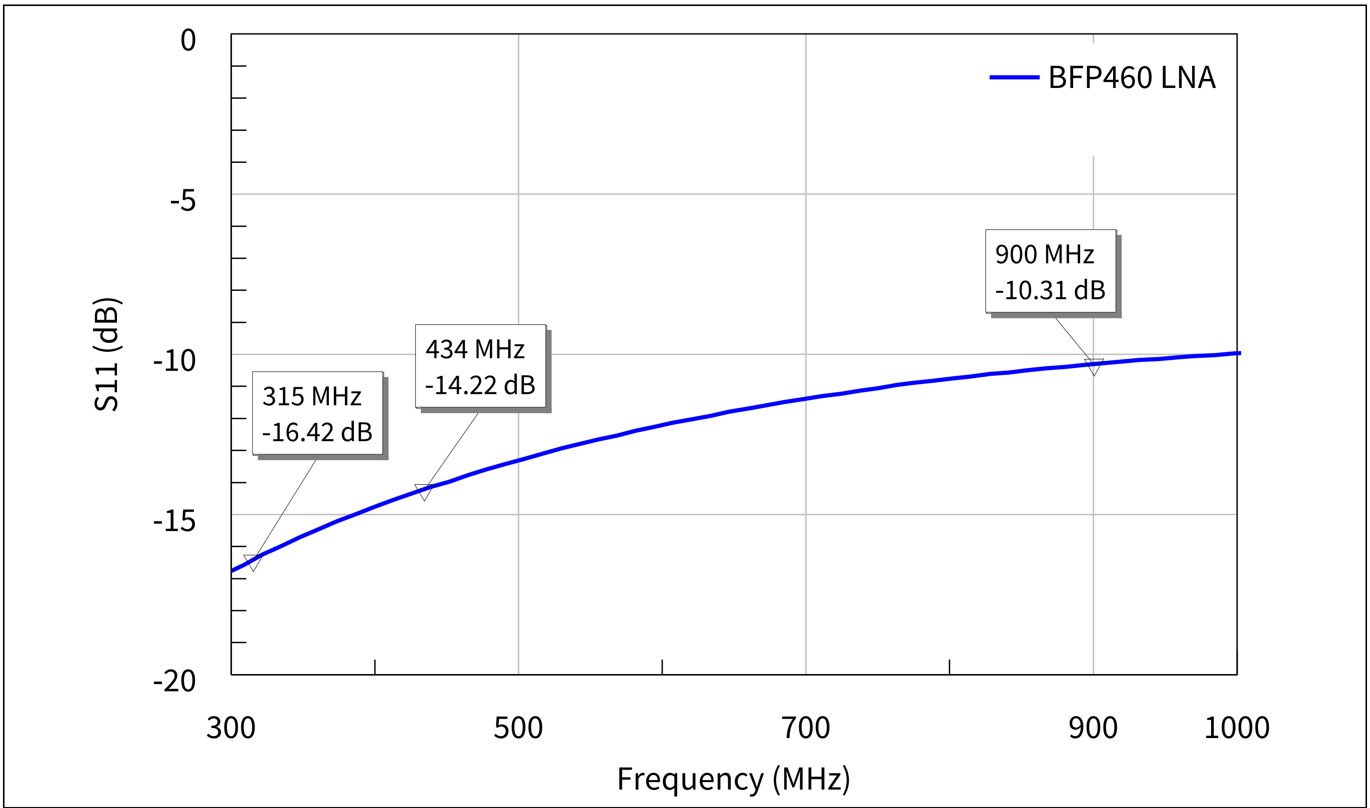


**Figure 6 Input return loss of BFP460 LNA for RKE applications**

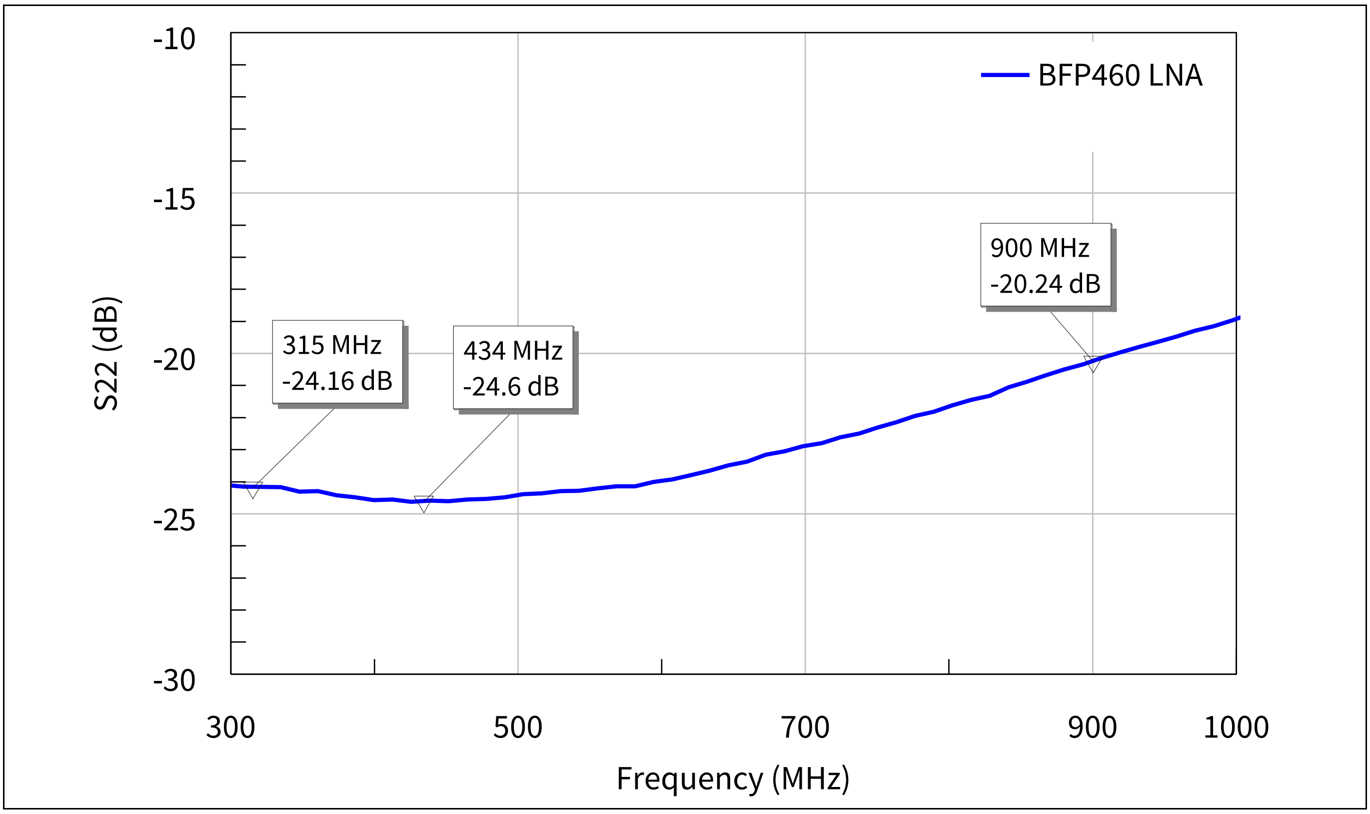


