

BFQ790 for 169 MHz Smart Meter Applications

About this document

Scope and purpose

This application note describes a medium power amplifier circuit that uses Infineon's SiGe bipolar transistor BFQ790 for 169 MHz smart meter applications.

1. BFQ790 is a 0.5 W reliable and cost effective NPN bipolar transistor, especially for radio frequency (RF) high linearity and high gain amplifier applications.
2. This application note presents the BFQ790 medium power amplifier circuit design and measurement results at 169 MHz.
3. Key performance parameters achieved (at 169 MHz):
 - a. Gain = 21.0 dB
 - b. Input return loss > 10 dB
 - c. Output return loss > 10 dB
 - d. Output P1dB = 26.7 dBm
 - e. Output IP3 = 38 dBm



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1) The graphs are generated with the simulation program AWR Microwave Office®.

1 Introduction

1.1 BFQ790/BFP780 Medium Power Amplifier in Smart Metering Applications

Driven by energy efficiency, traditional electricity meter is experiencing the gradual conversion to smart meter. The smart meter is “an electronic system that can measure energy consumption, providing more information than a conventional meter, and can transmit and receive data using a form of electronic communication”[1]. Smart meter is a key device in a efficient, flexible and intelligent energy distribution network, which provides not only for the utility companies the advanced ability of the energy grid management but also the detailed energy consumption report for the end users.

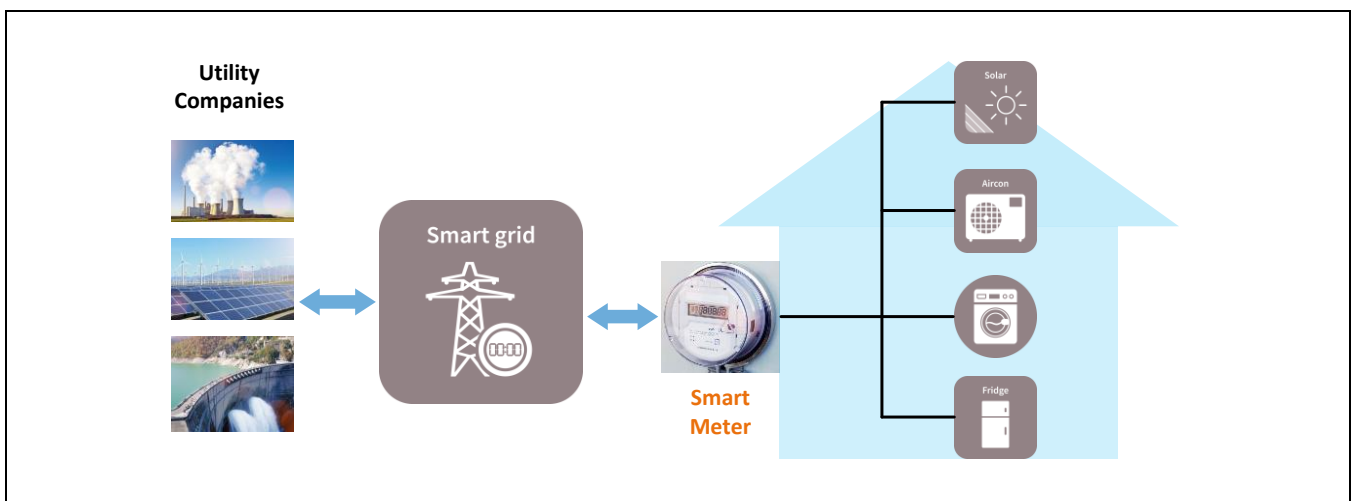


Figure 1 Smart Meter in Power Grid

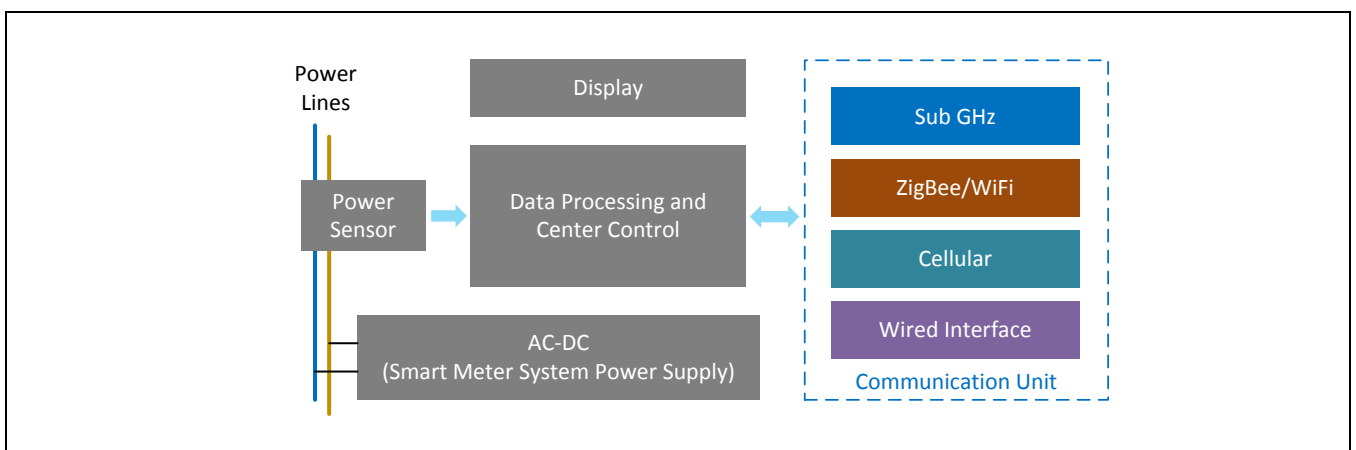


Figure 2 Smart Meter Block Diagram

The communication unit in a smart meter plays important role, since the data communication between smart meters and the power grid should be guaranteed in terms of quality, time, and security. As a result, more than one technology is adopted at the same time to fulfill the requirements. The function block diagram of a smart meter is shown in Figure 2. Among all the communication standards, sub-GHz unit communicates mainly between smart meter and the data collector or concentrator. Sub-GHz wireless technology, together with low data rate GFSK/GMSK modulation scheme, benefits in long range

Introduction

capability, better sensitivity and lower interference. Owing to the advantages of sub-GHz wireless technology features, the output power of the system is in the medium power range, which is perfectly matched with Infineon medium power transistor specifications. The block diagram of the sub-GHz RF front-end with Infineon medium power amplifier BFQ790/BFP780 is shown in **Error! Reference source not found.**

