High-linearity amplifier for 2.4 GHz WiFi frequency band

RF high-linearity bipolar transistor

About this document

Scope and purpose

This application note provides an application circuit design example of Infineon's high-linearity silicon germanium: carbon (SiGe:C) transistor BFP650 for the wireless local area network (WLAN) 2.4 GHz frequency band. In this document, the transistor-based schematic, printed circuit board (PCB) layouts and measurement results are shown.

Intended audience

The intended audience for this document includes design engineers, technicians, and developers of electronic systems.

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1 Introduction

1.1 WLAN radio front ends

The WLAN function is one of the most important connectivity functions between WLAN access points and smartphones, tablets, and laptops. WLAN standards according to IEEE 802.11b/g/n at 2.4 GHz have been widely implemented over the years. Due to the overcrowded WLAN at 2.4 GHz, the applications in the 5 to 6 GHz band according to IEEE 802.11a/ac/n are becoming popular for fast data throughput. Today, high-quality wireless multimedia data transmission requires even higher data throughput. Hence, the next generation standard 802.11be will increase the data rate to 46.1 Gbps through the high-order modulation scheme (4096QAM) and 16×16 multi-user multiple-input and multiple-output (MU-MIMO).

Key performance metrics for WLAN application are the speed of data transfer and coverage, which are greatly influenced by transmitted power, receiver sensitivity, noise, and interference. High data throughput related to the high-order modulation scheme requires better received signal quality, while the necessary solution of WLAN router for MU-MIMO with multiple antennas will introduce trace loss in the signal path to transceiver IC, resulting in a deteriorated signal quality. A radio front end including filter, switch, input-amplifier and PA close to the antenna is a popular method to improve the signal quality.

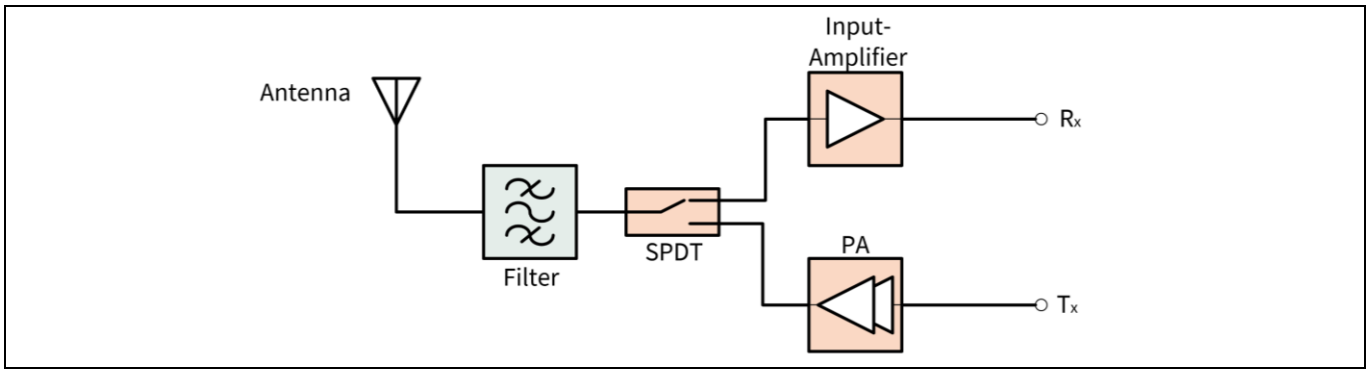


Figure 1 Block diagram of a WLAN radio front end

1.2 Infineon RF transistor family

Infineon Technologies provides high-linearity radio-frequency (RF) transistors targeting WLAN applications. Infineon's reliable high-volume RF transistors offer exceptionally low noise figure (NF), high gain and high linearity at low power consumption levels for RF applications. The fourth-generation transistor is based on bipolar Si technologies, and the sixth- and seventh-generation are based on robust ultra low-noise SiGe: C technologies. Their optimized inner transistor cell structures lead to best-in-class power gain and linearity at 2.4 GHz. The transistors maximize the design flexibility to customer requirements.

2 2.4 GHz band BFP650 application circuit

2.1 Performance overview

The following table shows the performance of the BFP650 transistor circuit at the 2.4 GHz band.