**Figure 7 Output return loss of BFP460 LNA for RKE applications**

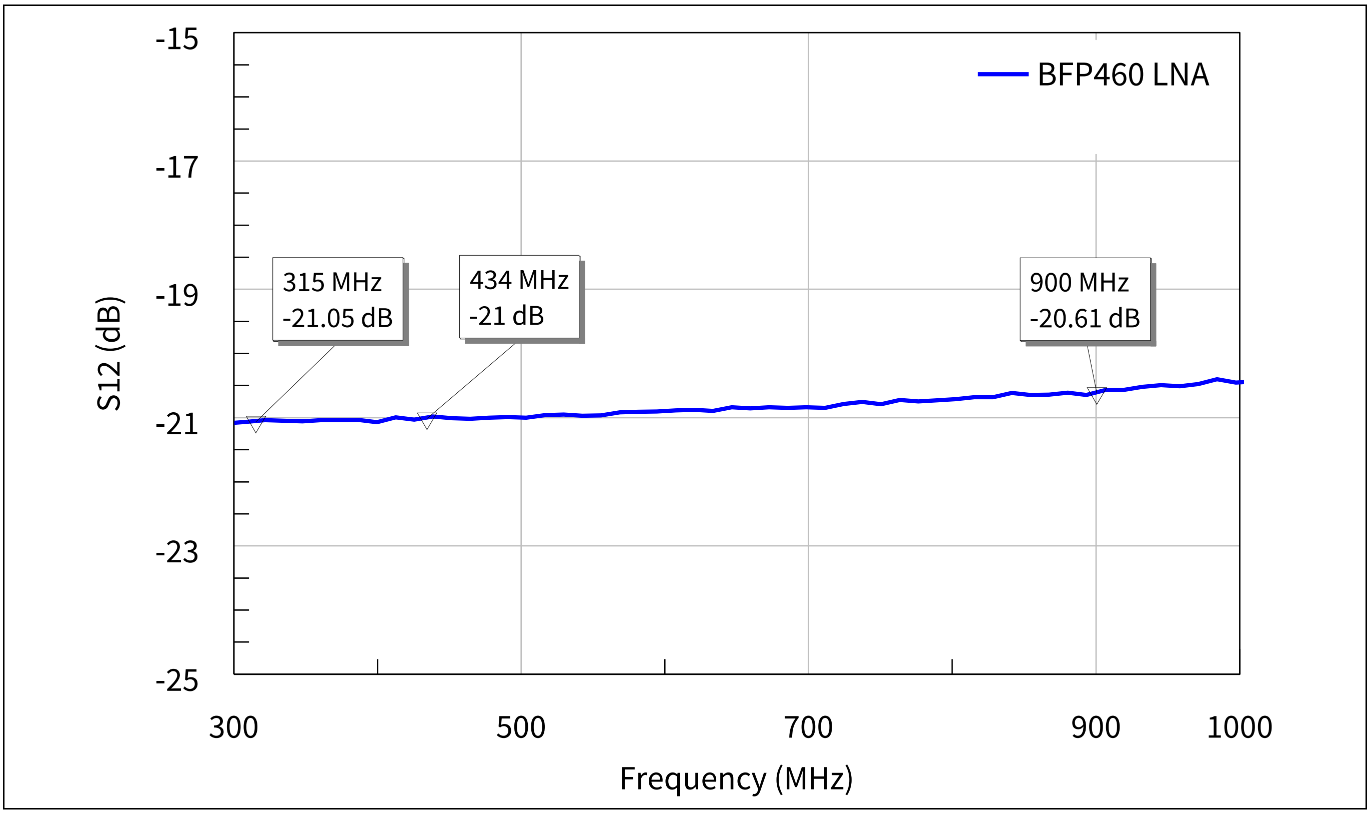


**Figure 8 Reverse isolation of BFP460 LNA for RKE