Driver Amplifier BFQ790 for GSM900 Cellular Repeater Applications

Application Note: AN460

About this document

Scope and purpose

Application note describes a driver amplifier circuit that uses Infineon's medium-power SiGe bipolar transistor BFQ790. This driver amplifier is designed for GSM900 (cellular repeaters) appplications.

1. This application note presents the measurement results of a driver amplifier design for 900 MHz application purposes.
2. BFQ790 is a single stage driver amplifier provides high linearity and high gain.
3. Key performance paramerters achieved (at 915 MHz)

    a. Gain = 20 dB

    b. Input return loss = 11 dB

    c. Output return loss =10 dB

    d. Output P1dB = 27 dBm

    e. Output IP3 = 38.7 dBm

Table of Contents

List of Figures

List of Tables

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

1 Introduction

1.1 BFQ790 as Driver Amplifier for GSM900 Cellular Repeaters

In the procedure normally used for effecting radio transmissions between base stations and cellpnes, when the strength of the signal from the base station falls below minimum levels (as the mobilephone moves from one point to another), the mobilephone does not transfer the transmission in progress to another station without interruption. Now, thanks to the capability of transmitting data between bas station and mobile phones, a transmission can be transferred without interruption from a base station to an adjacent fixed station which is closer to the mobile phone.

Besides an insufficient number of cells, the following factors - Road, railway and subway tunnels - Buildings that are especially well-shielded - Radio-electric shadow areas (city centres) - Mountainous or hilly areas - Zones without cells, where the coverage is necessarily limited. The situation involving tunnels is the most clear-cut case. The other cases can be resolved by increasing the density of the cells; however, this solution may not be advantageous because the radio-frequency signals may be reflected (especially in mountainous or shadow areas), which causes spurious handovers and probable losses of transmissions.

As was described above, the coverage limits of radio base stations can be extended by using cellular repeaters that retransmit a band of carriers from the nearest radio base station into the area or environment to be served. The simplest method for reaching this goal is to use a radio reception/transmission antenna pointed toward the nearest radio base station, a bi-directional amplifier and a radiating element (for example, an antenna) whose spatial transmission characteristics (range, angle of aperture and angle of curvature) can be controlled sufficiently.

As can be seen in figure 1, an antenna-antenna type of cellular repeater system is made up of an RBS antenna, a radio-frequency amplifier and an RMA antenna.

The signal received by the RBS antenna (from the closest RBS, which is called the "donor RBS"), is amplified and sent to the RMA antenna, which is pointed toward the shadow area to be "illuminated". The signal from the mobile station, which is received by the RMA antenna, is treated in the same way and sent to the donor RBS.