Table 1 Summary of measurement results for the 2.4 GHz band WLAN BFP650 transistor amplifier

Parameter	Symbol	Value	Unit	Notes
Bias voltage	V_{CC}	5	V	
Bias current	I_{CC}	60.4	mA	
Frequency	f	2.45	GHz	
Gain	G	15.5	dB	
NF	NF	1.63	dB	PCB and SMA loss subtracted: 0.2 dB
Input return loss	RL_{in}	22.5	dB	
Output return loss	RL_{out}	30.4	dB	
Reverse isolation	ISO_{rev}	19.7	dB	
Output 1 dB compression point	IP_{1dB}	18.9	dBm	
Output third-order intercept point	IIP_3	34.7	dBm	Input power: -25 dBm per tone Tone 1: 2449.5 MHz Tone 2: 2450.5 MHz
Stability	K	Greater than 1		Measured from 300 kHz to 10 GHz

2.2 Schematic

The following figure shows the schematic of the 2.4 GHz band WLAN BFP650 transistor amplifier. In the amplifier 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 C2 and C3 serve as the RF bypass. Transistor input matching is achieved by the inductors L1, L3 and the capacitor C1. The output matching network is formed by C4, L2 and L4.

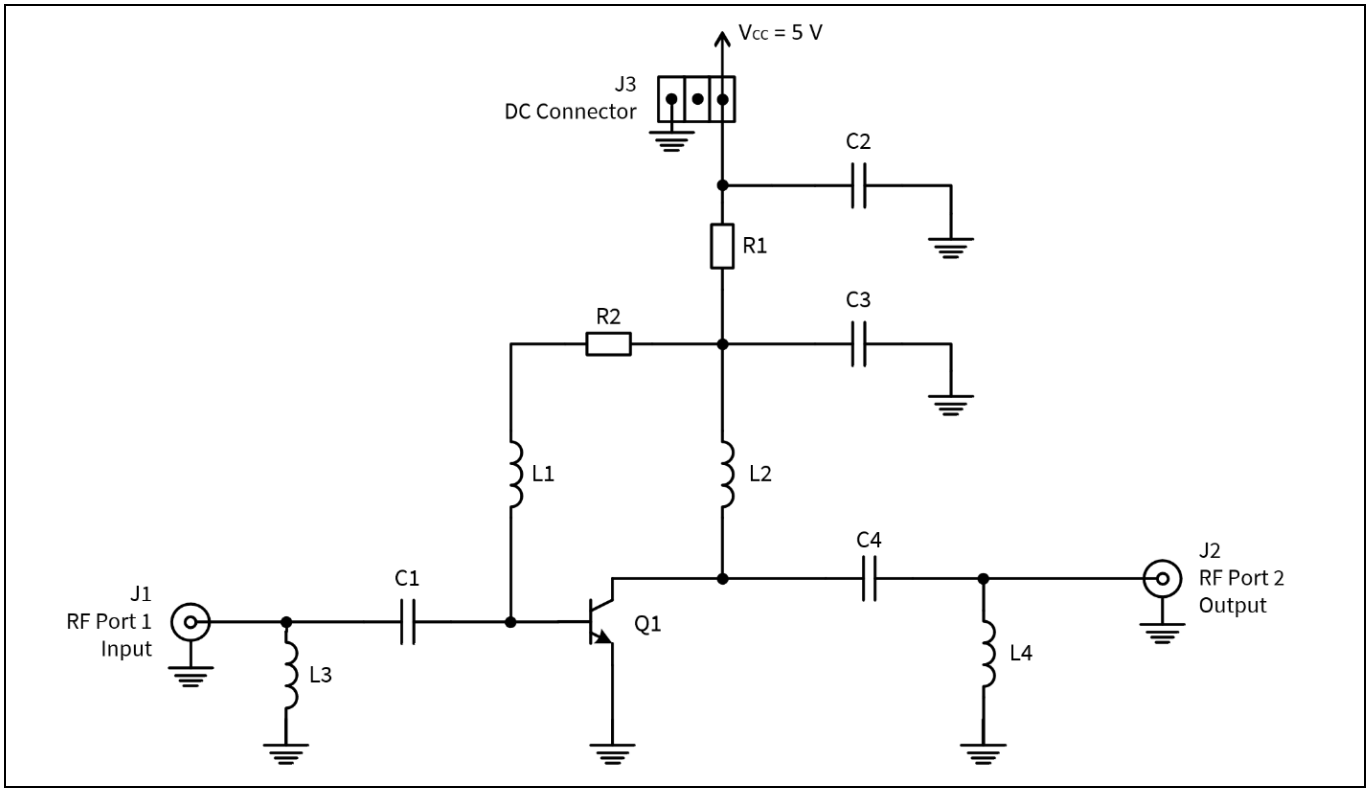


Figure 2 Schematic of the 2.4 GHz band WLAN BFP650 transistor amplifier

2.3 Bill of materials (BOM)

Table 2 BOM of the 2.4 GHz band WLAN BFP650 transistor amplifier

Symbol	Value	Unit	Size	Manufacturer	Notes
Q1	BFP650	–	–	Infineon	SiGe:C high-linearity transistor
C1	1.2	pF	0402	Various	Input matching and DC- blocking
C2	1	nF	0402	Various	RF- decoupling
C3	1	nF	0402	Various	RF- decoupling and stability improvement
C4	4.7	pF	0402	Various	Output matching and DC- blocking
L1	10	nH	0402	Various	RF- choke and input matching
L2	10	nH	0402	Various	RF- choke and output matching
L3	1.8	nH	0402	Various	Input matching
L4	4.7	nH	0402	Various	Output matching
R1	15	Ω	0402	Various	DC biasing
R2	8.2	kΩ	0402	Various	DC biasing

2.4 Evaluation boards and PCB layout information

The evaluation board for the 2.4 GHz band WLAN BFP650 transistor amplifier has the PCB material FR4 and the marking M101022.

The photo of the evaluation board for the amplifier and the detailed description of the PCB stack are shown in the following figures.