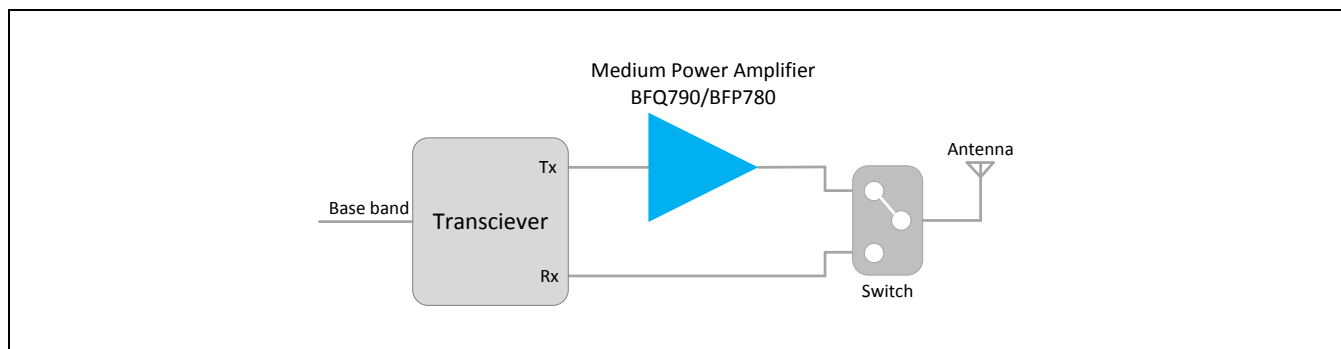


Figure 3 Sub-GHz RF Front-End with Infineon Medium Power Amplifier BFQ790/BFP780

1.2 Infineon Medium Power Transistor Family

BFQ790 and BFP780 are general purpose medium power Radio-Frequency (RF) NPN transistors in Infineon's Silicon Germanium (SiGe) product portfolio for wireless applications. These applications include mobile basestation transceivers, cellular repeaters, the industrial, scientific and medical (ISM) radio band amplifiers, and test equipments. 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 output power level of BFQ790 and BFP780 is 27 dBm and 23 dBm respectively.

BFQ790 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 temperature 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. 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 due to the special collector design protecting it from thermal runaway secondary breakdown, which makes BFQ790 rugged when exposed to mismatch at the output. The special design of the emitter/base diode makes BFQ790 robust and allows for high maximum RF input power.

BFQ790 can serve in a single-stage RF amplifier with very high linearity. This application note presents the RF amplifier circuit of BFQ790 for 169 MHz applications and the measurement results. The BFQ790 amplifier provides a 21 dB gain with the 26.7 dBm output 1dB compression point (OP1dB). Besides, in two-tone test with tone spacing of 1 MHz, the output third order intercept point (OIP3) reaches 38 dBm.

2 Medium Power Amplifier BFQ790 for Smart Meter Applications

2.1 Performance Overview

Device: BFQ790
 Application: Medium Power Amplifier BFQ790 for 169 MHz Smart Meter Applications
 PCB Marking: M130314

Table 1 Summary of Measurement Results

Parameter	Symbol	Value	Unit	Comments/Test Conditions
Frequency	Freq	169	MHz	
DC Voltage	V _{CC}	5.0	V	
DC Current	I _{CC}	240	mA	Biasing DC Current
Gain	G	21.0	dB	V _{CC} = 5.0 V, I _{CC} = 240 mA, the PCB and SMA losses are not subtracted.
Input Return Loss	RL _{in}	27.5	dB	
Output Return Loss	RL _{out}	14.2	dB	
Reverse Isolation	IRev	32	dB	
Output P1dB	OP1dB	26.7	dBm	Measured at 169 MHz
Output IP3	OIP3	38	dBm	Power @ Input: 14 dBm f1 = 169 MHz, f2 = 170 MHz
Stability	μ1, μ2	> 1	--	Unconditionally stable