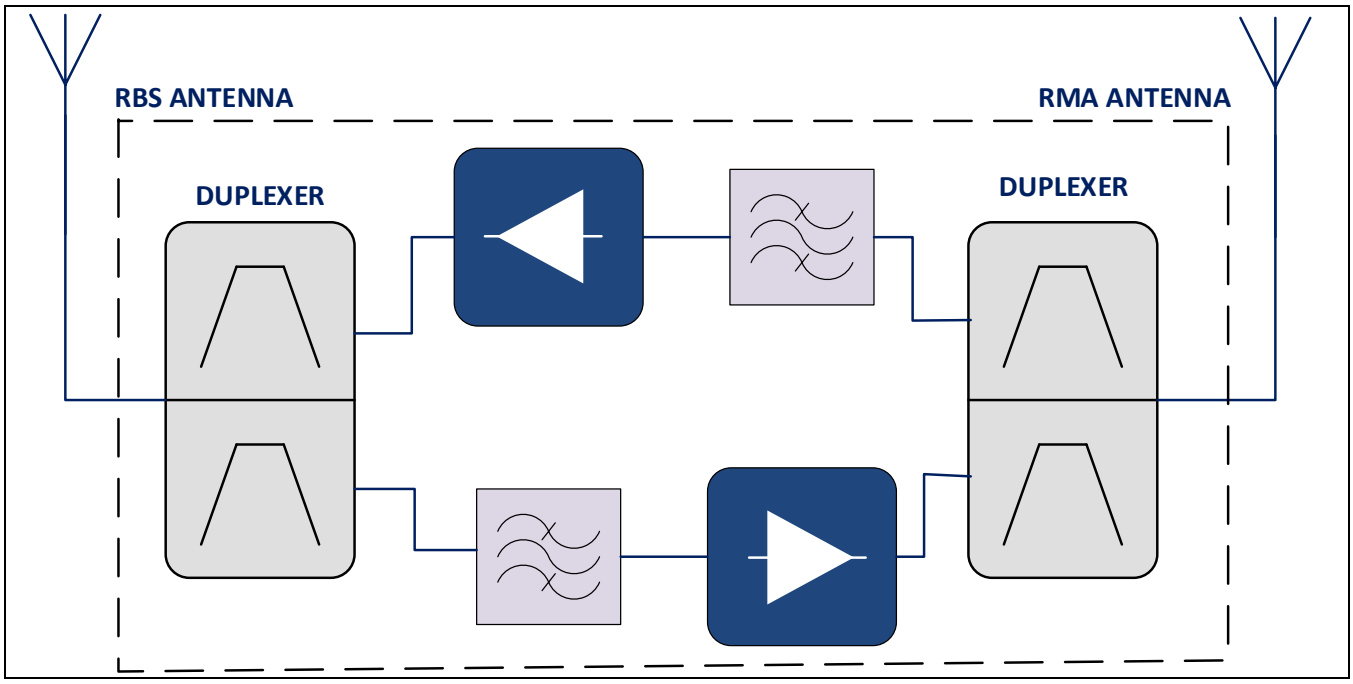

Figure 1 Bi-directional cellular repeater

1.2 Infineon Driver Amplifier Family

The driver amplifier, also known as a 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.

BFQ790 and BFP780 are general-purpose medium-power transistors in Infineon's Silicon Germanium (SiGe) product portfolio for wireless infrastructure applications. These applications include mobile basestation transceivers, cellular repeaters, the industrial, scientic and medical (ISM) radio 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 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. 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 protects it from thermal runaway secondary breakdown, which makes it rugged when exposed to mismatch at the output. The special design of the emitter/base diode makes it robust and allows for high maximum RF input power.

In this application note, the driver application cirucit of BFQ790 for ISM Band (890 - 960 MHz) and its measurement results are presented. The BFQ790 driver provides 20 dB gain in the frequency range of 890 to 960 MHz. The output 1dB compression point (OP1dB) is 27 dBm measured at 915 MHz. Besides, in two-tone test with tone spacing of 1 MHz, the output third order intercept point (OIP3) reaches 38.75 dBm.

2 Driver Amplifier BFQ790 for GSM900 Cellular Repeater Applications

2.1 Performance Overview

Device: BFP740FESD
Application: Driver Amplifier BFQ790 for GSM900 Cellular Repeater Applications
PCB Marking: M15211

Table 1 Summary of Measurement Results

Parameter	Symbol	Value	Unit	Comments/Test Conditions
DC Voltage	V_{CC}	5	V	
DC Current	I_{Cq}	260	mA	
Frequency	F_{req}	890 - 960	MHz	
Gain	G	20	dB	Vcc = 5 V, Icc = 260 mA, the PCB and SMA losses (0.1 dB) are substracted.
Input Return Loss	RLin	11.5	dB	
Output Return Loss	RLout	10	dB	
Reverse Isolation	IRev	30	dB	
Output P1dB	OP1dB	27	dBm	Measured at 915 MHz
Output IP3	OIP3	38.7	dBm	Power @ Input: 14 dBm f_1 = 915 MHz, f_2 = 916 MHz
Stability	µ1, µ2	> 1	--	Measured up to 10 GHz