applications**

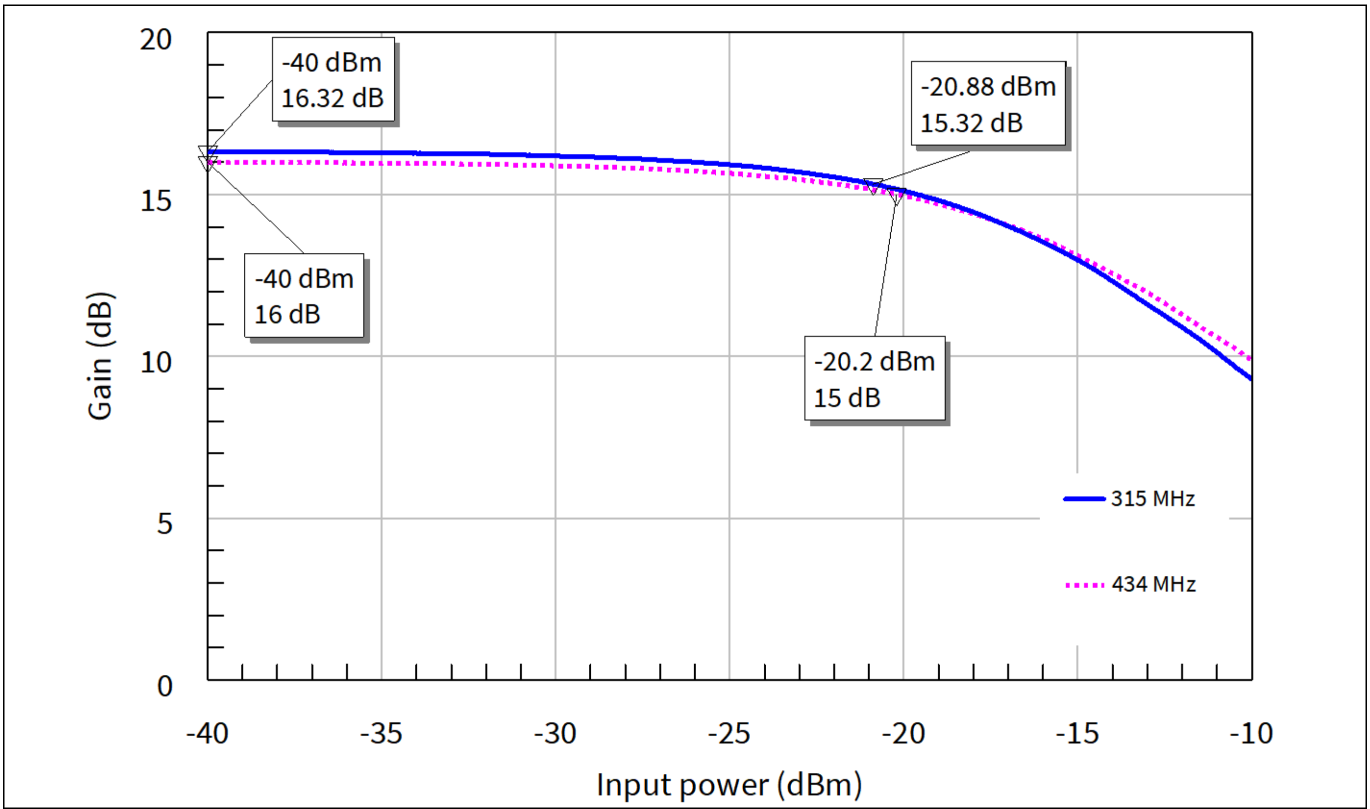


**Figure 9** **Input 1 dB compression point of BFP460 LNA for RKE applications**

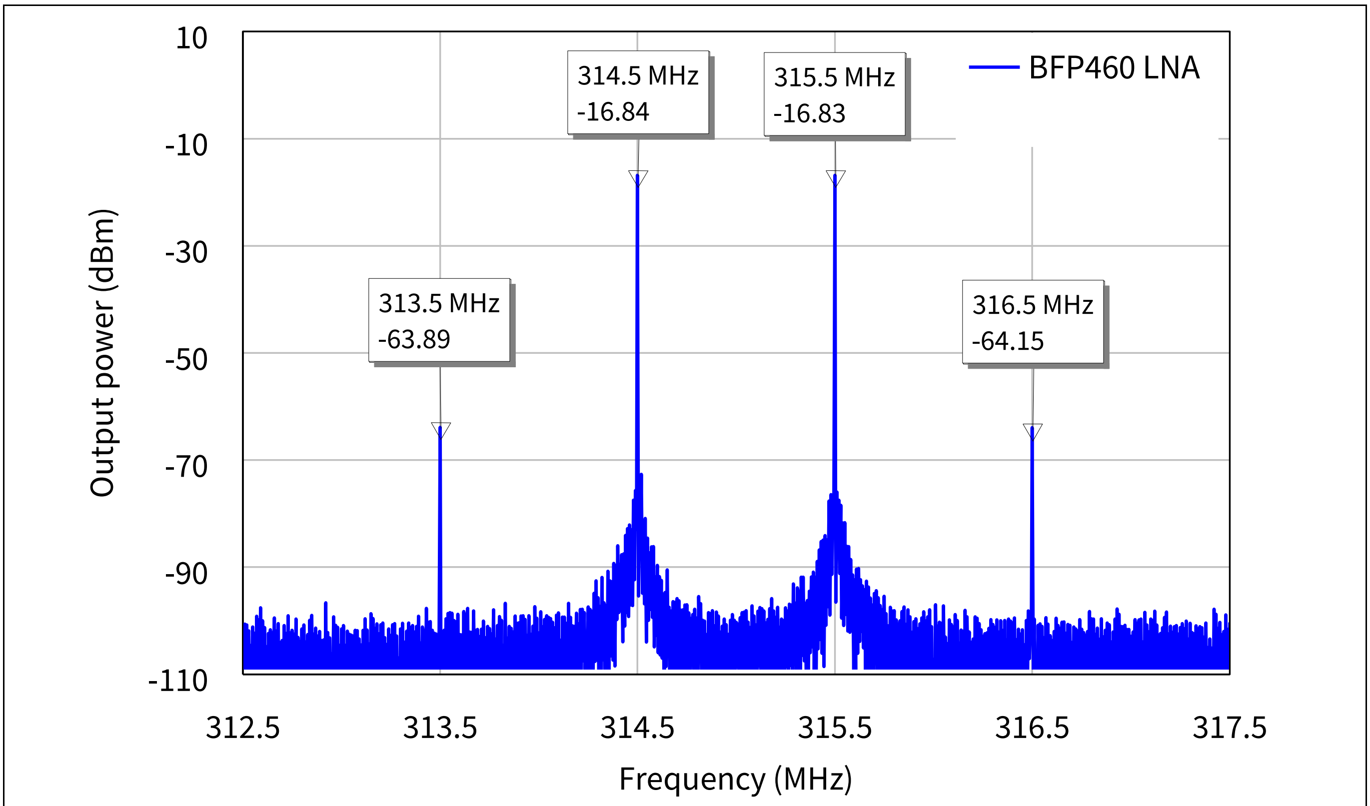


**Figure 10** **Output third order intermodulation products of the BFP460 LNA at 315 MHz with -33 dBm input power per tone for RKE applications**