*Note: Please refer to **Chapter 3** for corresponding graphs*

2.2 Schematic and Bill-of-Materials

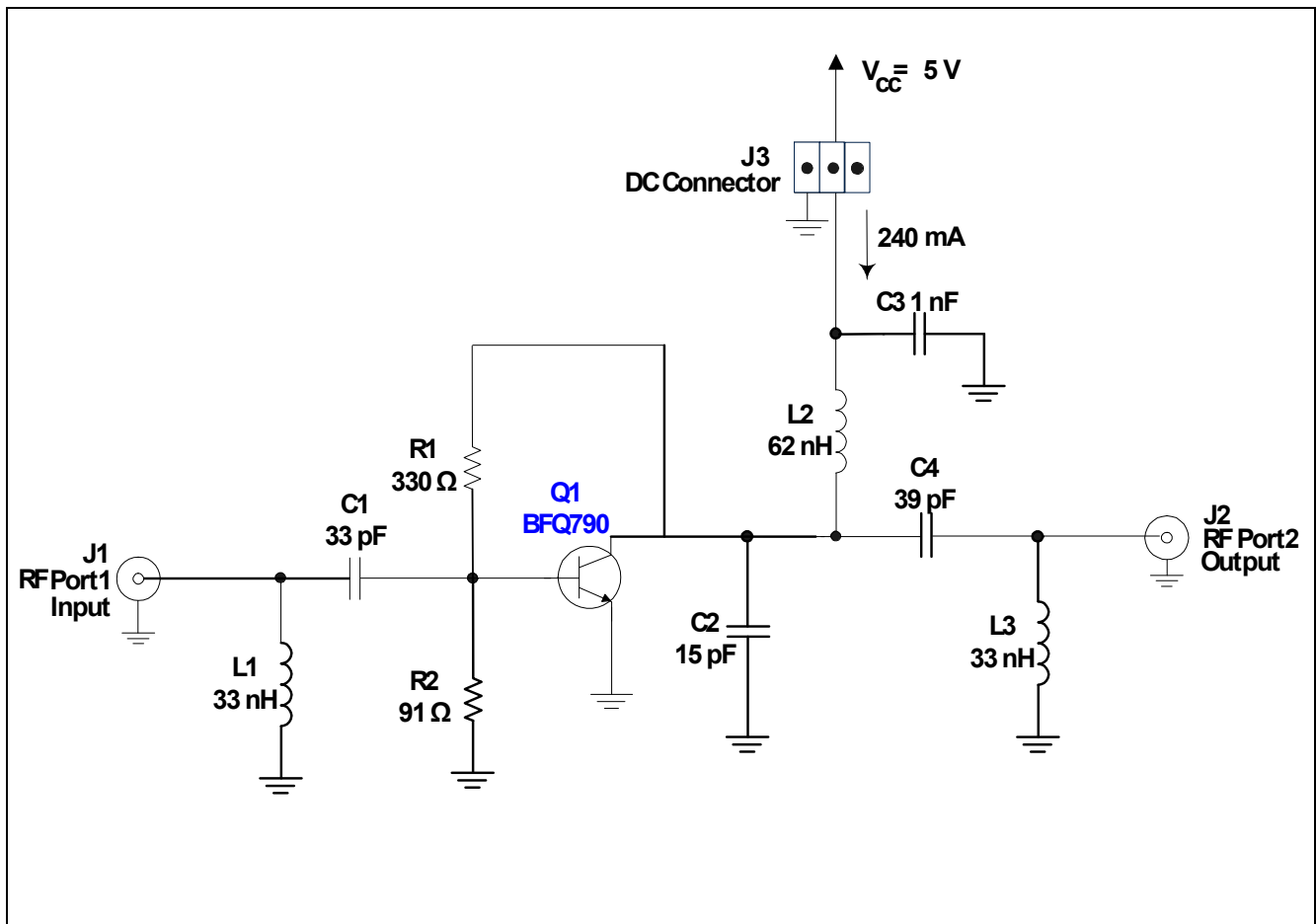


Figure 4 Schematic of the BFQ790 Medium Power Amplifier Circuit for 169 MHz Smart Metering

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
Q1	BFQ790		SOT89	Infineon	SiGe medium power transistor
C1	33	pF	0603	Various	Input matching & DC blocking
C2	15	pF	0603	Various	Output matching
C3	1.0	nF	0603	Various	RF bypass
C4	39	pF	0603	Various	Output matching & DC blocking
L1	33	nH	0603	Murata LQW	Input matching
L2	62	nH	0603	Murata LQW	RF chock/output matching
L3	33	nH	0603	Murata LQW	Output matching
R1	330	Ω	0603	Various	DC biasing/feedback
R2	91	Ω	0603	Various	DC biasing