2.2 Schematic and Bill-of-Materials

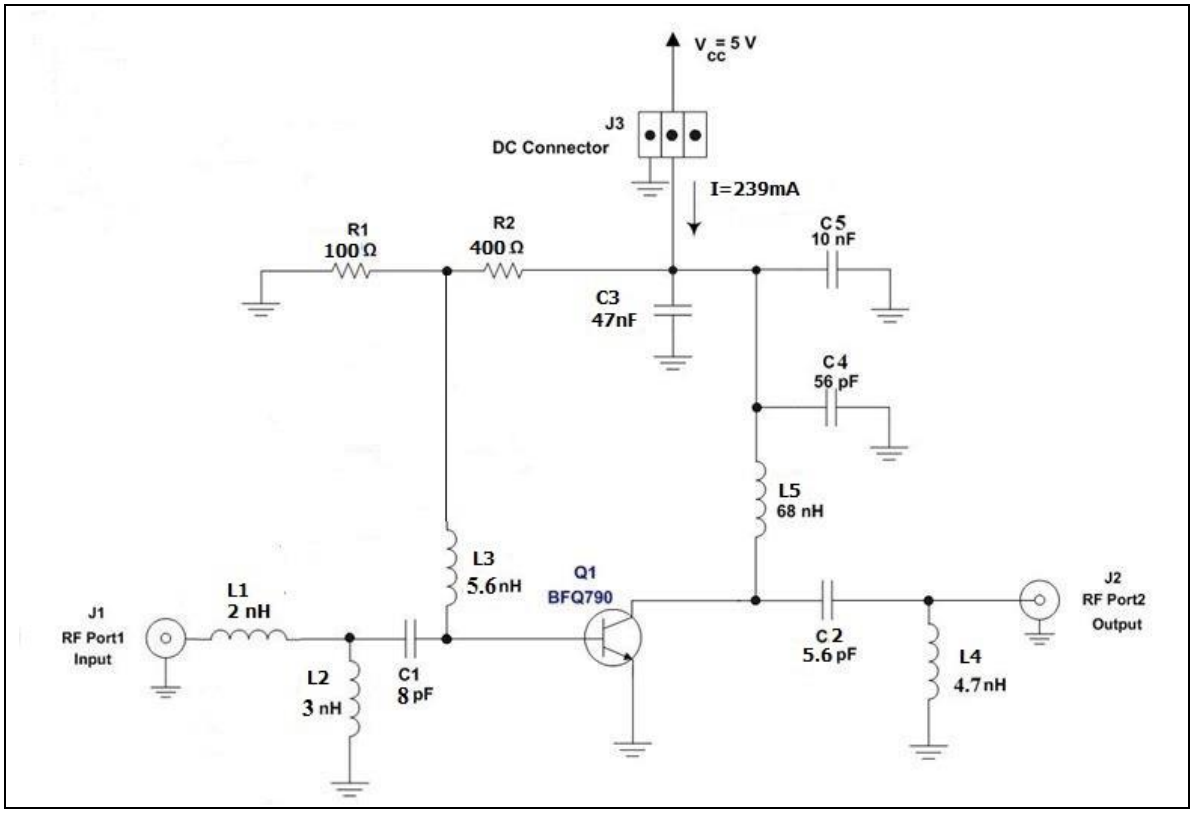

Figure 1 Schematic of the BFQ790 Application Circuit for GSM900

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
Q1	BFQ790		SOT89	Infineon	SiGe driver transistor
C1	8	pF	0402	Various	Input matching & DC blocking
C2	5.6	pF	0402	Various	Output matching & DC blocking
C3	47	nF	0402	Various	RF bypass
C4	56	pF	0402	Various	RF bypass
C5	10	nF	0402	Various	RF bypass
L1	2	nH	0402	Murata LQG	Input matching
L2	3	nH	0402	Murata LQG	Input matching
L3	5.6	nH	0402	Murata LQG	RF chock & Input matching
R1	100	Ω	0402	Various	DC biasing
R2	400	Ω	0402	Various	DC biasing

