High Gain RF Driver Amplifier: BFP780

Driver Amplifier for 434 MHz ISM Band Applications

Application Note AN415

About this document

Scope and purpose

This application note describes Infineon's High Gain RF Driver Amplifier: BFP780 for 434 MHz ISM band applications.

1. This application note presents the design circuit and measurement result of driver amplifier for 434 MHz application purposes.
2. The design presented in this application note uses Infineon BFP780 High Gain RF Driver Amplifier.
3. Key performance parameters achieved (@ 434 MHz):
    a. OP1dB = 22.4 dBm,
    b. OIP3 = 36.5 dBm
    c. Gain = 25 dB,
    d. Input return loss > 10 dB,
    e. Output return loss >10 dB.
4. The performances of quiescent current, gain and OP1dB v.s. ambient temperature are provided.

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Overview of ISM Band

The Industrial, Scientific and Medical (ISM) bands refer to a group of reserved Radio Frequency (RF) bands for industrial, scientific, medical or similar purposes. In recent years, ISM bands have been also widely applied for short range, low power communication systems, such as Bluetooth, Wi-Fi networks and Near Field Communication (NFC). Figure 1 presents an example of a RF Front-End block diagram for this purpose.

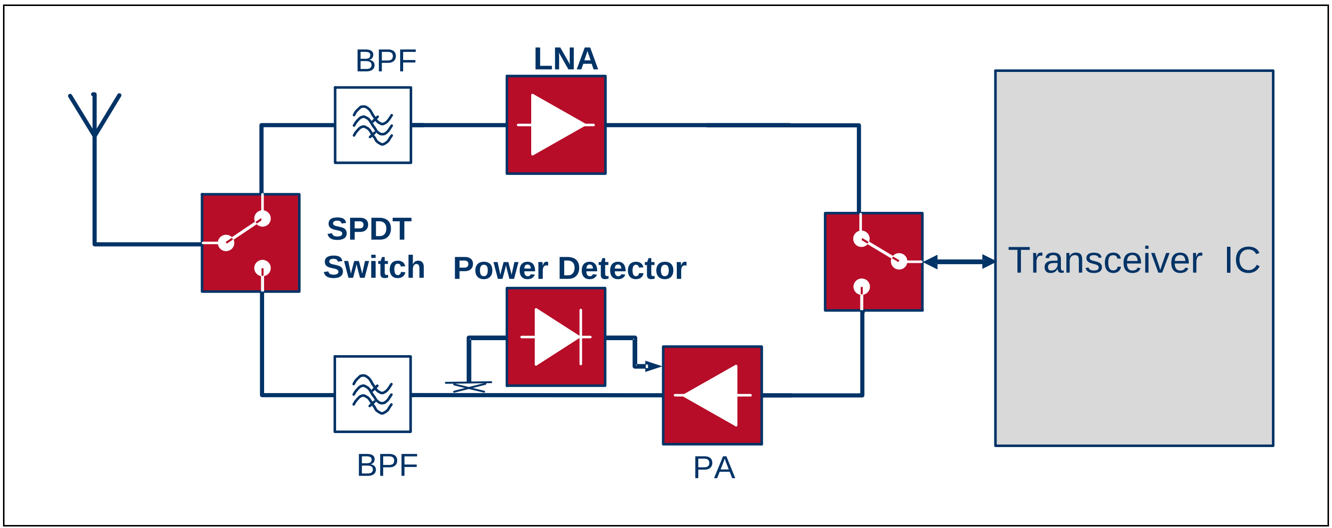

Figure 1 An Example RF Front-End Block Diagram

Infineon Technologies is the leading company with a broad portfolio of RF product solutions including driver amplifiers, Low Noise Amplifiers (LNAs), RF switches, ESD protection diodes and GNSS module for mobile phone as well as for general applications.

1.2 Infineon Driver Amplifier Family

The driver amplifier, also known as gain block, is an important functional block in RF transceiver systems requiring high output power. The Power Amplifier (PA), the final stage of a signal amplifier chain, requires a certain input power level to operate in the linear mode, which usually cannot be delivered by the transceiver IC directly. In these cases, external one or two stage driver amplifiers are required. Driver amplifiers are generally operated in linear class-A mode to enable high linearity and high gain, thereby keeping spurious signals generated by the PA low, by reducing intermodulation products. Class-A amplifiers are also the right choice for broadband operation at low power levels.

BFP780 and BFQ790 are described as general purpose medium power transistor in Infineon´s Silicon Germanium (SiGe) product portfolio for wireless infrastructure applications. These include mobile basestation transceivers, cellular repeaters, ISM band amplifiers and test equipment. Their operating frequency range can be as high as 3.6 GHz, and the application circuit can be optimized for specific frequency bands with external matching components.

The BFP780 is a single stage driver amplifier with high linearity and high power gain. Its output 1dB compression point is 22 dBm. The chip is housed in a halogen-free industry standard package SOT343. The proper die attach with good thermal contact is 100% tested and verified. The device is based on Infineon's reliable and cost effective NPN SiGe technology running in high volume. The collector design allows safe operation with 5 V supply voltage.

The BFQ790 is a single stage driver amplifier with very high linearity. Its output 1dB compression point is 27 dBm. The device is housed in the halogen-free industry standard package SOT89. The high thermal conductivity of silicon substrate and the low thermal resistance of the package add up to a thermal resistance of only 35 K/W, which leads to moderate junction temperatures even at high dissipated power values. The proper die attach with good thermal contact is 100% tested, so that there is minimum variation of thermal properties. Same as BFP780, the device is based on Infineon's reliable and cost effective NPN SiGe technology running in high volume. The collector design allows safe operation with 5 V supply voltage. The BFQ790 is very rugged. A special collector design prevents from thermal runaway respectively 2nd breakdown, which leads to a high ruggedness against mismatch at the output. The special design of the emitter/base diode makes it robust and yields to a high maximum RF input power capability. For further information about BFQ790, please refer its datasheet and application notes.

In this application note, the driver amplifier application circuit of BFP780 for ISM band (434 MHz) and its measurement results are presented. The BFP780 driver amplifier provides 25 dB gain at 434 MHz. The output 1dB compression point (OP1dB) is 22.4 dBm. Besides, in the two-tone test with tone spacing of 500 kHz, the output third order intercept point (OIP3) reaches 36.5 dBm.