3 Measurement Graphs

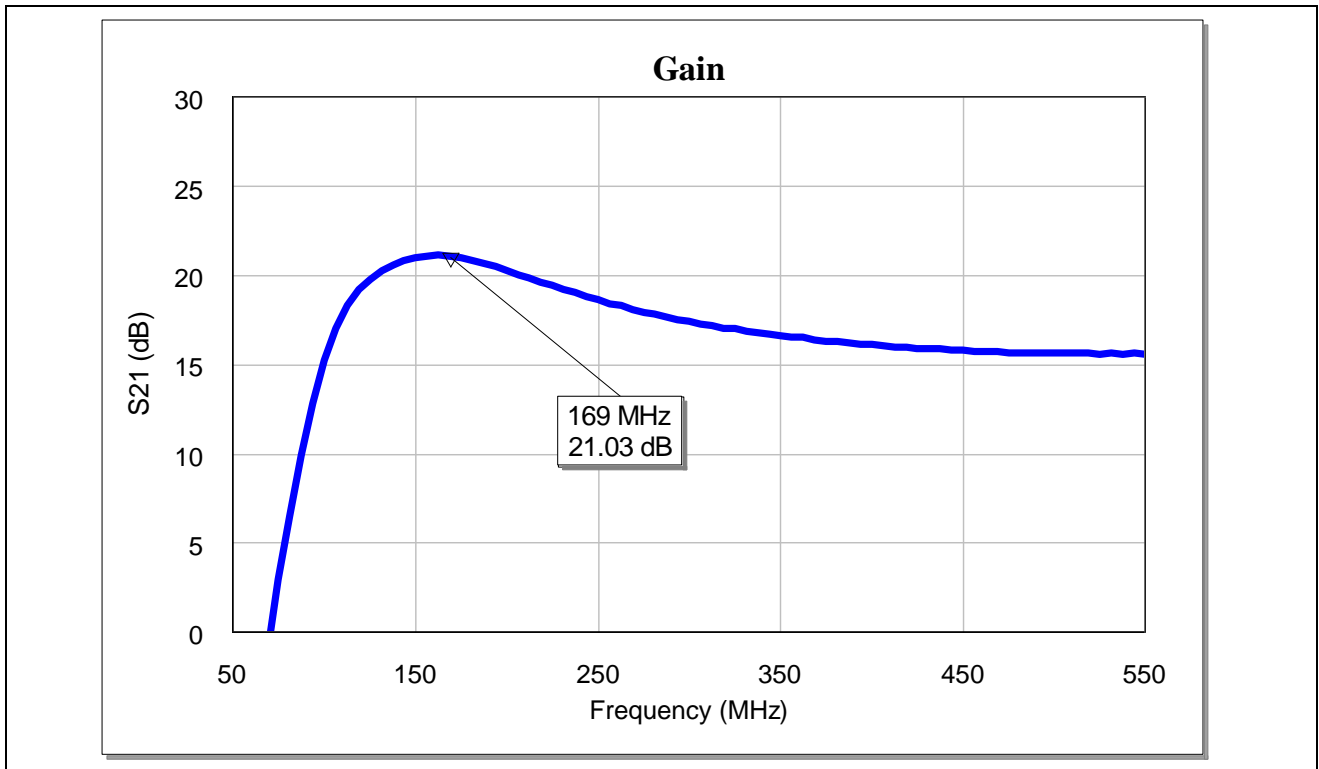


Figure 5 Power Gain of 169 MHz BFQ790 Medium Power Amplifier

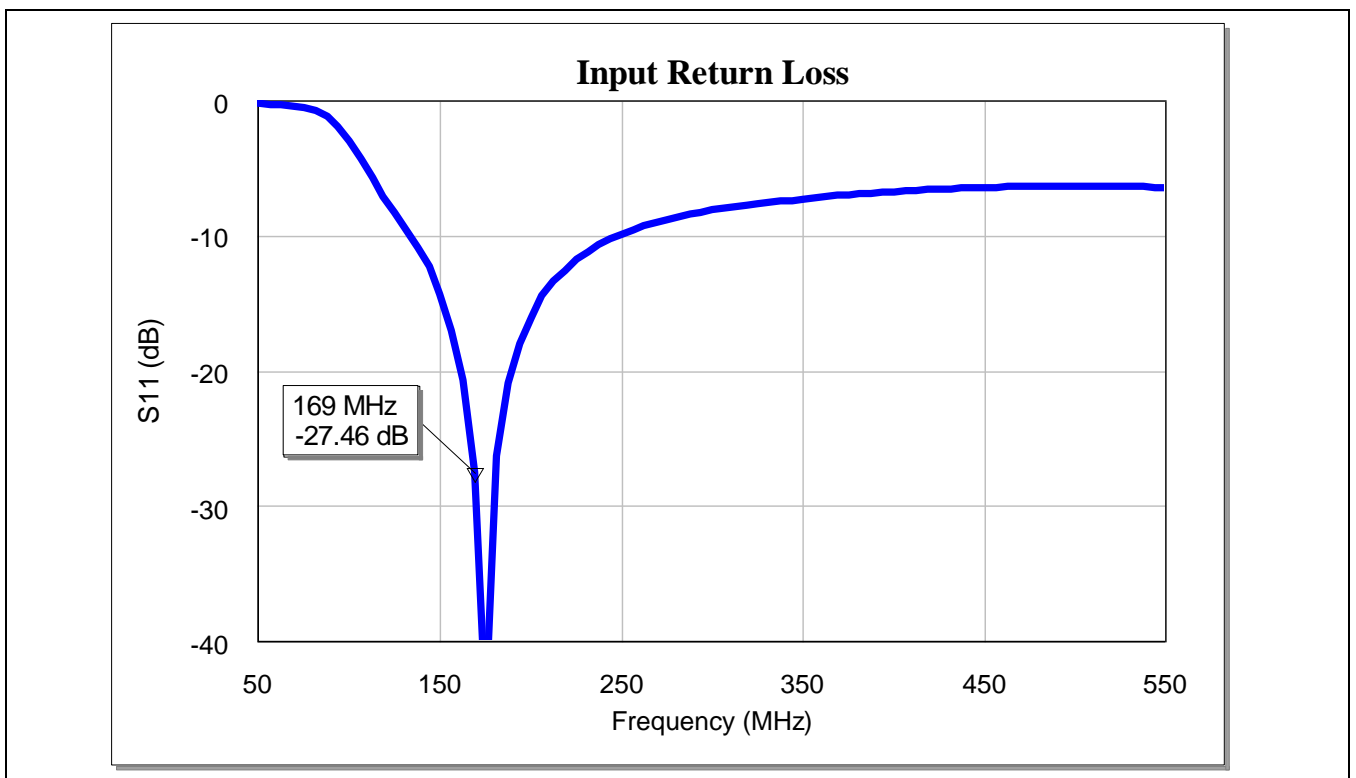


Figure 6 Input Matching of 169 MHz BFQ790 Medium Power Amplifier

Measurement Graphs

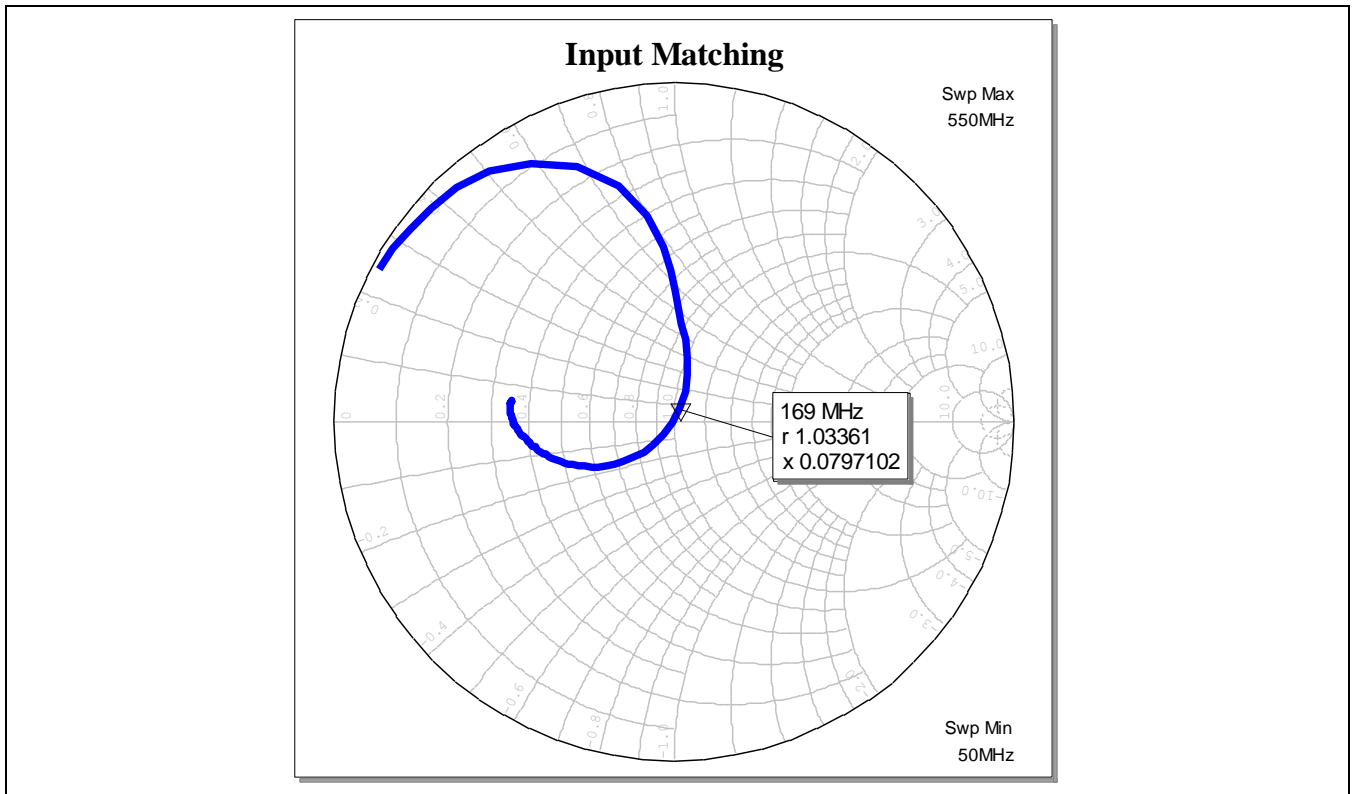