3 Measurement Graphs

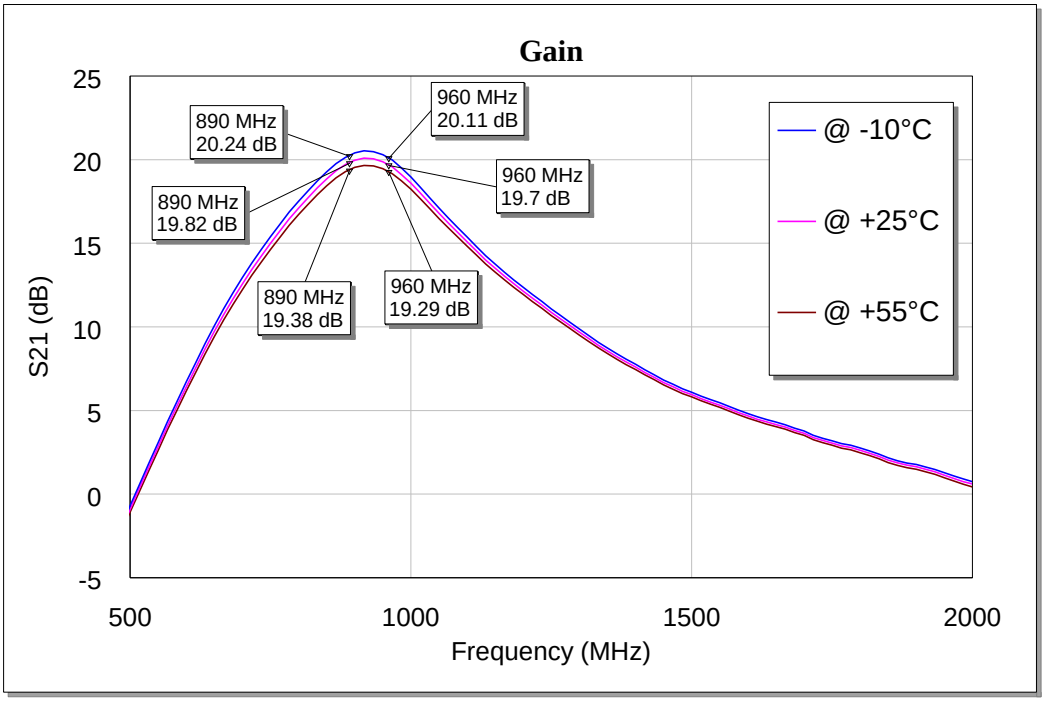

Figure 2 Insertion Power Gain of the BFQ790 Driver Amplifier

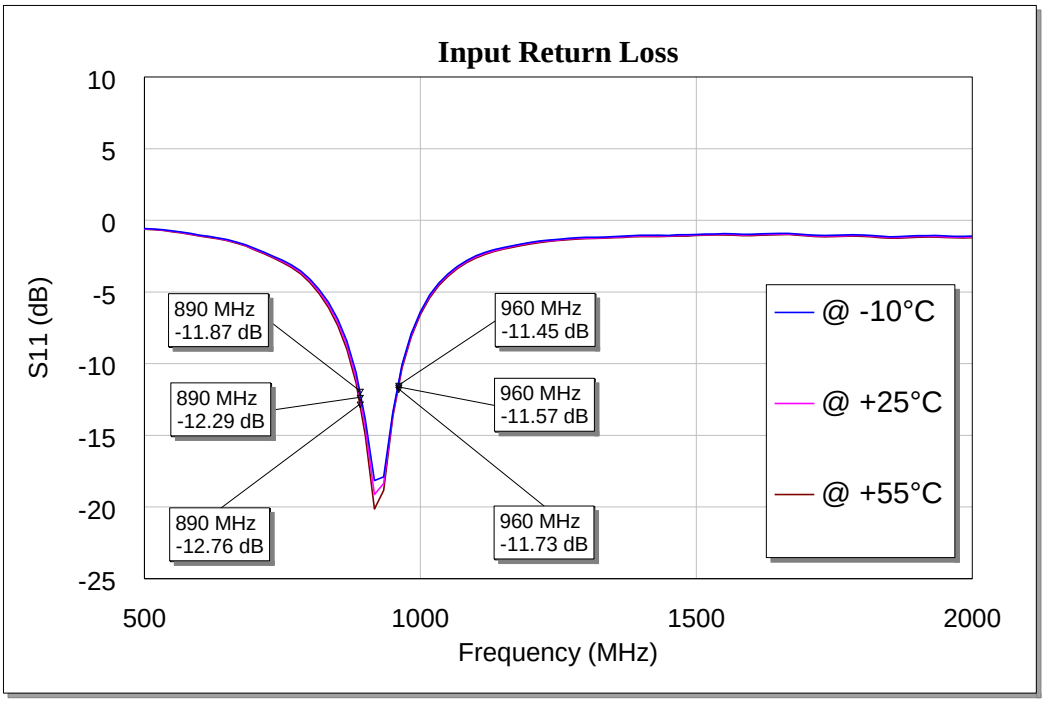