2 BFP780 Overview

2.1 Features

• High 3rd order intercept point OIP3 of 34.5 dBm @5 V, 90 mA
• High compression point OP1dB of 23 dBm @5 V, 90 mA corresponding to 45 % collector efficiency
• Low minimum noise figure of 1.3 dB @ 900 MHz, 5 V, 30 mA
• Single stage, intended for external matching
• High maximum RF input power PRFinmax of 20 dBm
• Safe operation with single 5 V supply
• 100% test of proper die attach for reproducible thermal contact
• 100% DC and RF tested
• Easy to use large signal compact (VBIC) model in development
• Cost effective NPN SiGe technology running in very high volume
• Easy to use Pb-free (RoHS compliant) and halogen-free industry standard package SOT343, low RTHJS of 95 K/W

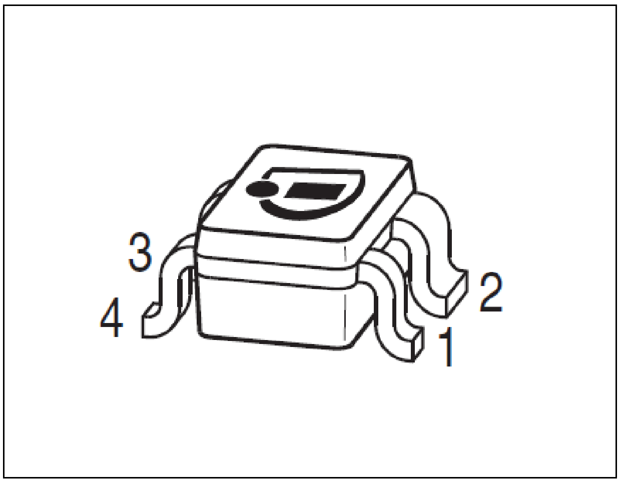

Figure 2 BFP780 in SOT343

2.2 Key Applications of BFP780

Applications

As
• High linearity driver or pre-driver in the transmit chain
• 2nd or 3rd stage LNA in the receive chain
• IF or LO buffer amplifier

In
• Commercial / industrial wireless infrastructure / basestations
• Repeaters
• Automated test equipment

For
• Cellular, PCS, DCS, UMTS, LTE, CDMA, WCDMA, GSM, GPRS
• WLAN, WiMAX, WLL and MMDS
• ISM, AMR
• UHF television, CATV, DBS

Attention: ESD-class 1a (Electrostatic discharge) sensitive device, observe handling precautions

3 Application Circuit and Performance Overview

In this chapter the performance of the application circuit, the schematic and bill-of-materials are presented.

Device: **BFP780**
Application: **Driver Amplifier for 434 MHz ISM Band Application**
PCB Marking: **M101022 V2.0NF SOT343**
EVB Order No.: **AN415**

3.1 Summary of Measurement Results

The performance of BFP780 434 MHz driver amplifier is summarized in the following table.

Table 1 Electrical Characteristics (at room temperature 25°C)

Parameter	Symbol	Value	Unit	Comment/Test Condition
Frequency Range	Freq	434	MHz	
DC Voltage	Vcc	5.0	V	
DC Current	Icc	80	mA	
Gain	G	25.1	dB	
Input Return Loss	RLin	17.8	dB	
Output Return Loss	RLout	15.9	dB	
Reverse Isolation	IRev	29.2	dB	
Input P1dB	IP1dB	-1.8	dBm	Measured at 434 MHz
Output P1dB	OP1dB	22.4	dBm	Measured at 434 MHz
Input IP3	IIP3	11.6	dBm	Power @ output: 10 dBm per tone f_1=434 MHz, f_2=434.5 MHz
Output IP3	OIP3	36.7	dBm	Power @ output: 10 dBm per tone f_1=434 MHz, f_2=434.5 MHz
Noise Figure	NF	2.4	dB	
Stability	k	> 1	--	Measured up to 10 GHz

3.2 Schematics and Bill-of-Materials

The schematic of BFP780 driver amplifier for 434 MHz ISM band application is presented in **Figure 3** and its bill-of-materials is shown in **Table 2**.

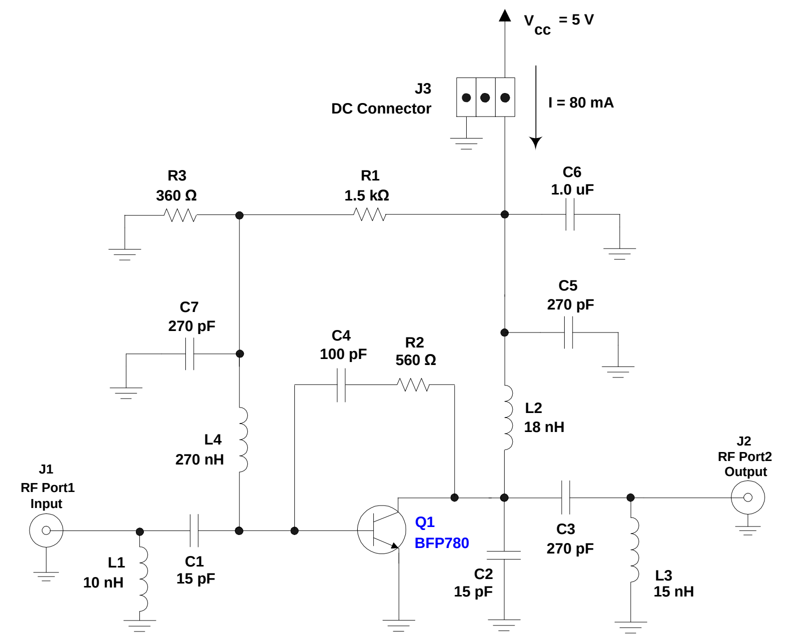

Figure 3 Schematics of the BFP780 434 MHz Application Circuit

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
Q1	BFP780	SOT343	--	Infineon	SiGe bipolar transistor
C1	15	pF	0402	Murata GRM series	Input matching and DC blocking
C2	15	pF	0402	Murata GRM series	Output matching
C3	270	pF	0402	Murata GRM series	Output matching and DC blocking
C4	100	pF	0402	Murata GRM series	DC blocking
C5	270	pF	0402	Murata GRM series	RF decoupling
C6	1.0	µF	0402	Murata GRM series	RF decoupling
C7	270	pF	0402	Murata GRM series	RF decoupling
L1	10	nH	0402	Murata LQW series	Input matching
L2	18	nH	0402	Murata LQW series	RF choke and output matching
L3	15	nH	0402	Murata LQW series	Output matching
L4	270	nH	0402	Murata LQG series	RF choke
R1	1.5	kΩ	0402	various	DC biasing
R2	560	Ω	0402	various	Feedback
R3	360	Ω	0402	various	DC biasing

4 Measurement Graphs

The performance of the application circuit is presented with the following graphs.