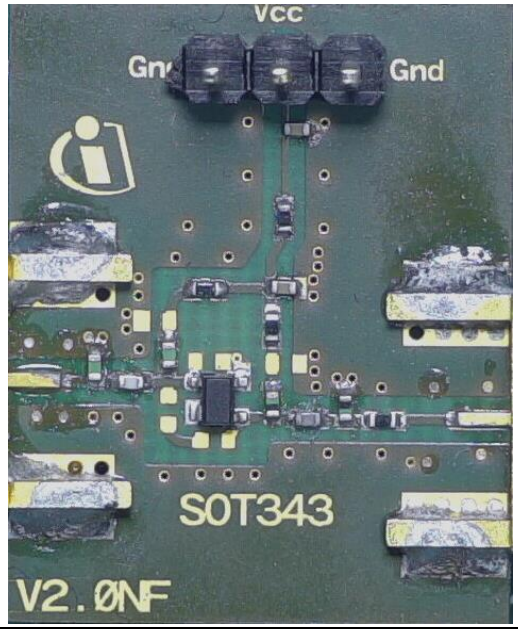


Figure 3 Photo of the evaluation board with PCB marking M101022

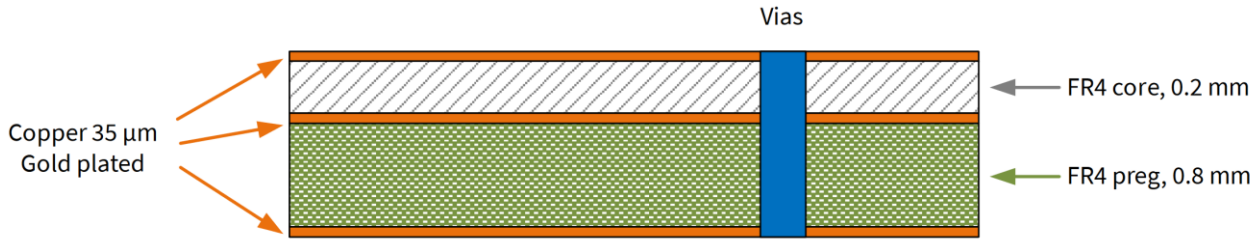


Figure 4 PCB stack information for the evaluation board with PCB marking M101022