Figure 3 Input Matching of the BFQ790 Driver Amplifier

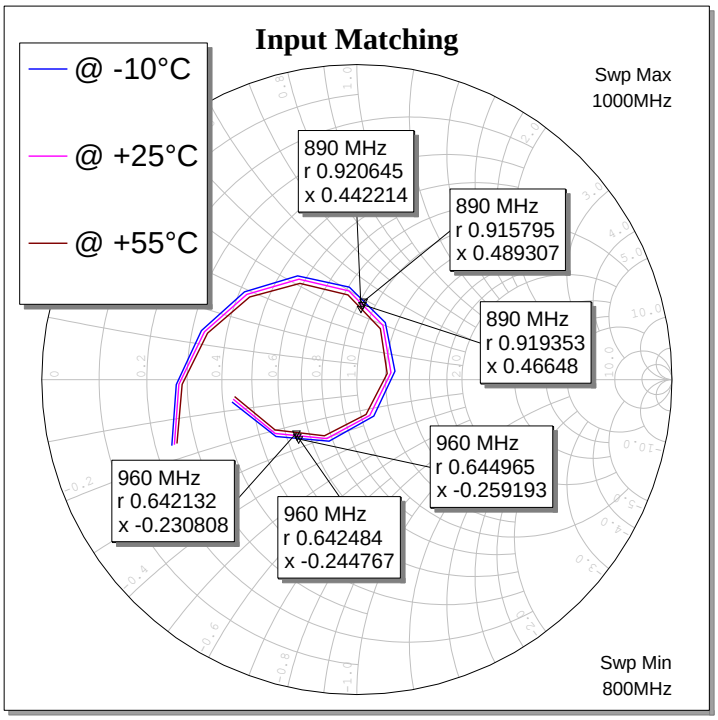

Figure 4 Input Matching of the BFQ790 Driver Amplifier