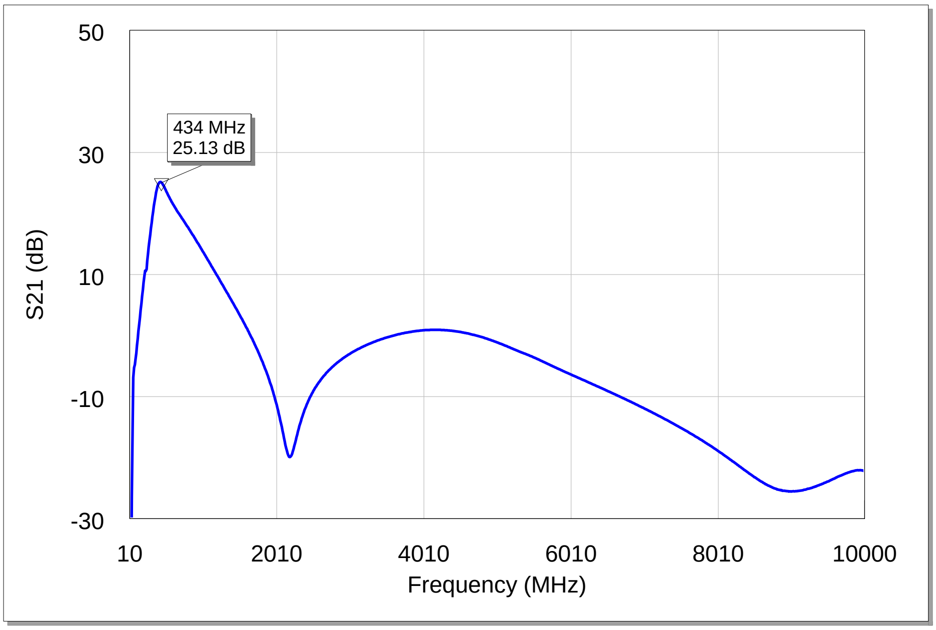

Figure 4 Wideband Insertion Power Gain of the BFP780 434 MHz Driver Amplifier

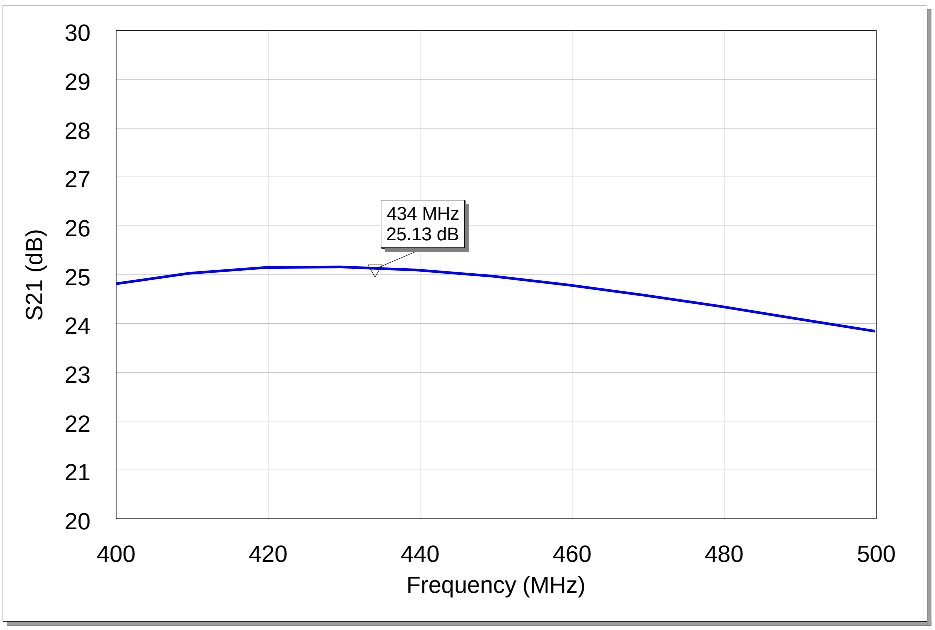

Figure 5 Narrowband Insertion Power Gain of the BFP780 434 MHz Driver Amplifier

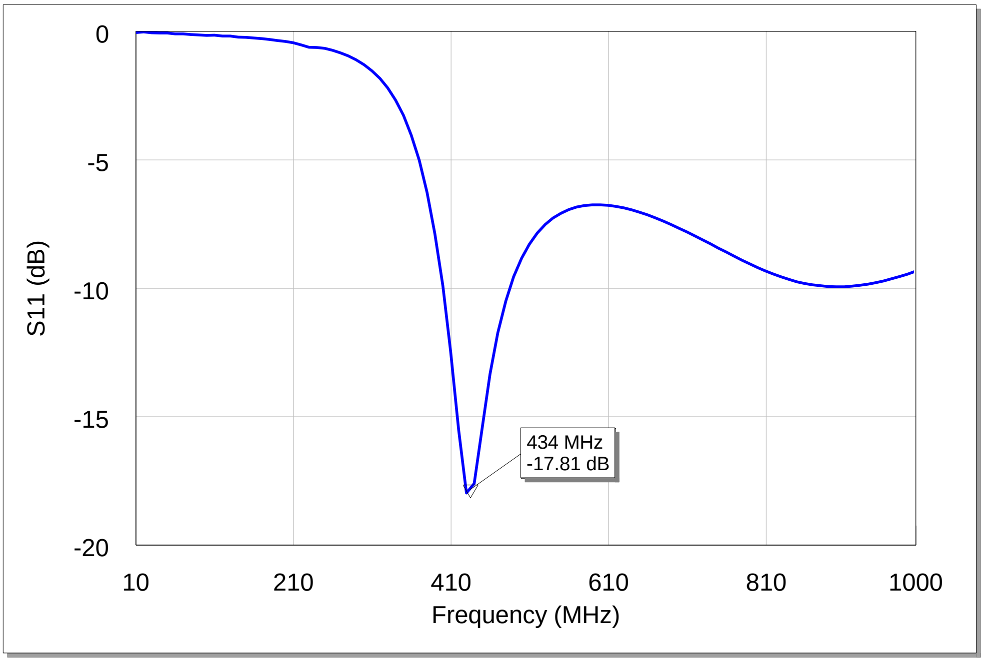

Figure 6 Input Matching of the BFP780 434 MHz Driver Amplifier