2.5 Measurement results of 2.4 GHz band WLAN BFP650 transistor circuit

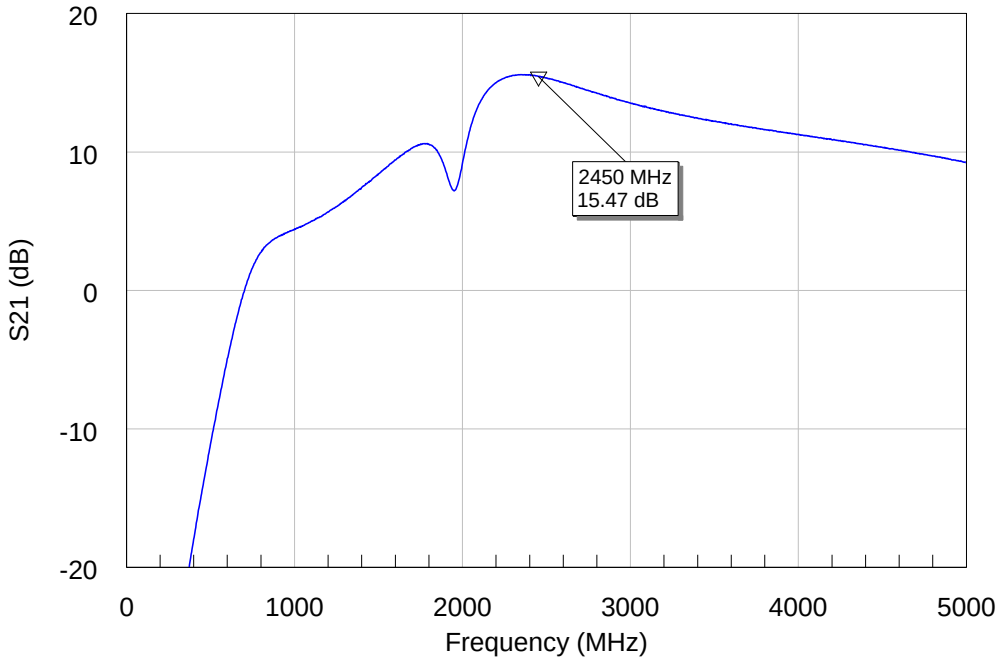


Figure 5 Wideband gain

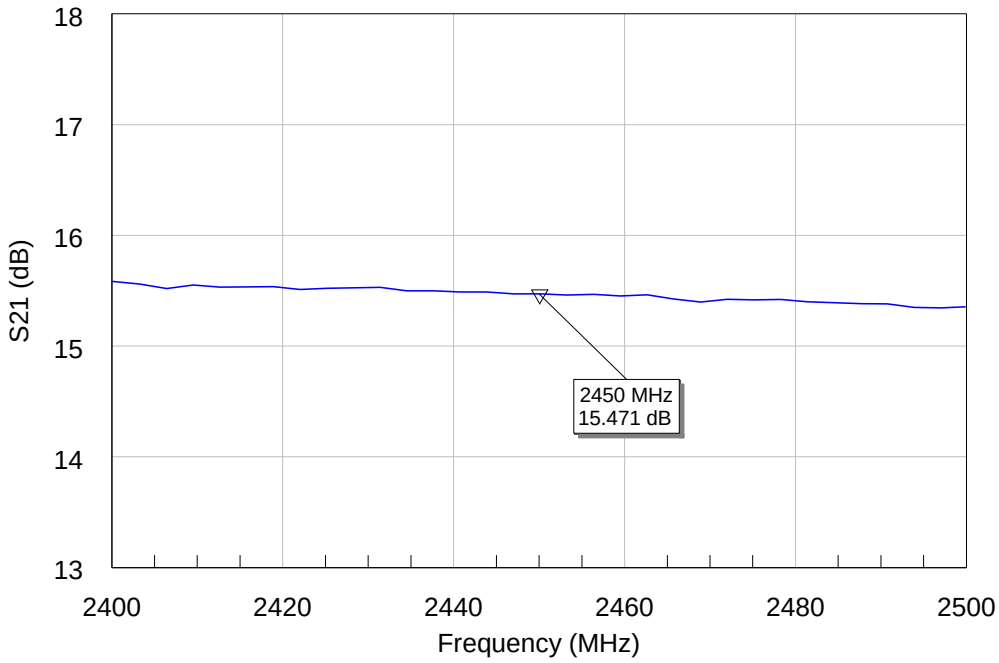


Figure 6 Inband gain

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