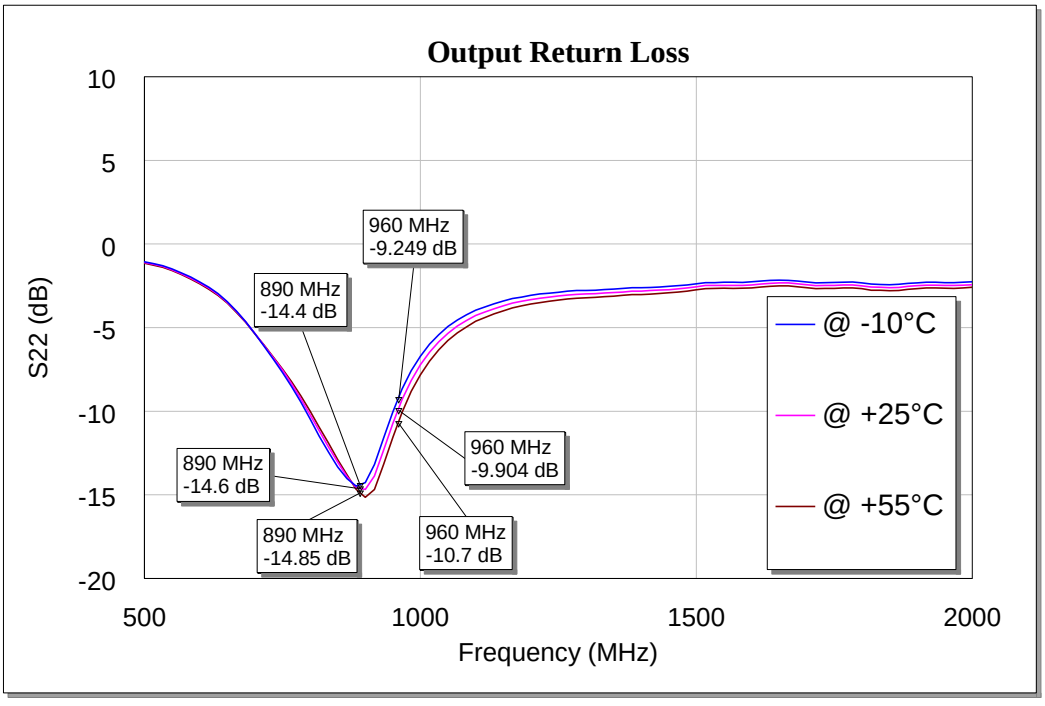

Figure 5 Output Matching of the BFQ790 Driver Amplifier

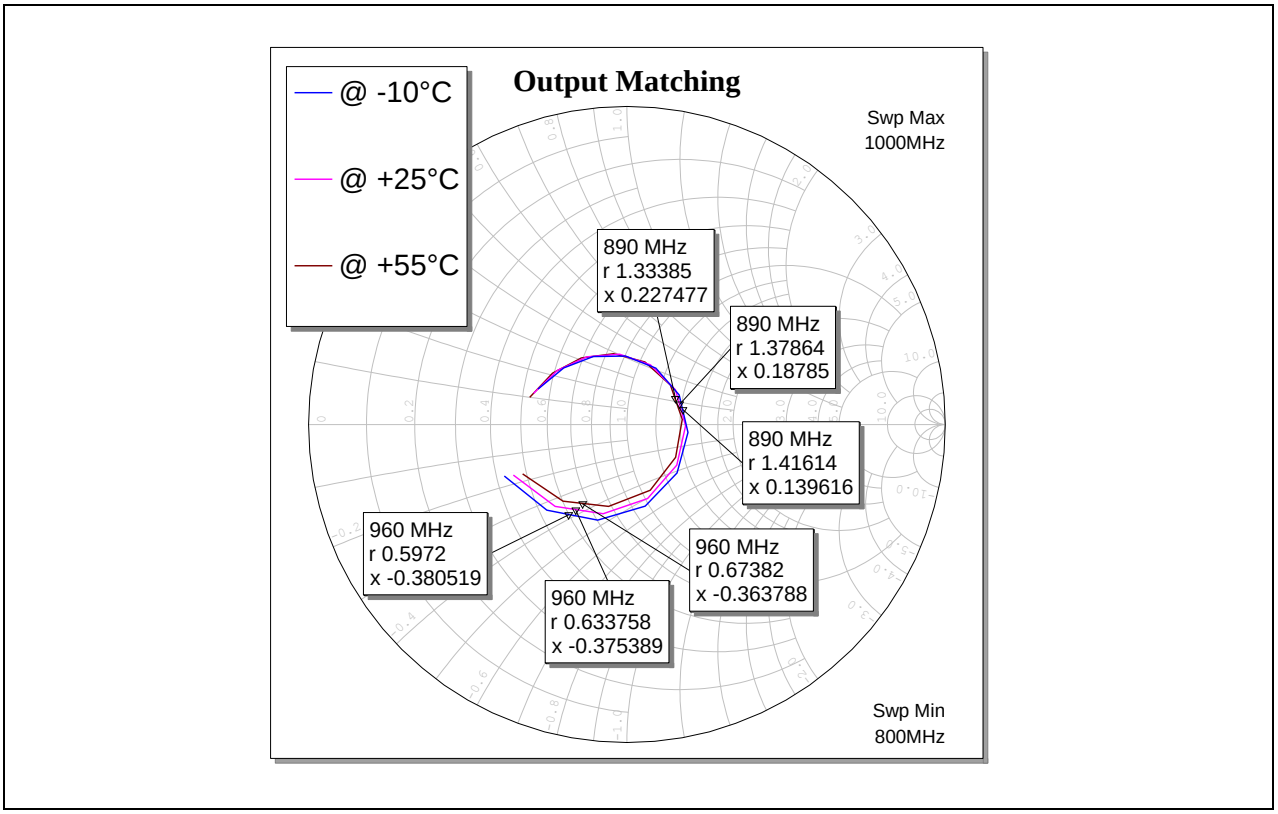