Figure 7 Input Matching (Smith Chart) of 169 MHz BFQ790 Medium Power Amplifier

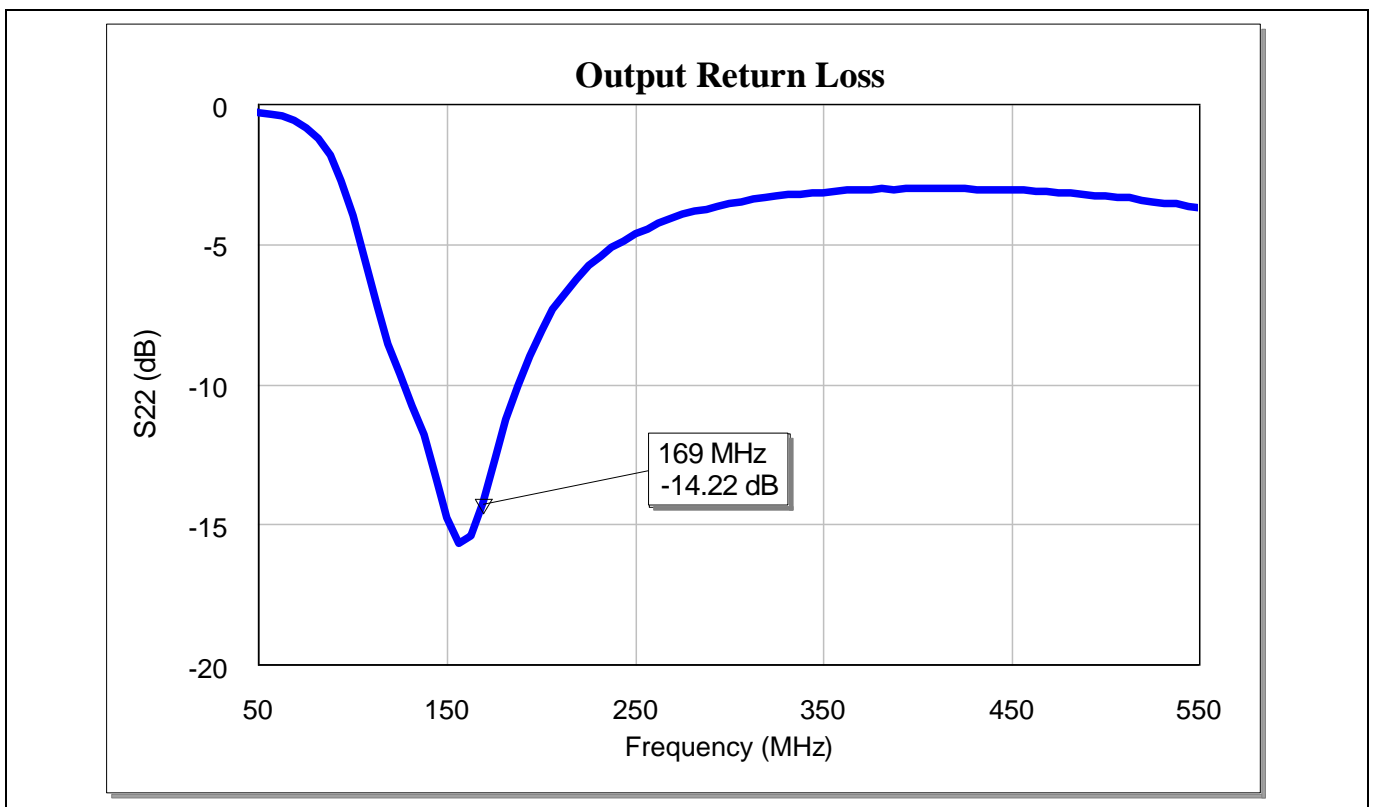


Figure 8 Output Matching of 169 MHz BFQ790 Medium Power Amplifier

Measurement Graphs

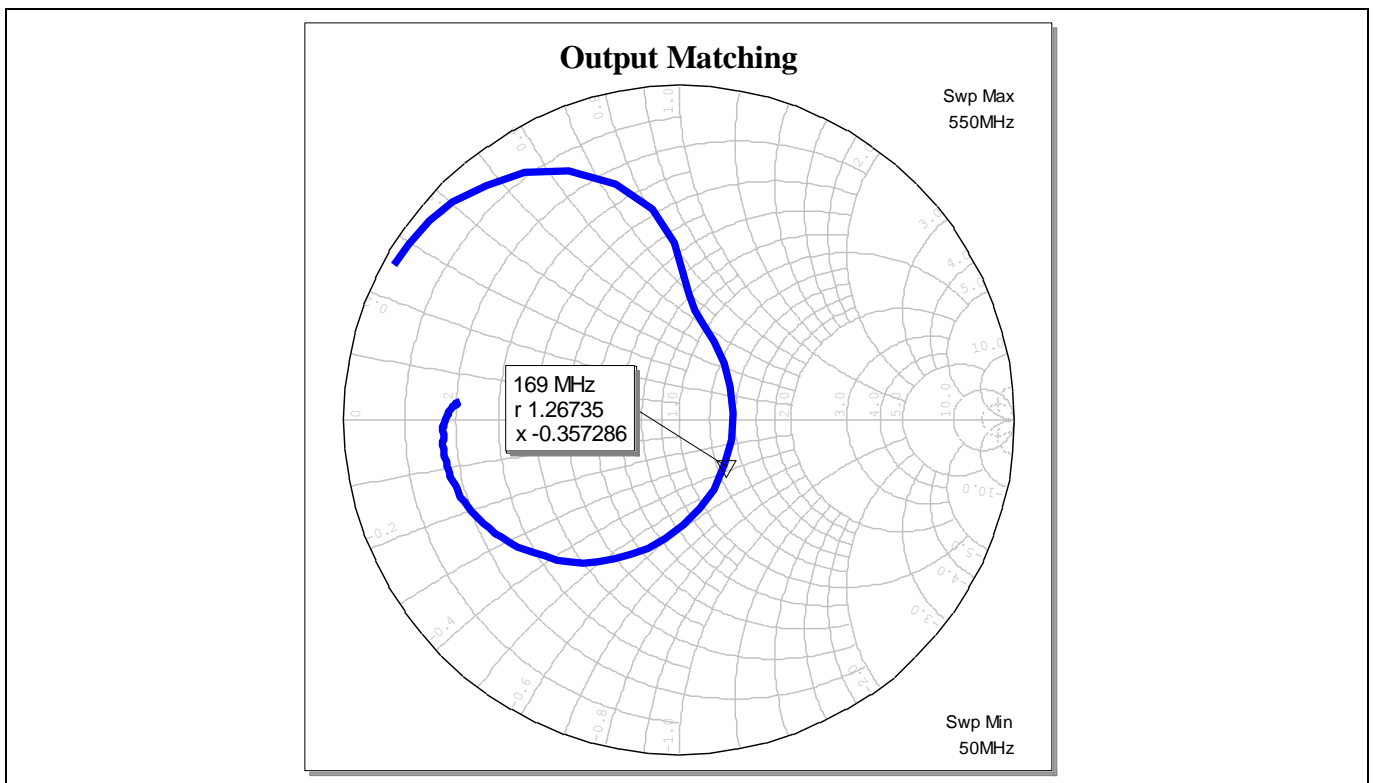


Figure 9 Output Matching (Smith Chart) of 169 MHz BFQ790 Medium Power Amplifier