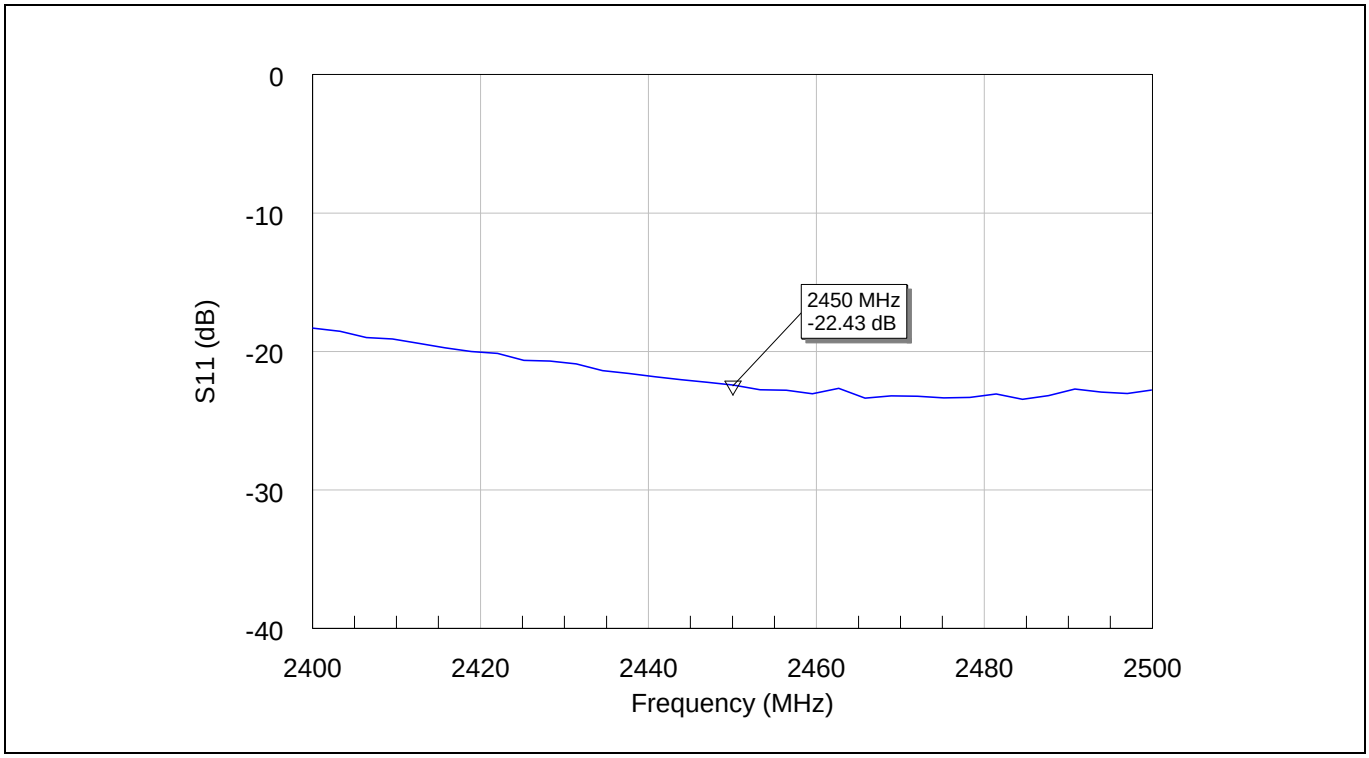


Figure 7 Input return loss

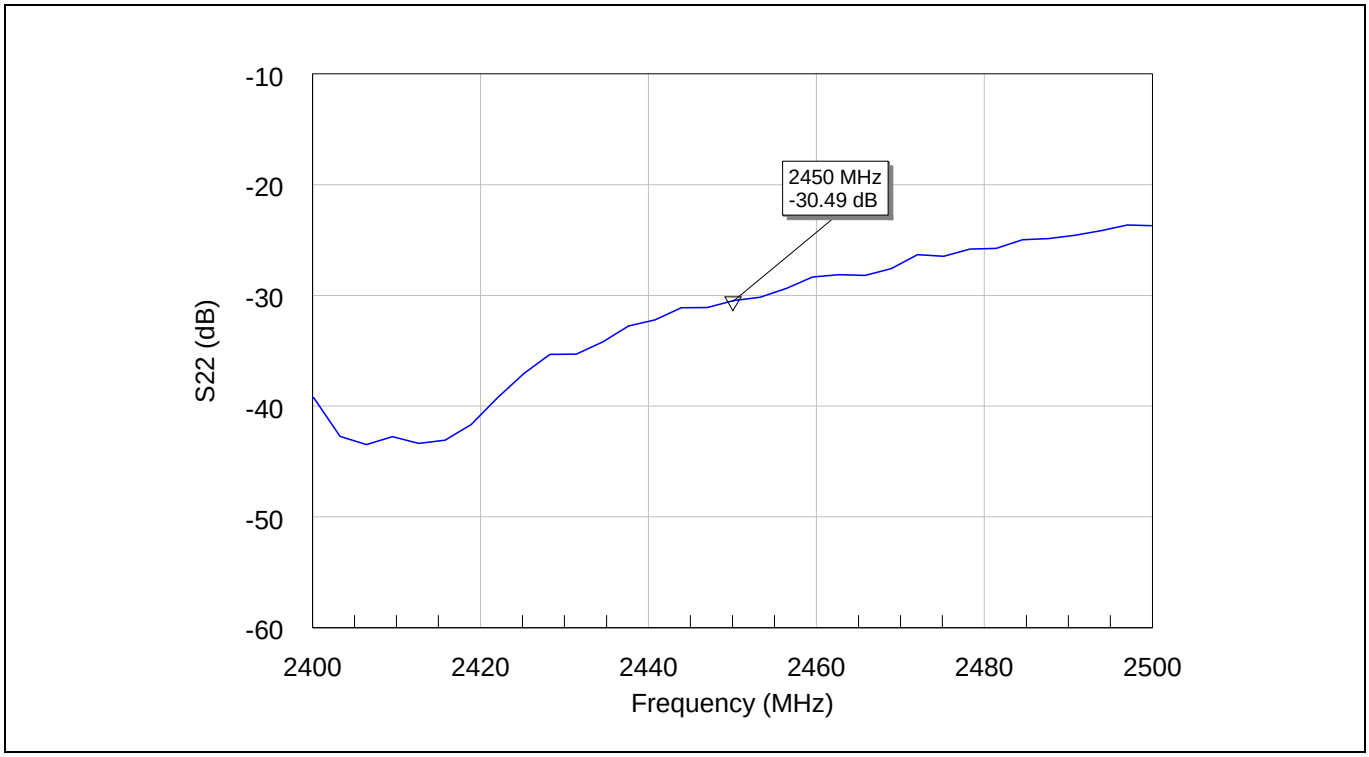


Figure 8 Output return loss

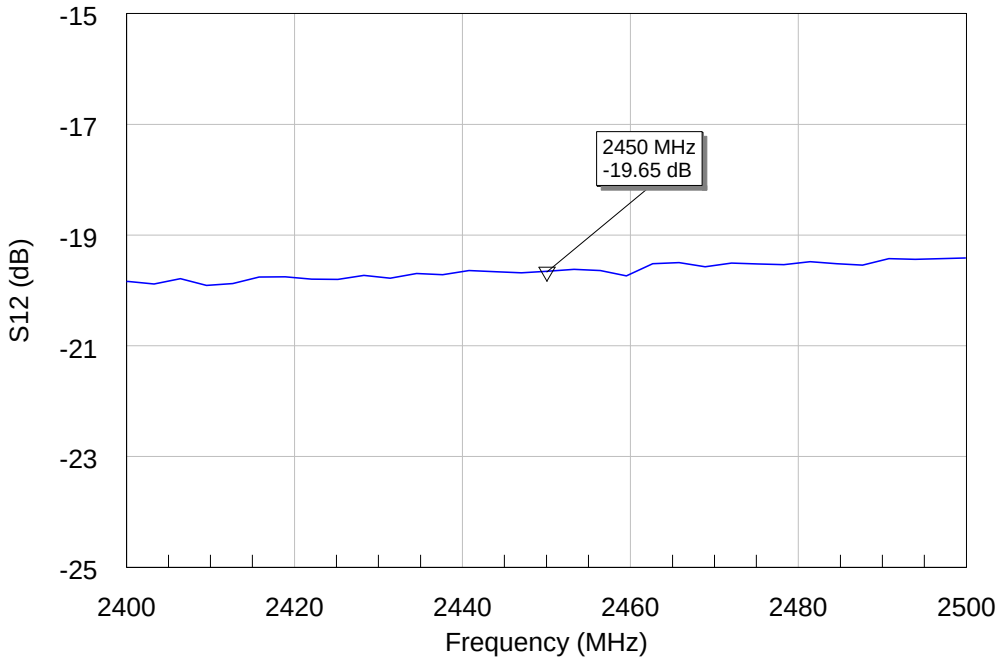


Figure 9 Reverse isolation