Figure 6 Output Matching of the BFQ790 Driver Amplifier

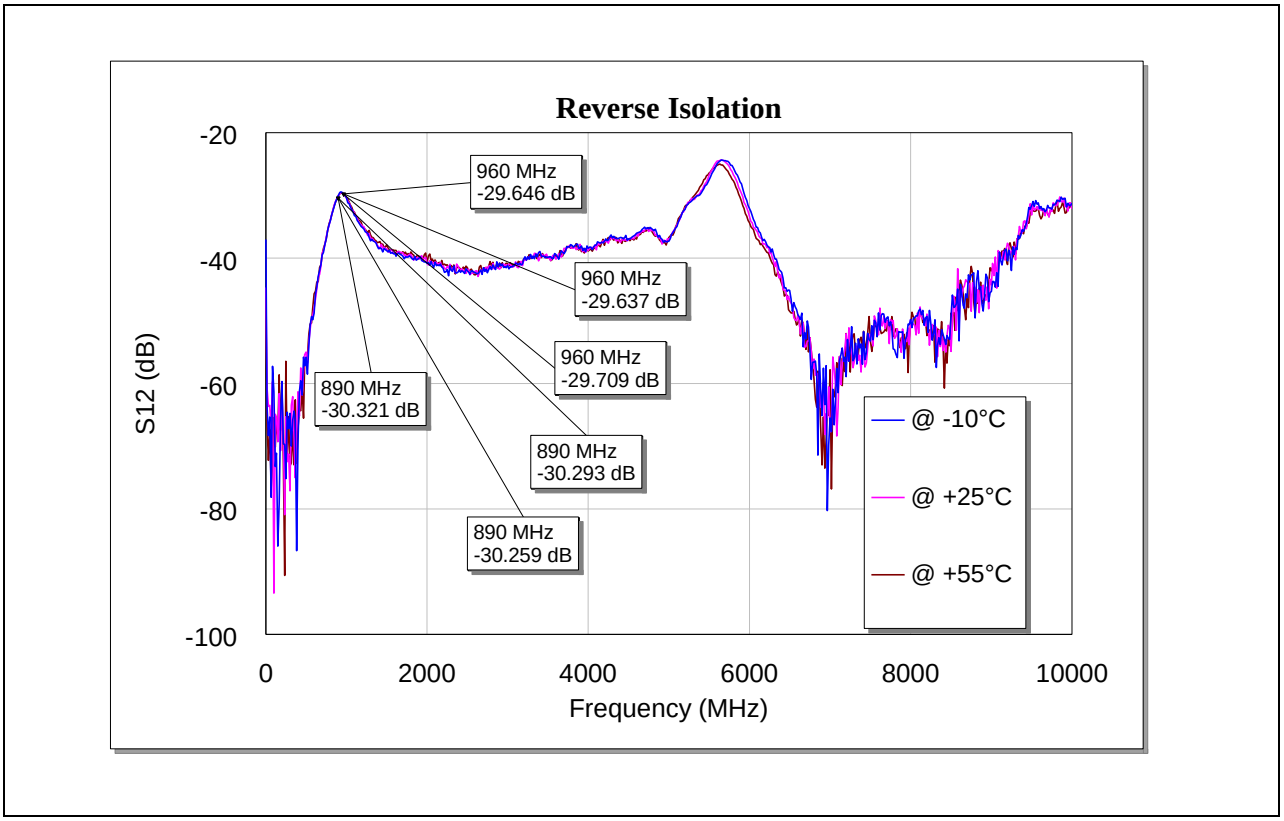

Figure 7 Reverse Isolation of the BFQ790 Driver Amplifier

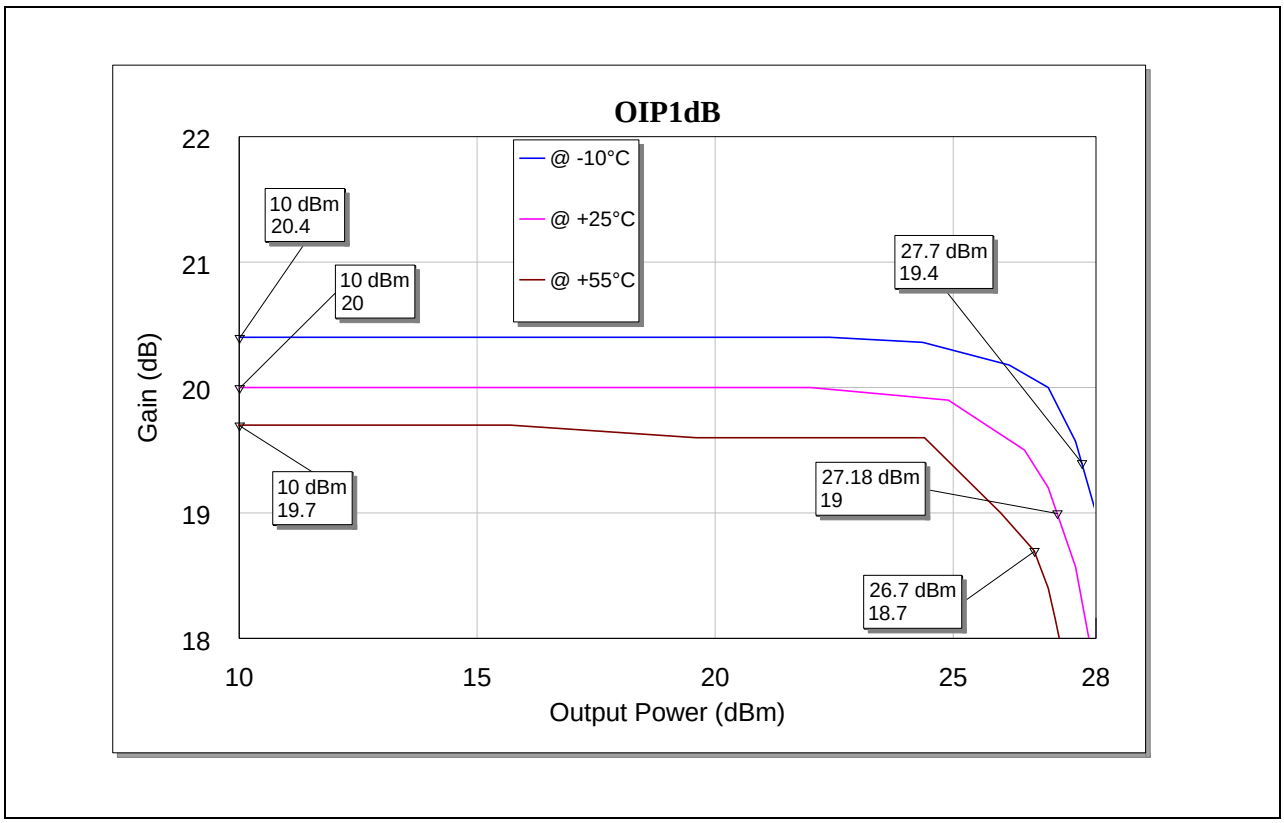