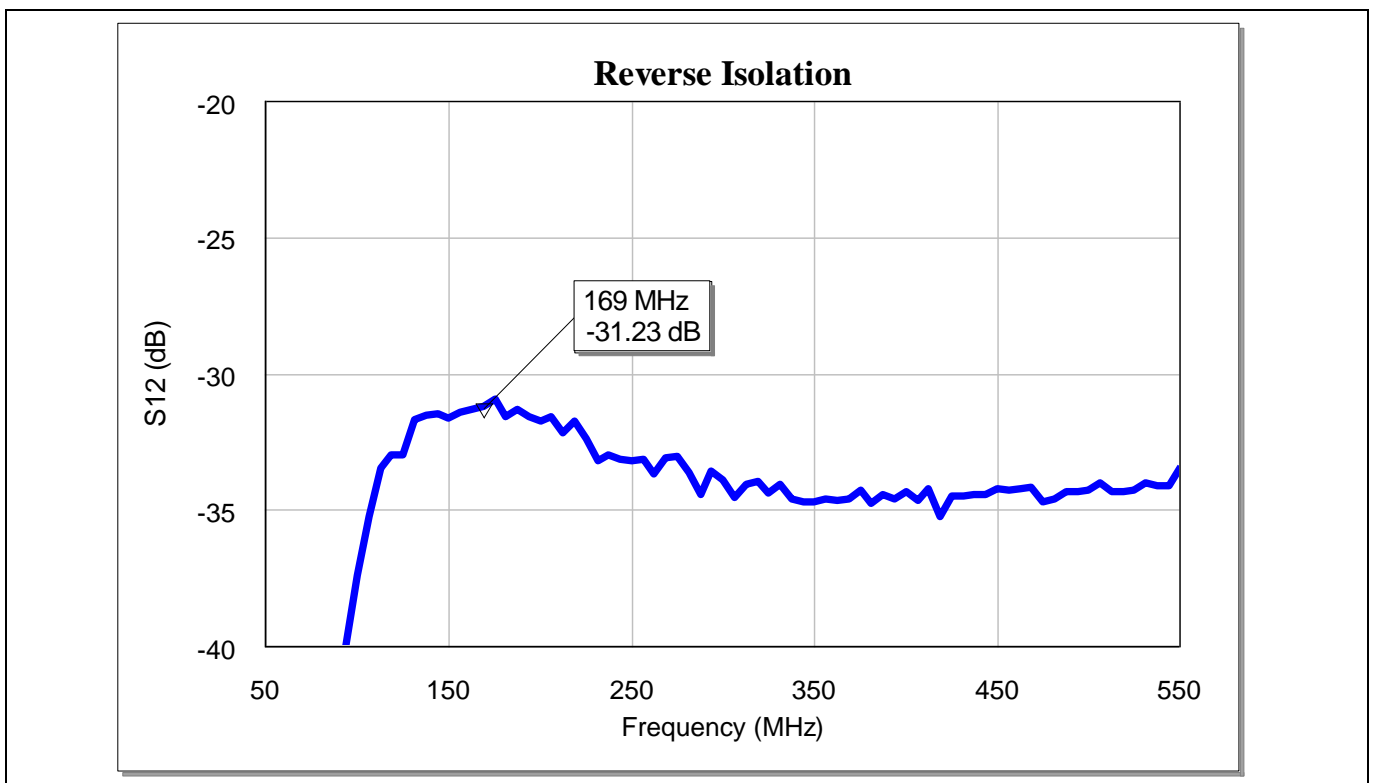


Figure 10 Reverse Isolation of 169 MHz BFQ790 Medium Power Amplifier

Measurement Graphs

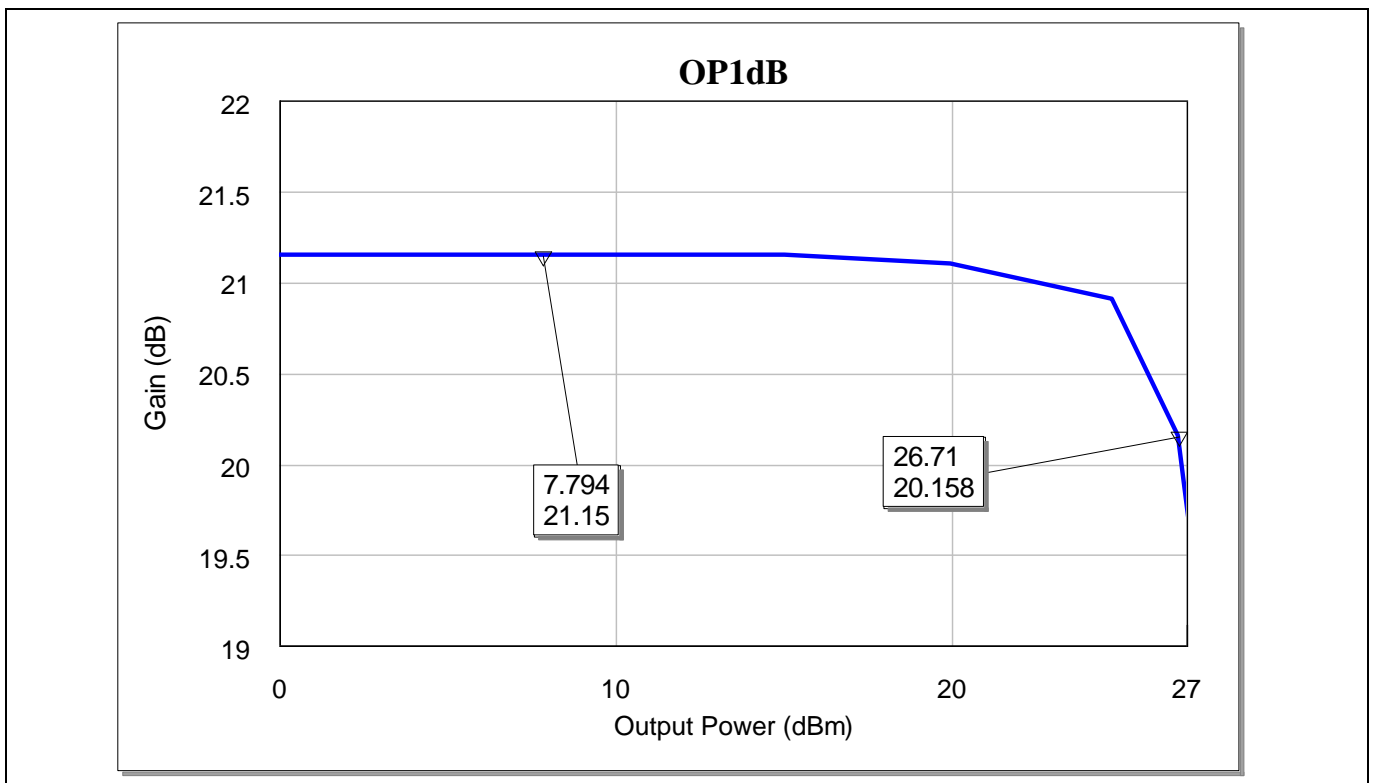


Figure 11 Output 1 dB Compression Point of 169 MHz BFQ790 Medium Power Amplifier

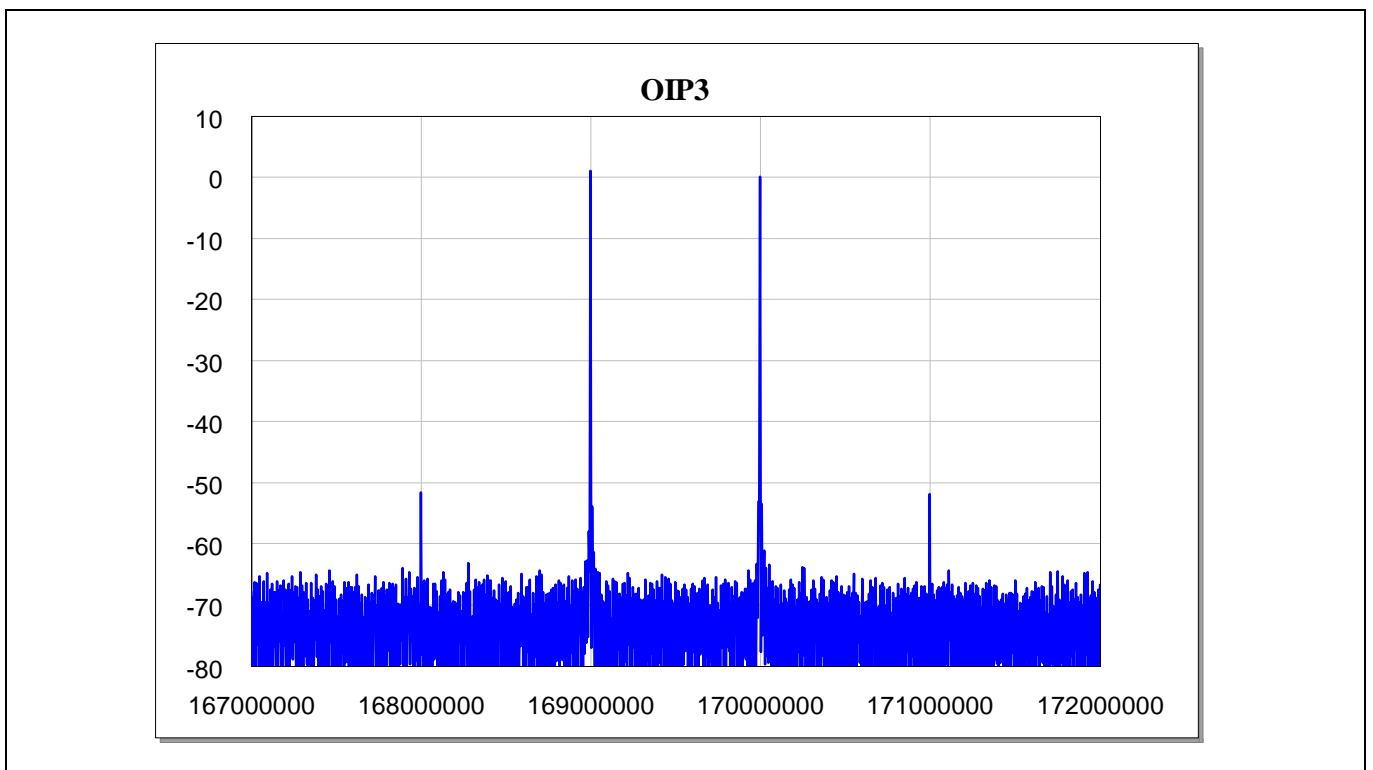