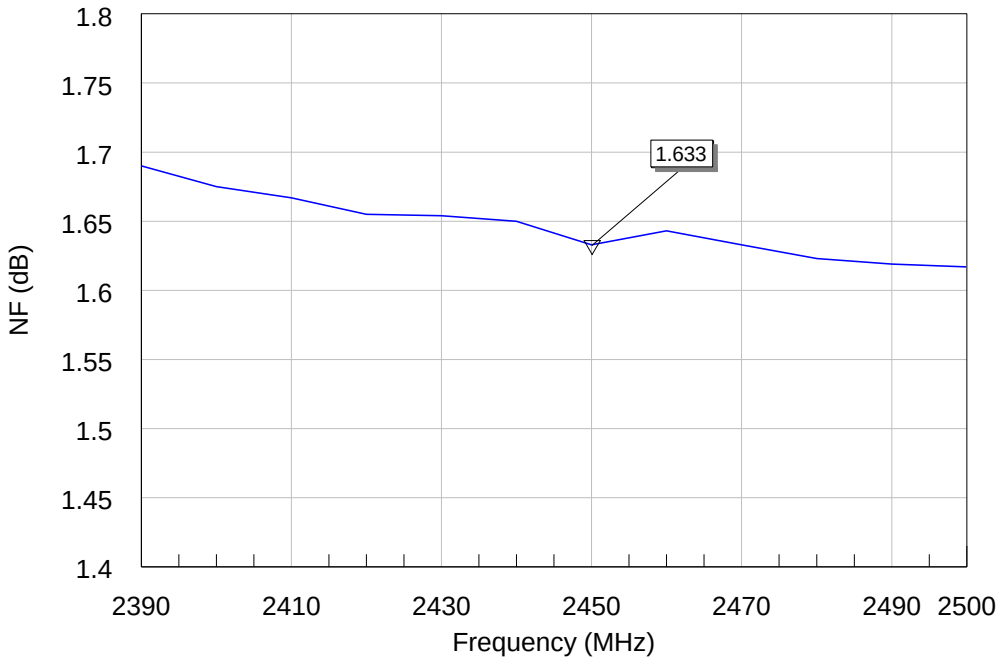


Figure 10 NF measurement

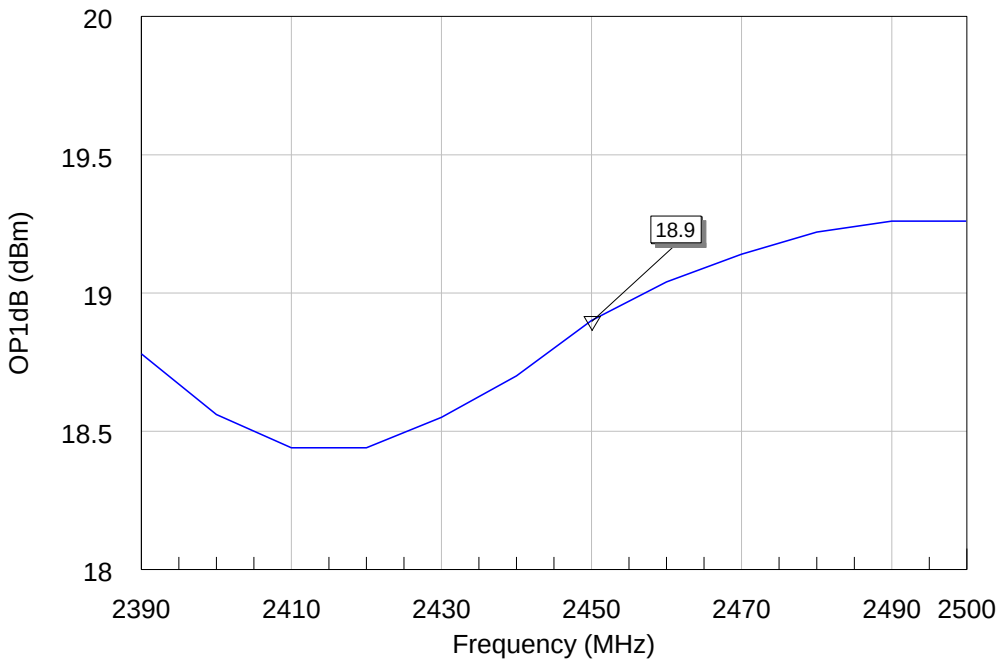


Figure 11 Output 1 dB compression point measurement

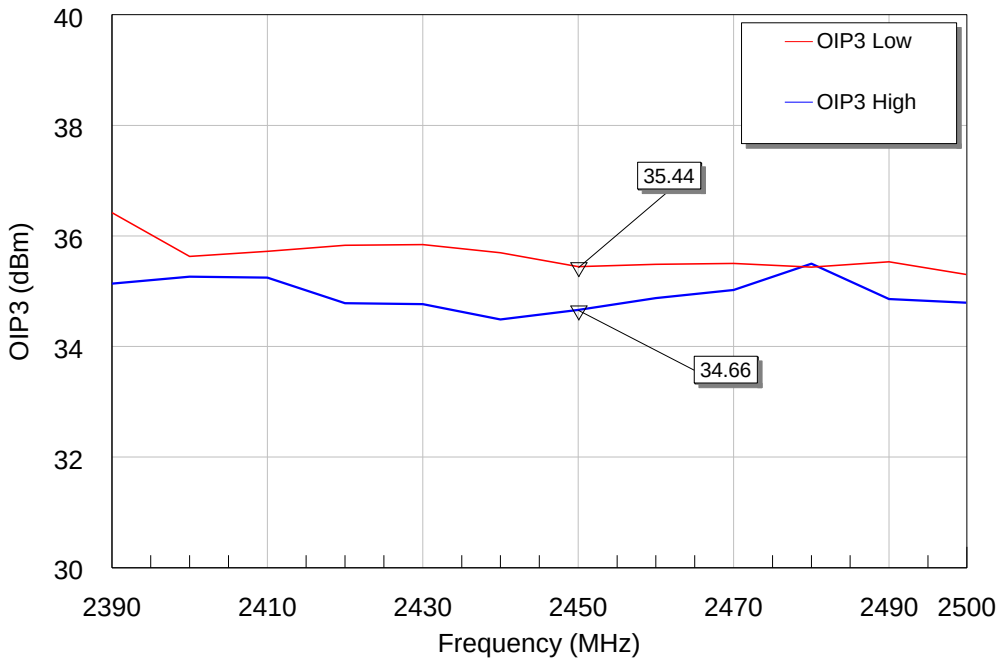


Figure 12 Output IP_3 measurement