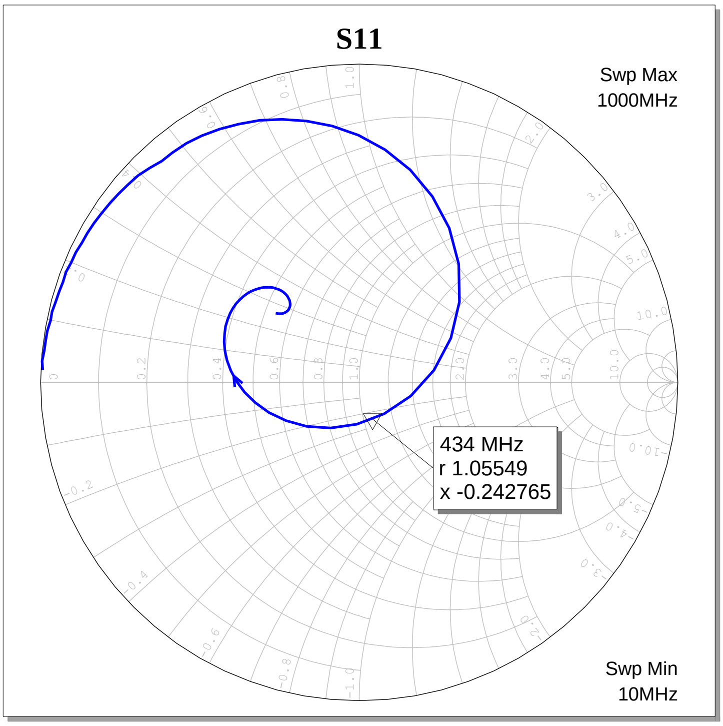

Figure 7 Input Matching (Smith Chart) of the BFP780 434 MHz Driver Amplifier

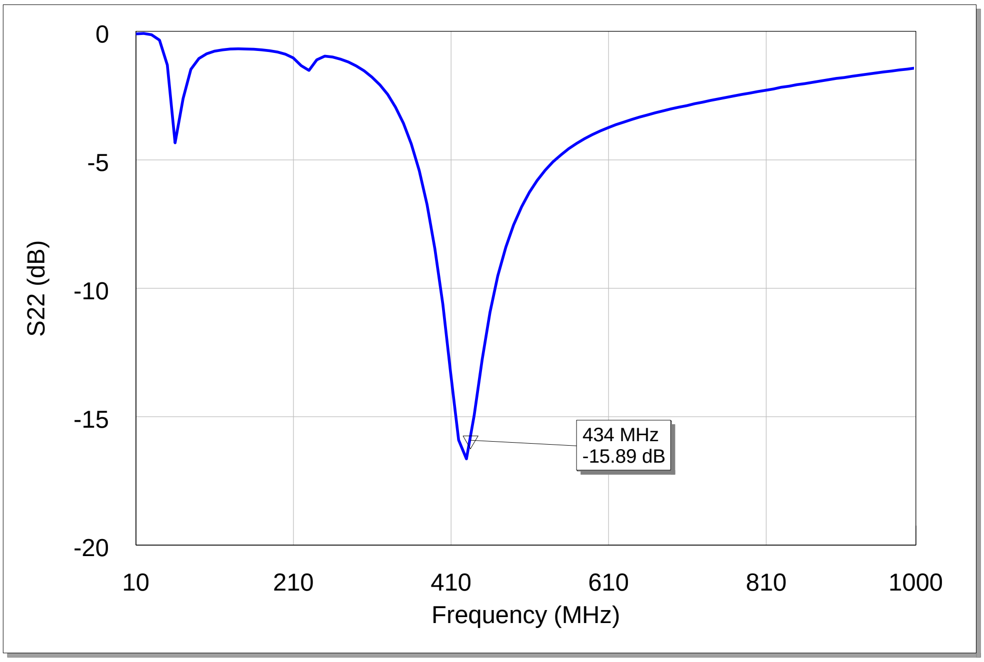

Figure 8 Output Matching of the BFP780 434 MHz Driver Amplifier

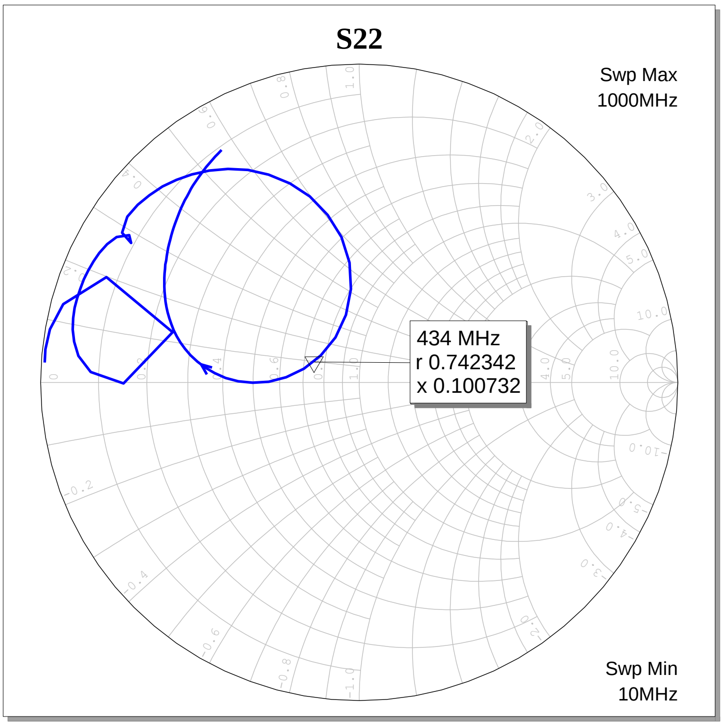

Figure 9 Output Matching (Smith Chart) of the BFP780 434 MHz Driver Amplifier