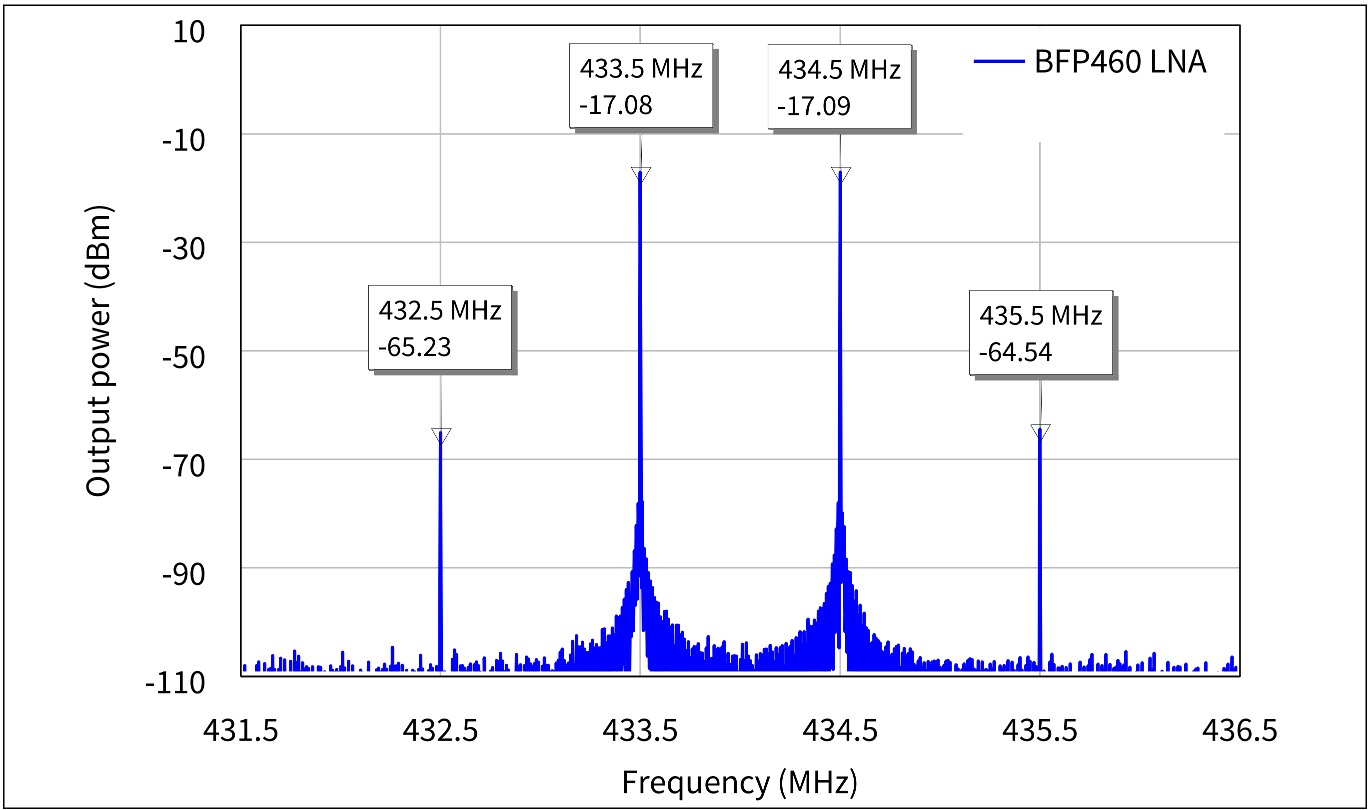


**Figure 11** **Output third order intermodulation products of the BFP460 LNA at 434 MHz with -33 dBm input power per tone for RKE applications**