Figure 12 3rd Order Intermodulation product of 169 MHz BFQ790 Medium Power Amplifier

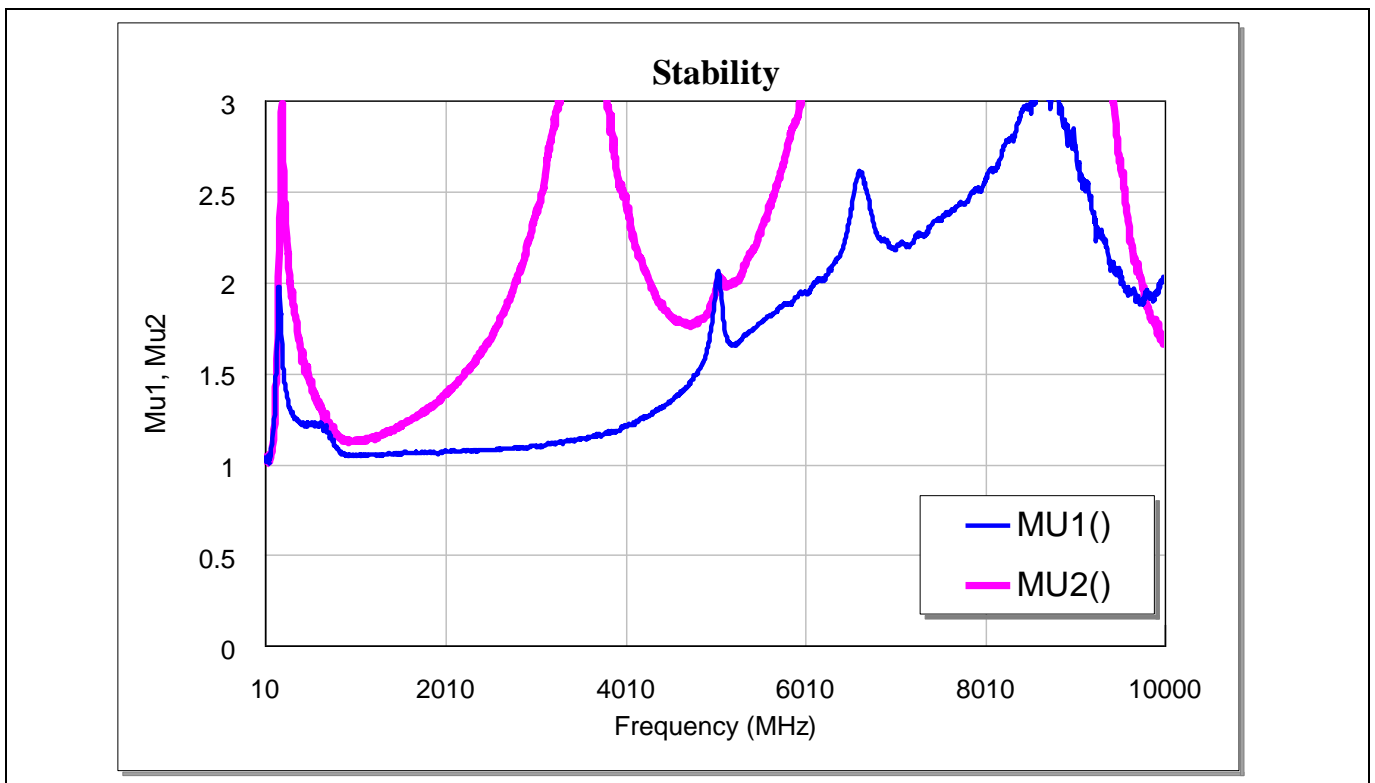


Figure 13 Stability μ_1 , μ_2 -factors of 169 MHz BFQ790 Medium Power Amplifier

4 Evaluation Board and Layout Information

In this application note, the following PCB is used:

- PCB Marking: **M130314**
- PCB material: **FR4**
- ϵ_r of PCB material: **4.6**

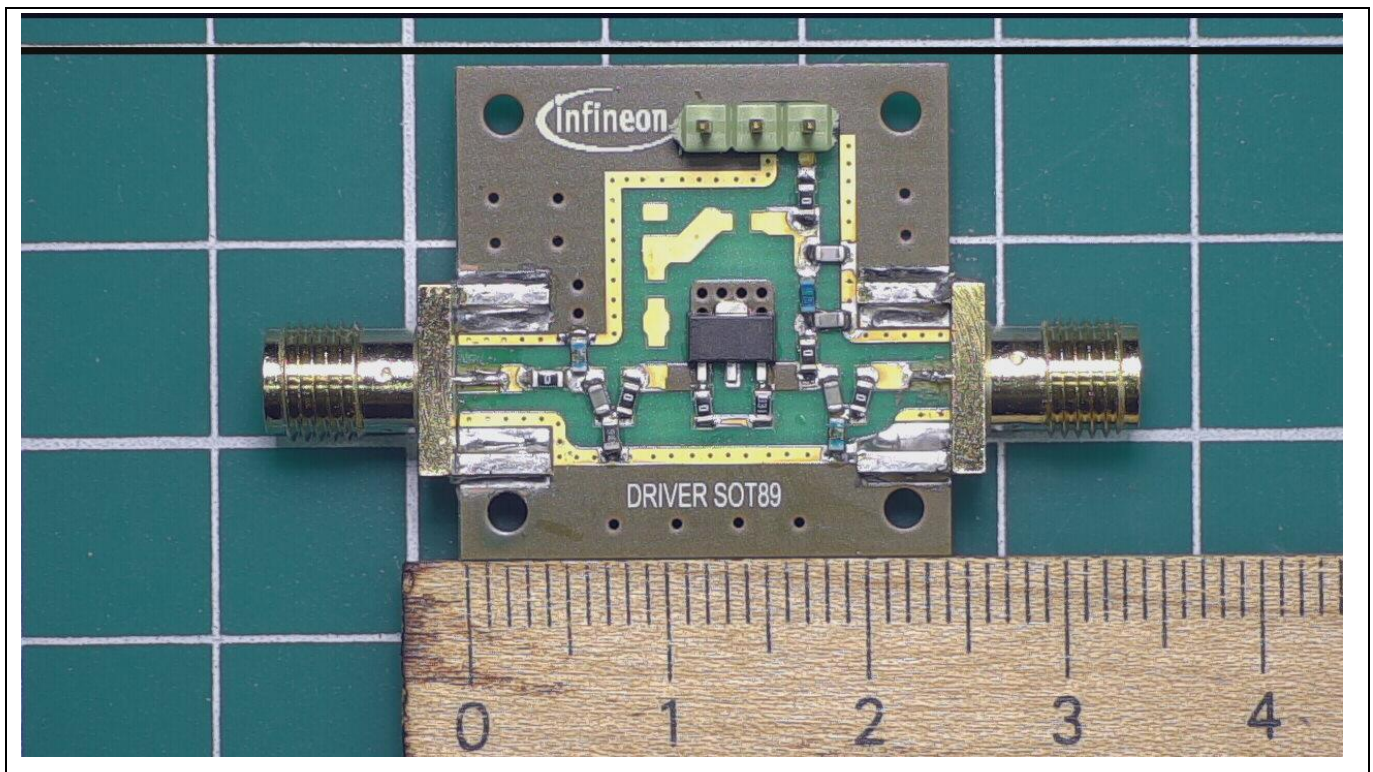


Figure 14 Photo of BFQ790 Medium Power Amplifier Evaluation Board

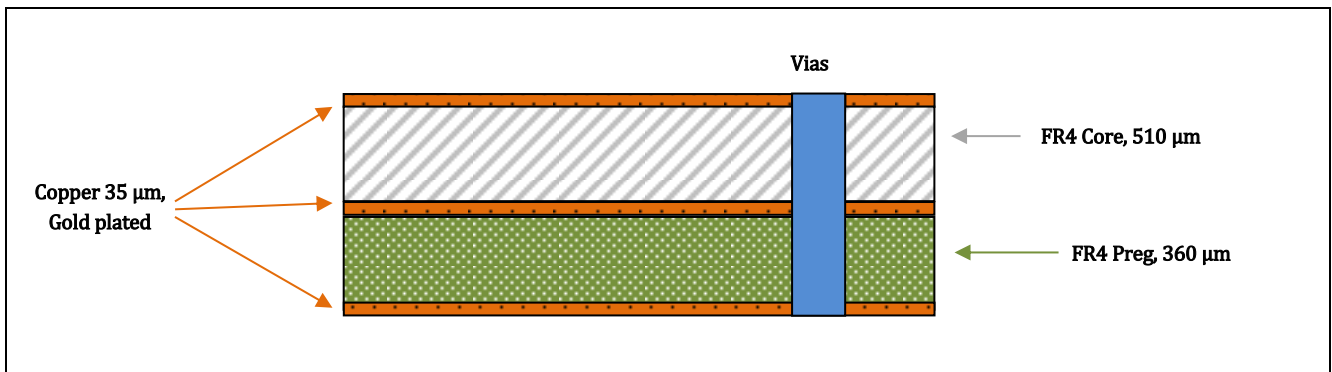


Figure 15 PCB Layer Information

5 Authors

Yiwen Zhang, Intern of business unit “RF and Protection Sensors”.

Dr. Jie Fang, RF application engineer of business unit “RF and Sensors”.

6 Reference

- [1] Directive 2012/27/EU of the European Parliament and of the Council of 25 October on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, 2012/27/EU. Official Journal of the European Union, L315/1. 2012

Revision History

Major changes since the last revision

Page or Reference	Description of change

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