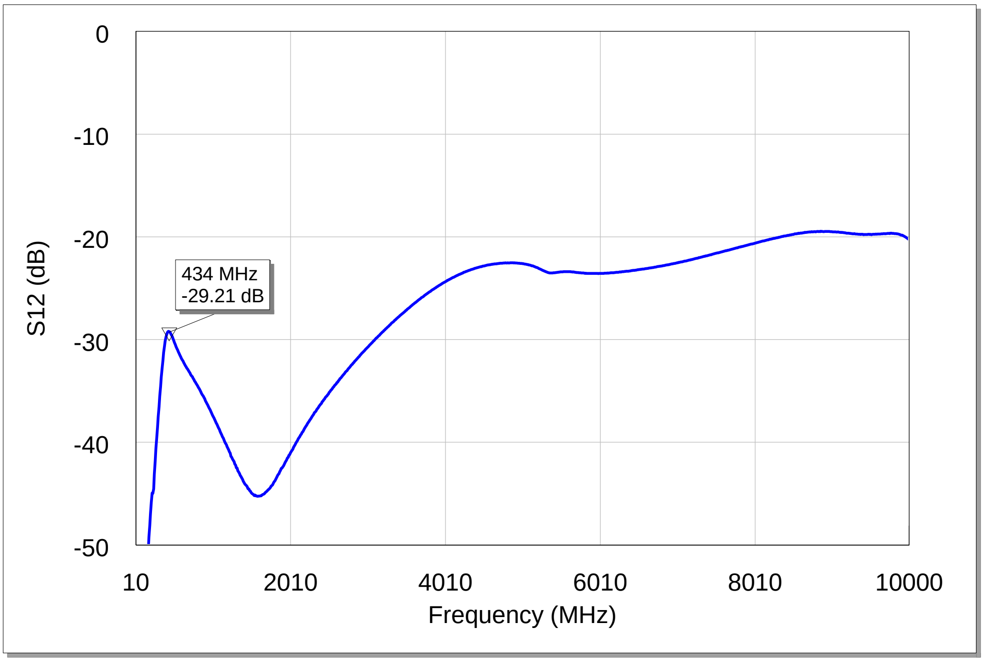

Figure 10 Reverse Isolation of the BFP780 434 MHz Driver Amplifier

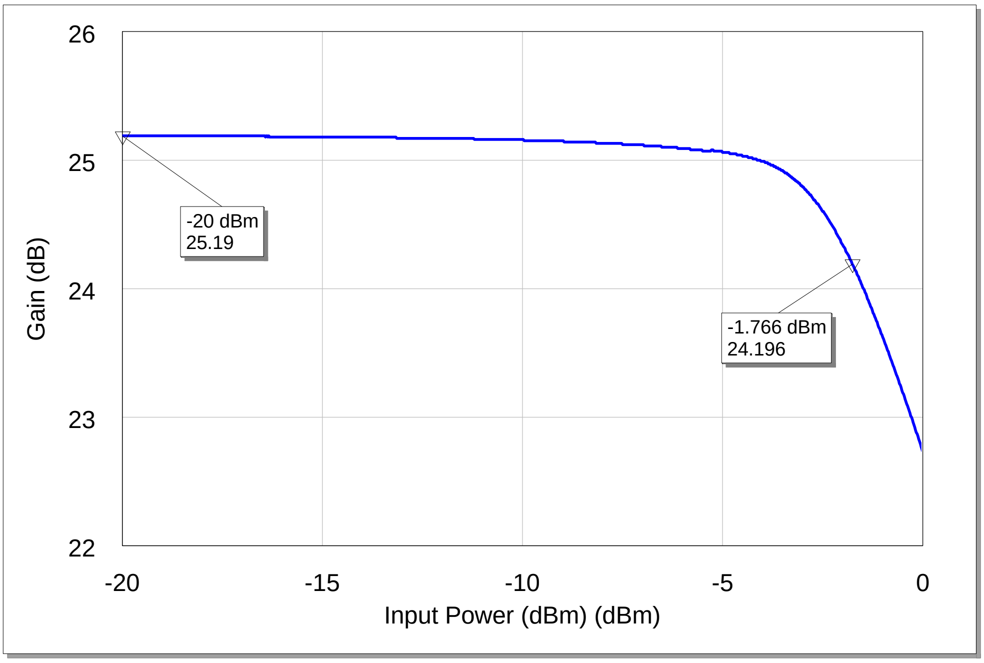

Figure 11 Input 1 dB Compression Point of the BFP780 434 MHz Driver Amplifier

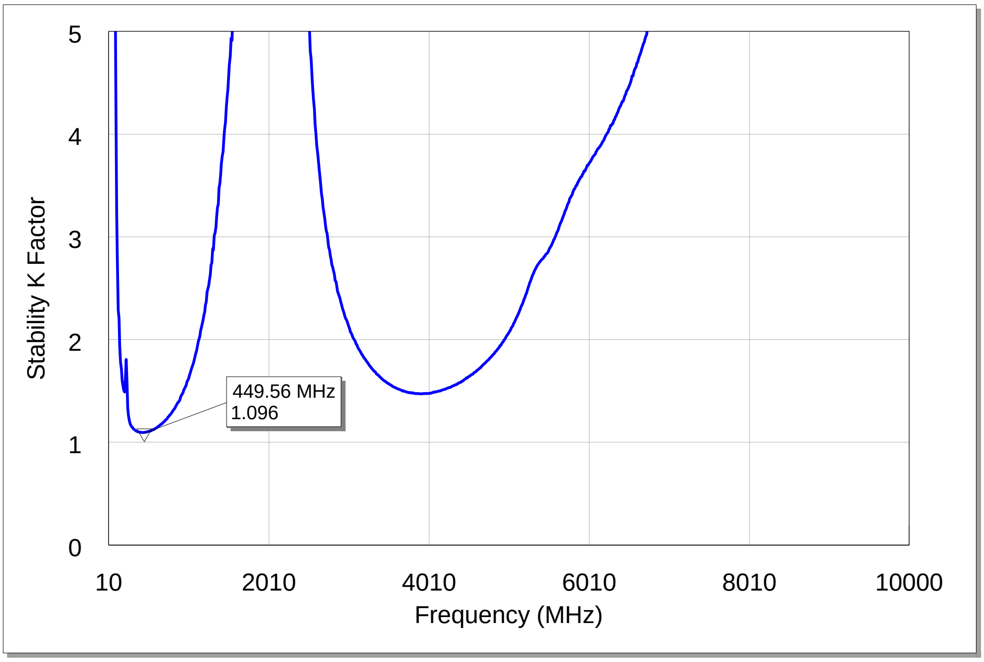

Figure 12 Stability K factor of BFP780 434 MHz Driver Amplifier

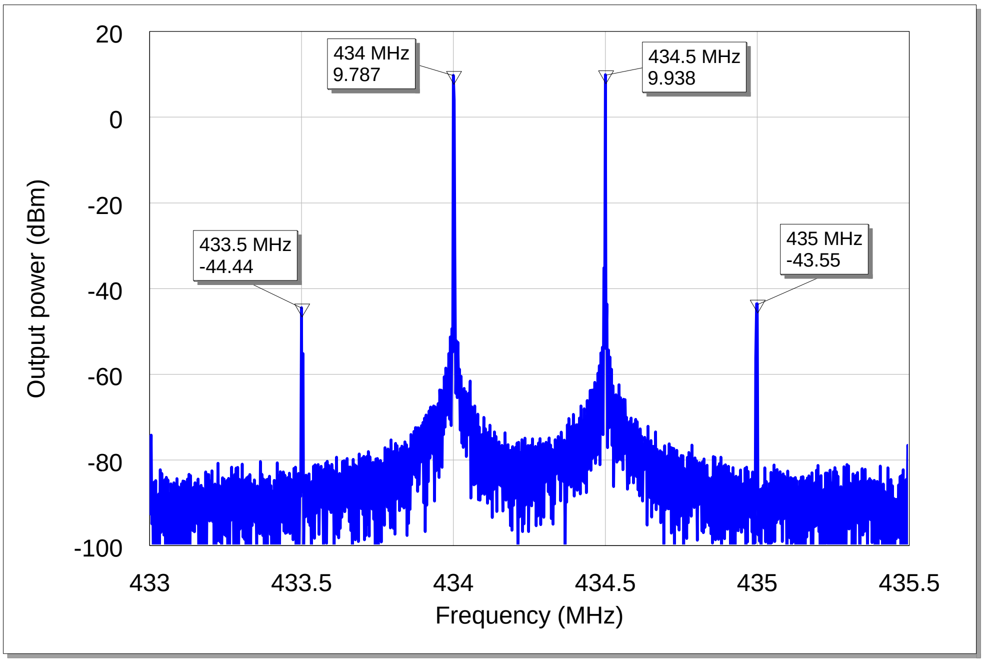