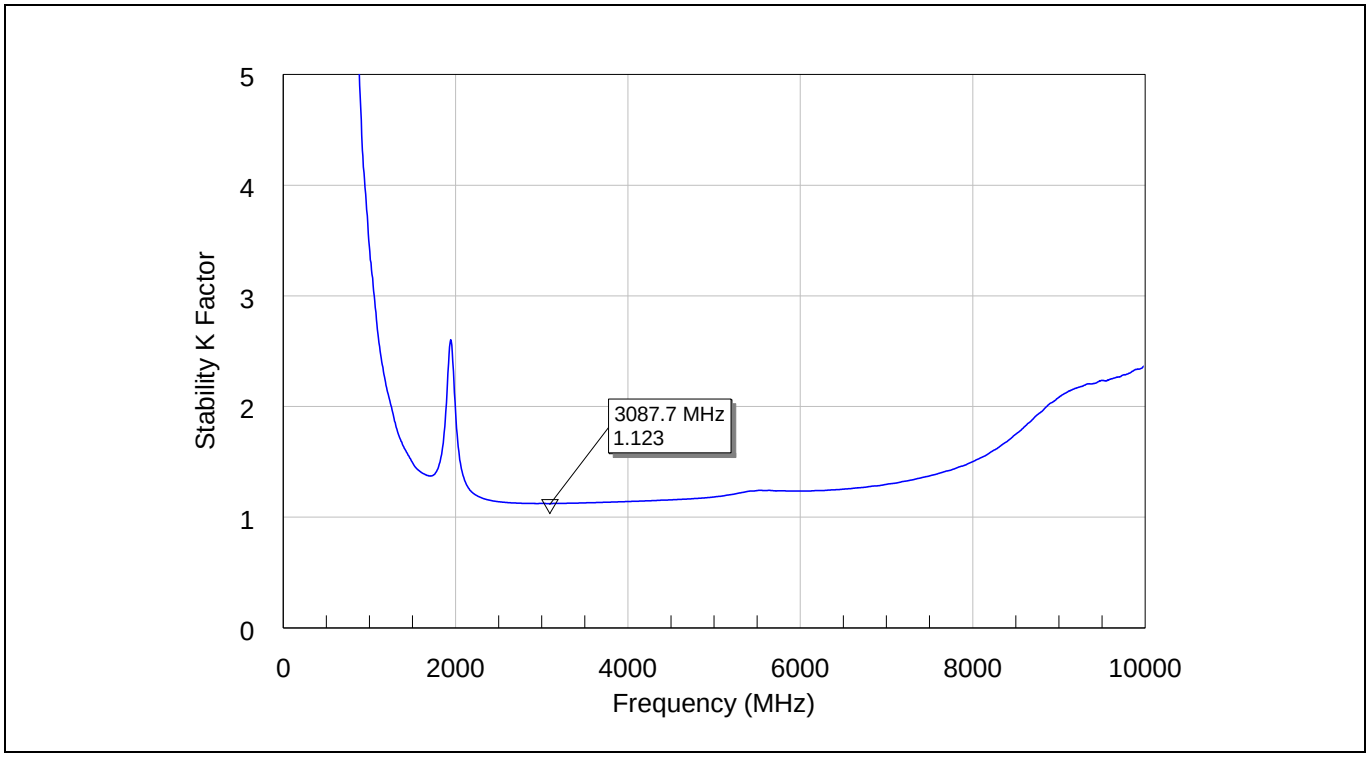


Figure 13 Stability K-factor plot

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Revision history

Document revision	Date	Description of changes

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Edition 2023.10.08

Published by

Infineon Technologies AG

81726 Munich, Germany

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Document reference

AN_2308_PL55_2309_110442

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