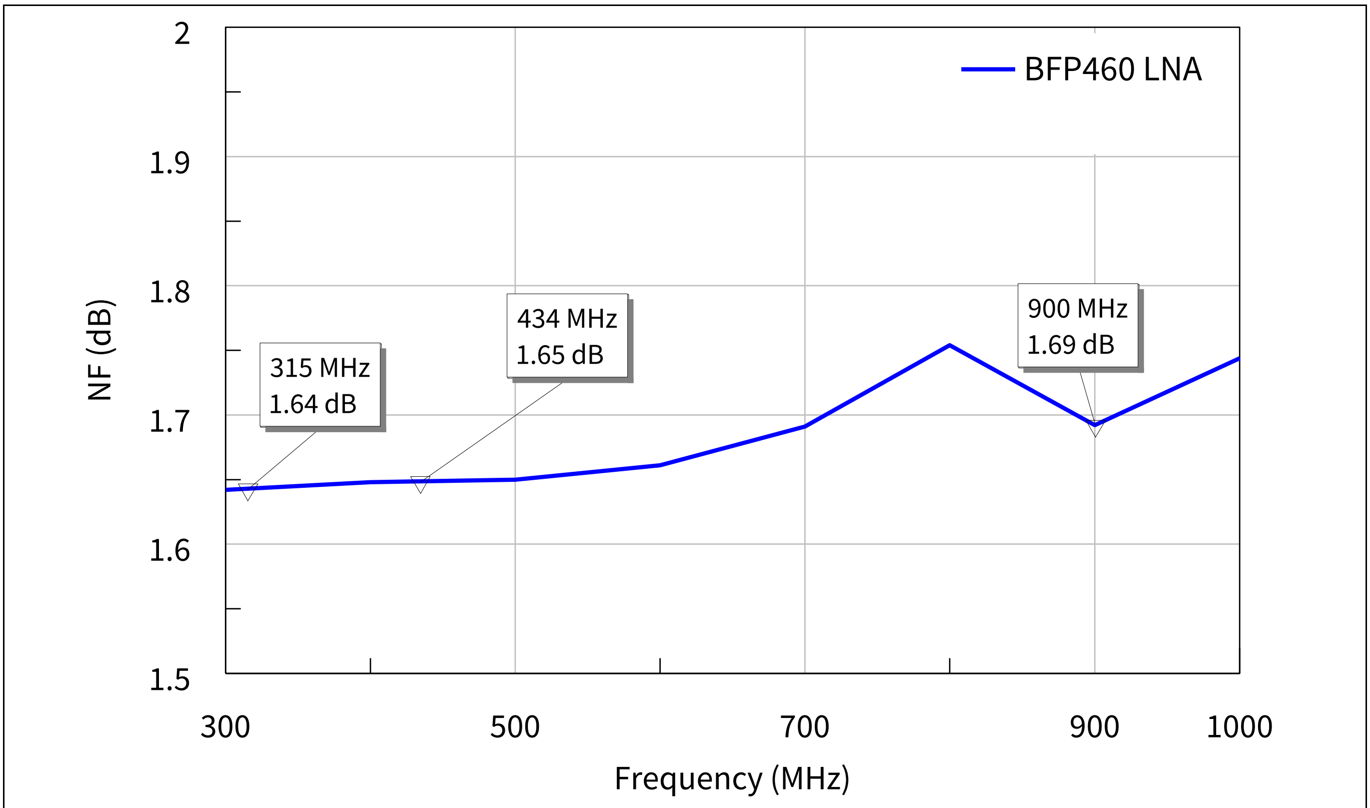


**Figure 12** **NF measurement of BFP460 LNA for RKE applications**

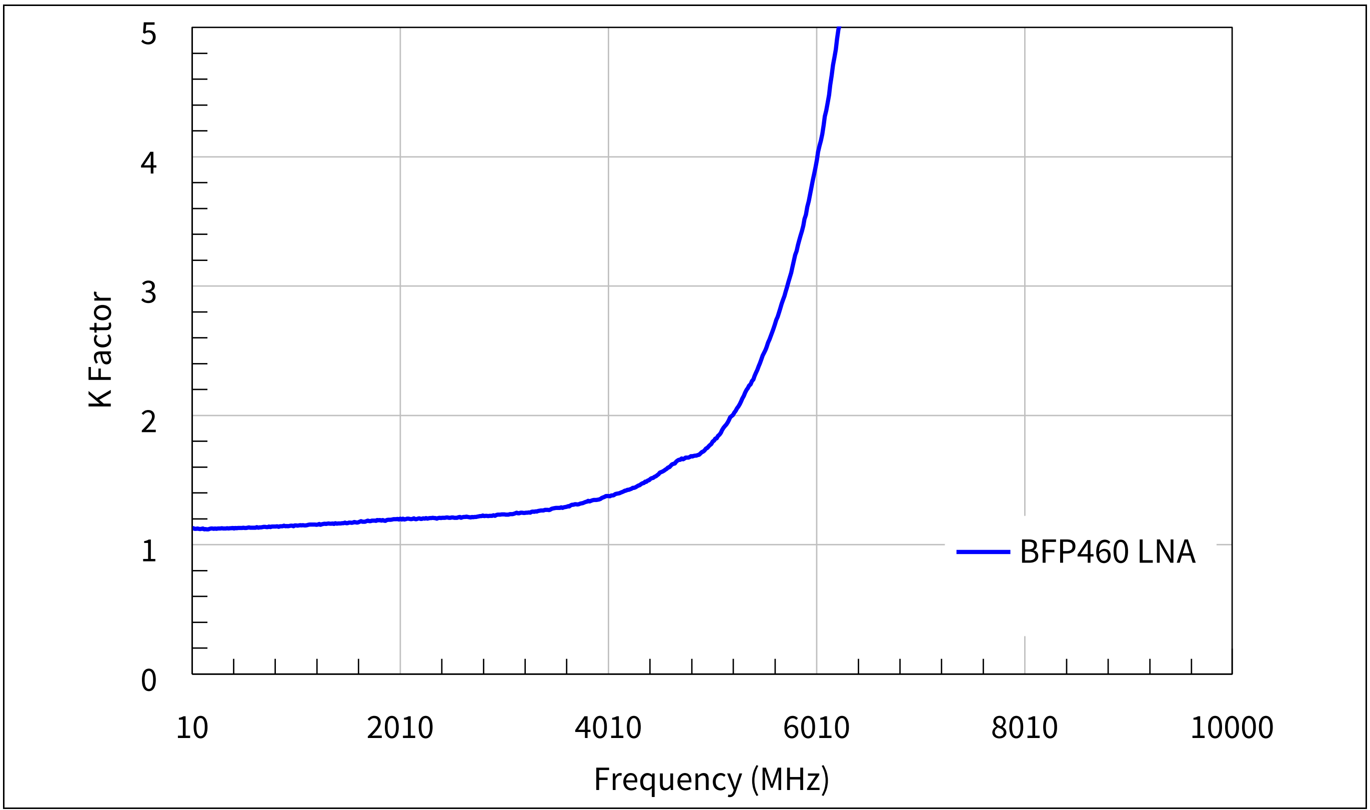


**Figure 13** **K-factor measurement of BFP460 LNA for RKE applications**

# 4 Author

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# Revision history

| Document version | Date of release | Description of changes |
|---|---|---|
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**Edition 2018-08-21**

**Published by**

**Infineon Technologies AG**

**81726 Munich, Germany**



**Do you have a question about this document?**

**Email:** erratum@infineon.com

**Document reference**
**AN_1808_PL32_1809_133505**