Figure 13 Output 3rd Order Products of the BFP780 434 MHz Driver Amplifier at 10 dBm Output Power per Tone

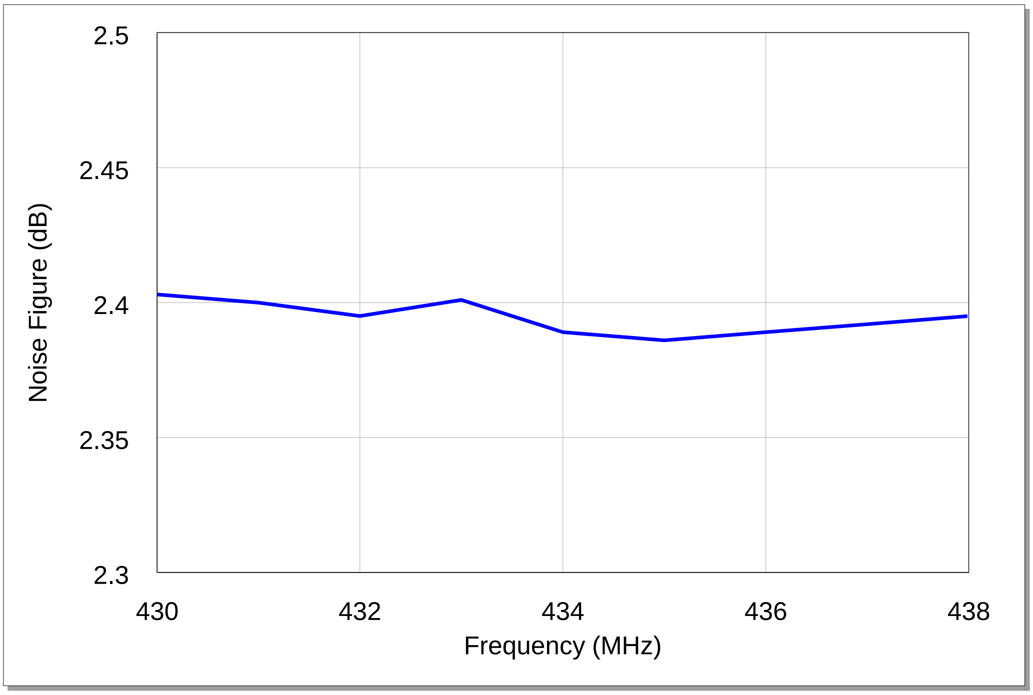

Figure 14 Noise Figure of the BFP780 434 MHz Driver Amplifier

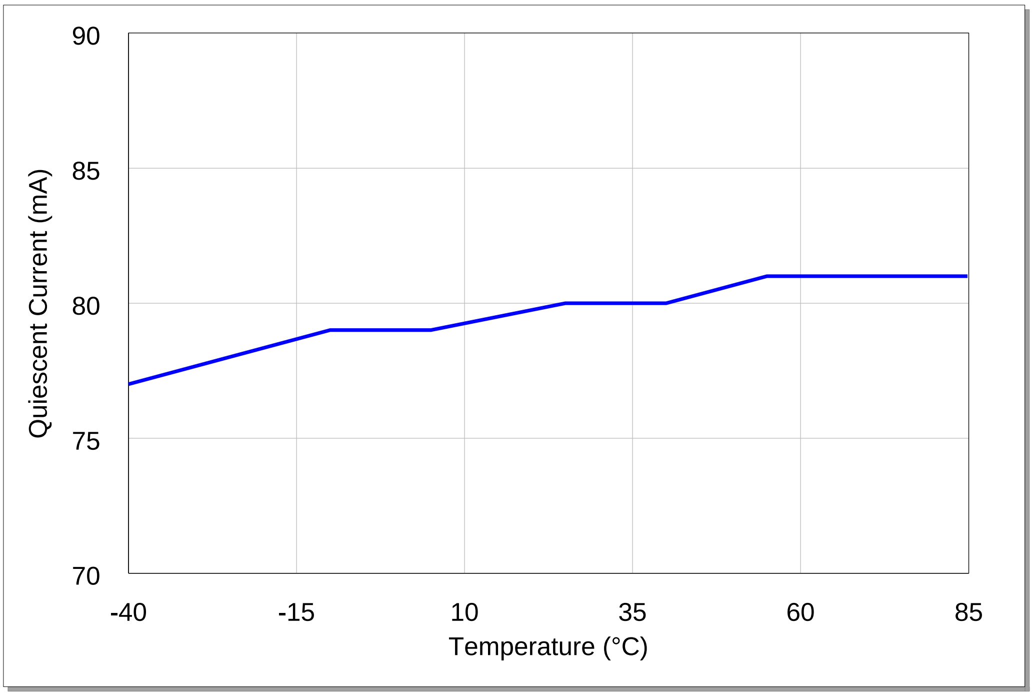

Figure 15 Quiescent Current of the BFP780 434 MHz Driver Amplifier v.s. Ambient Temperature

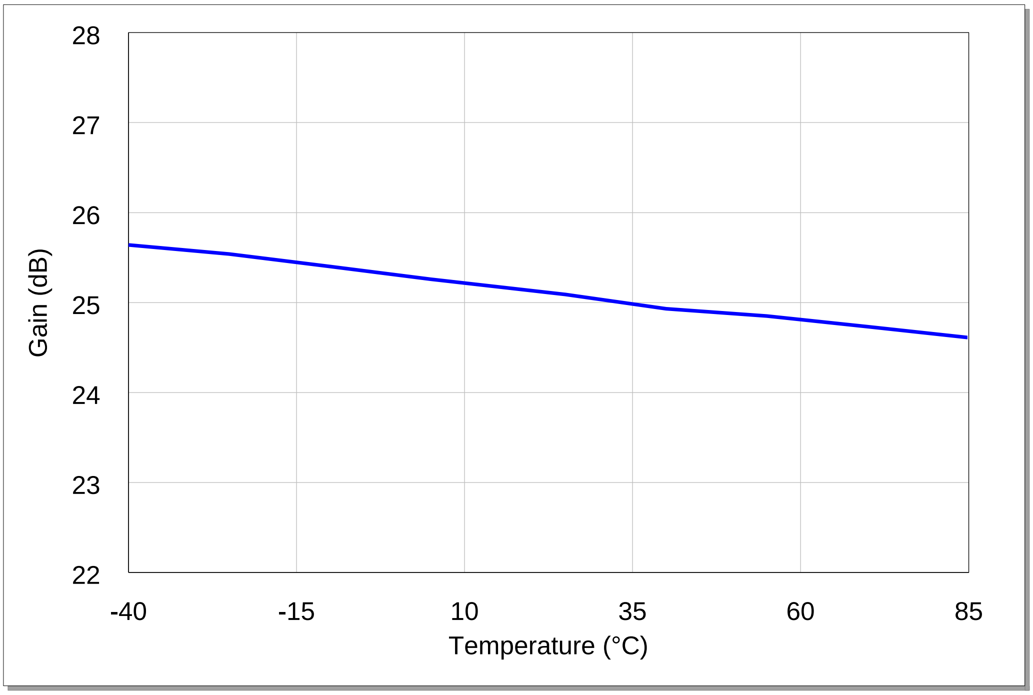

Figure 16 Gain of the BFP780 434 MHz Driver Amplifier v.s. Ambient Temperature

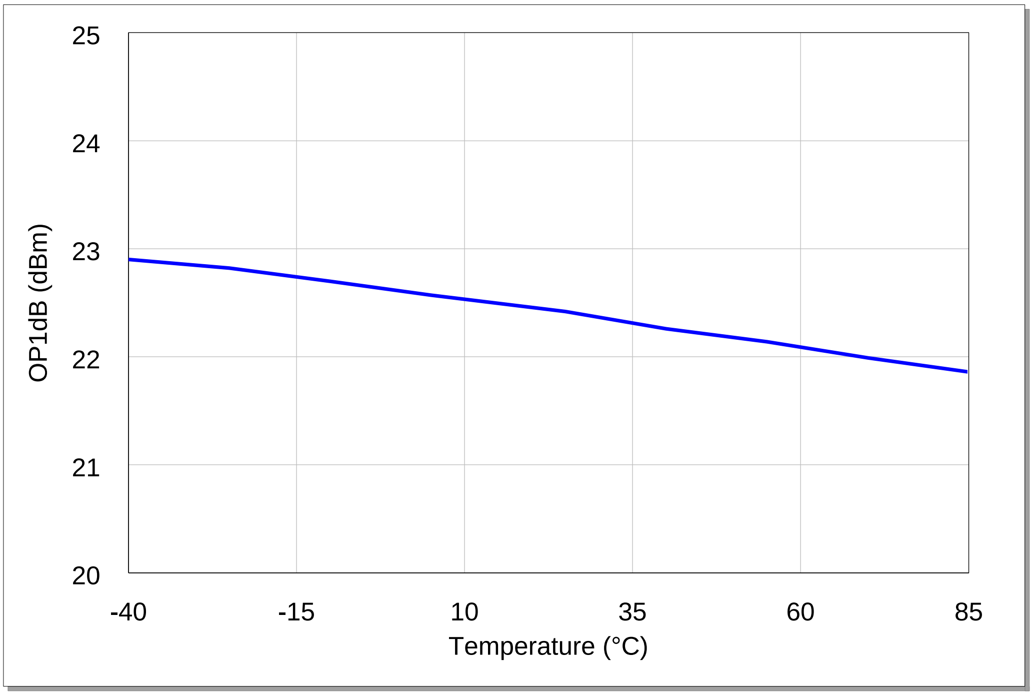

Figure 17 Output 1dB Compression Point of the BFP780 434 MHz Driver Amplifier v.s. Ambient Temperature

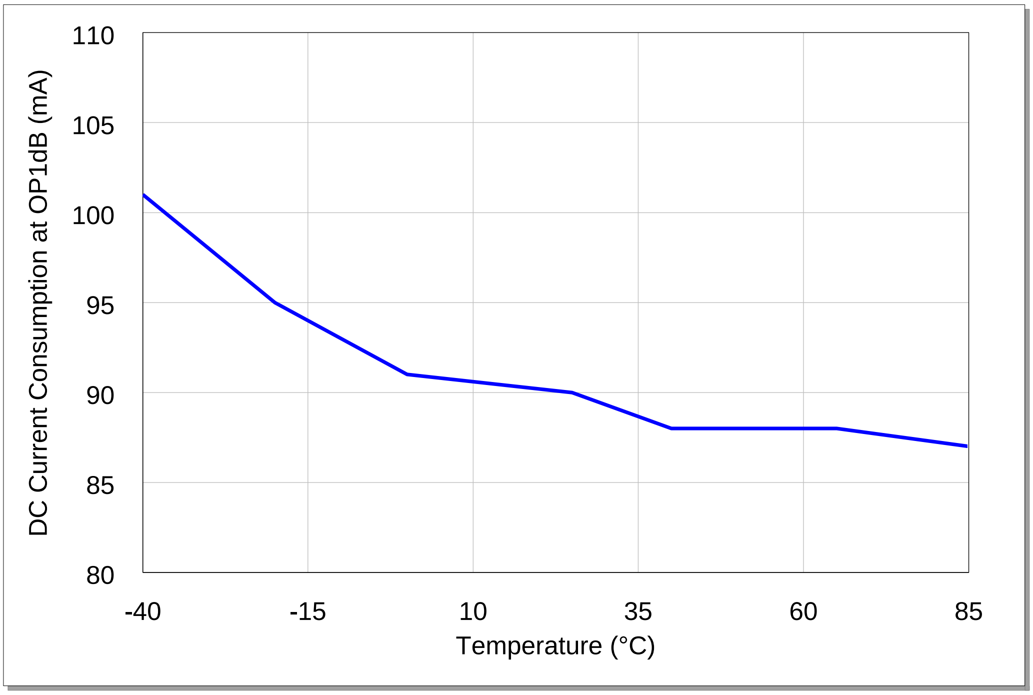

Figure 18 DC Current Consumption at OP1dB of the BFP780 434 MHz Driver Amplifier v.s. Ambient Temperature

5 Evaluation Board and Layout Information

In this application note, the following PCB is used:

PCB Marking: **M101022 V2.0NF SOT343**

PCB material: **FR4**

ε_r of PCB material: **4.6**

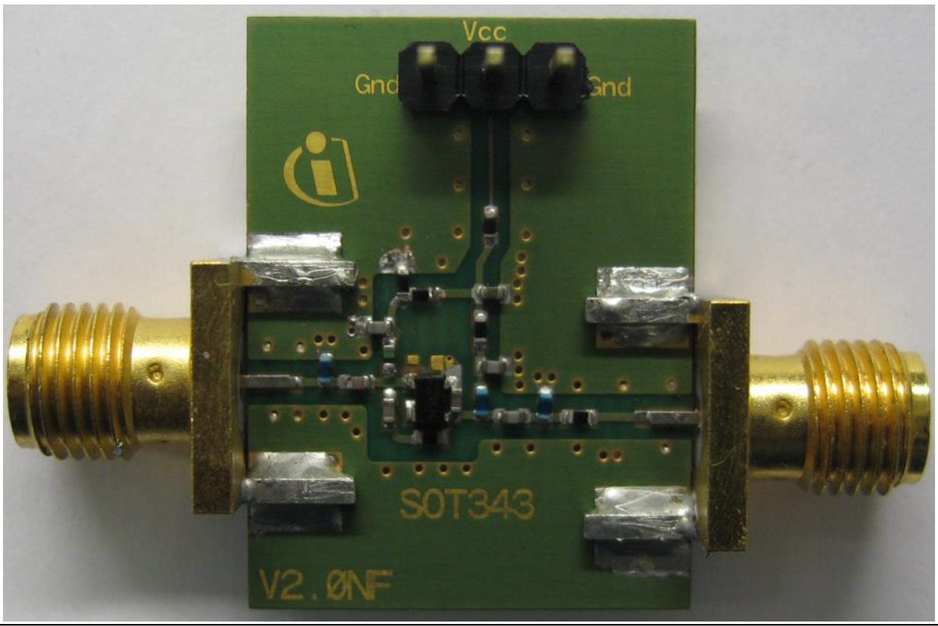

Figure 19 Photo of Evaluation Board (overview) PCB Marking M101022 V2.0NF SOT343

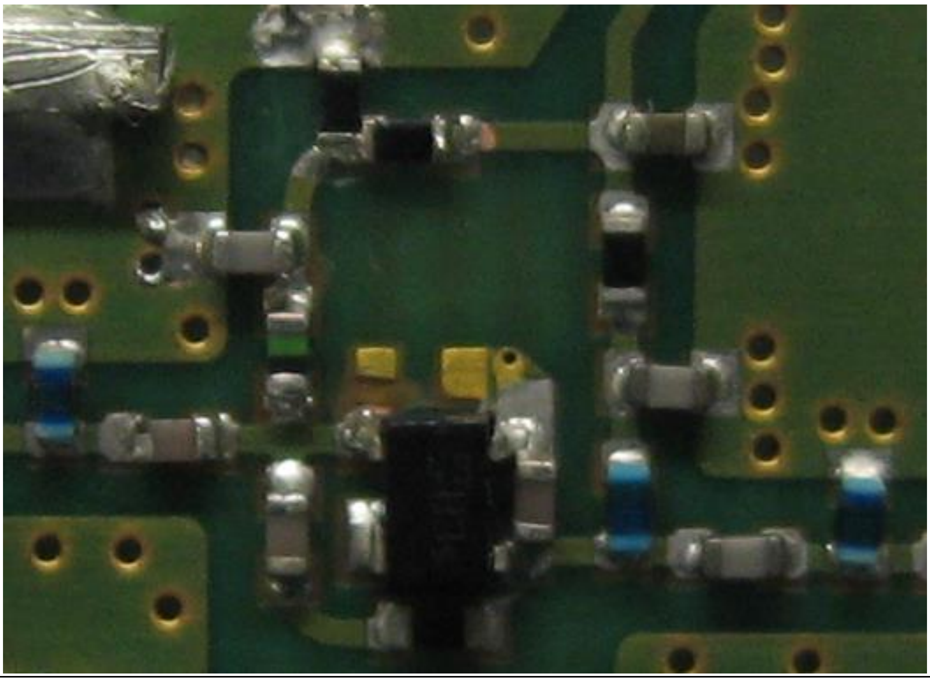

Figure 20 Photo of Evaluation Board (detailed view)

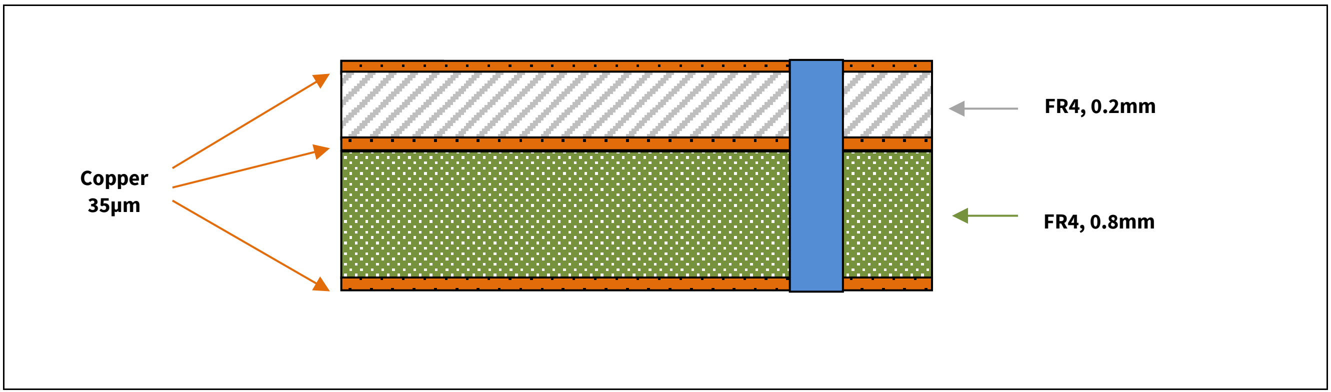

Figure 21 PCB Layer Information

6 Authors

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Revision History

Major changes since the last revision

Page or Reference	Description of change

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