Figure 8 Output 1dB Compression Point

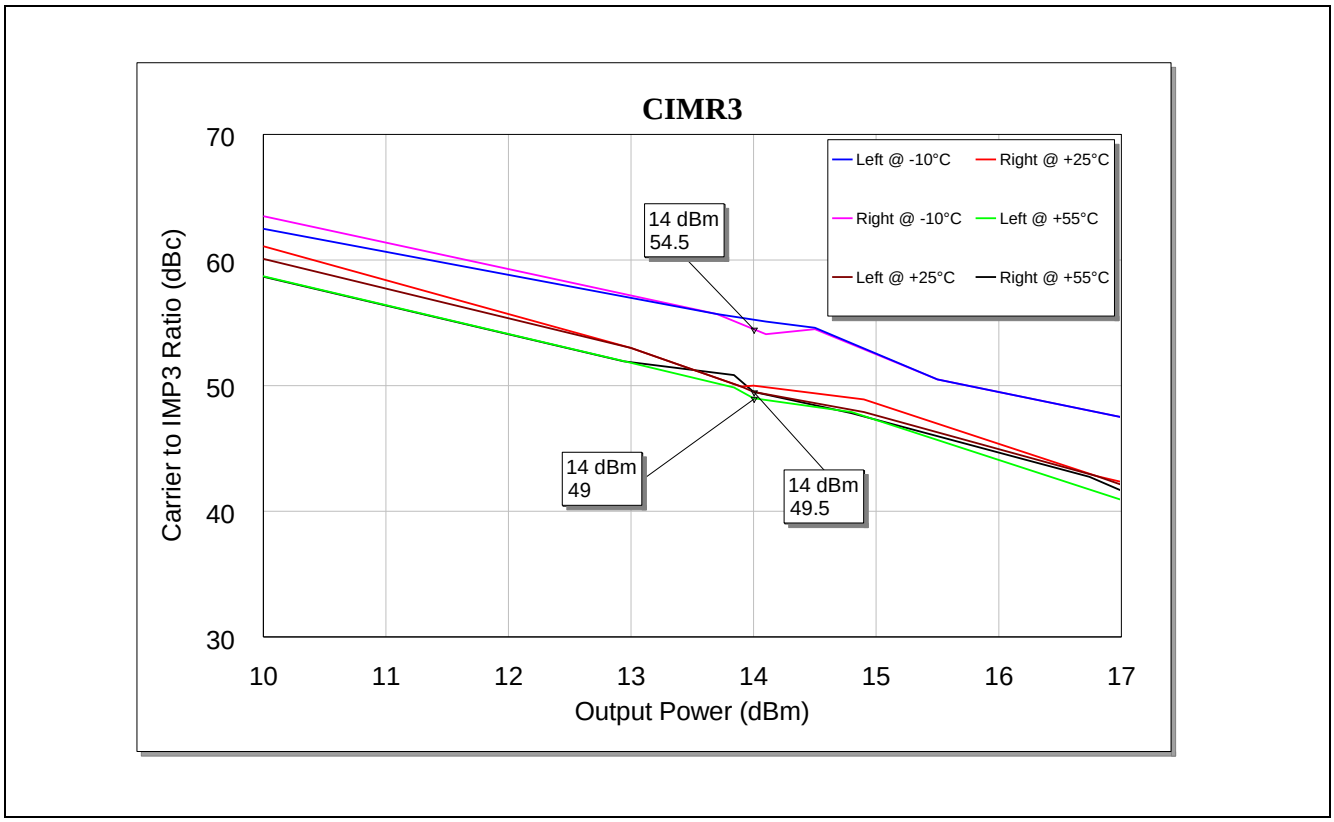

Figure 9 Carrier to IM3 Ratio of the BFQ790 Driver Amplifier

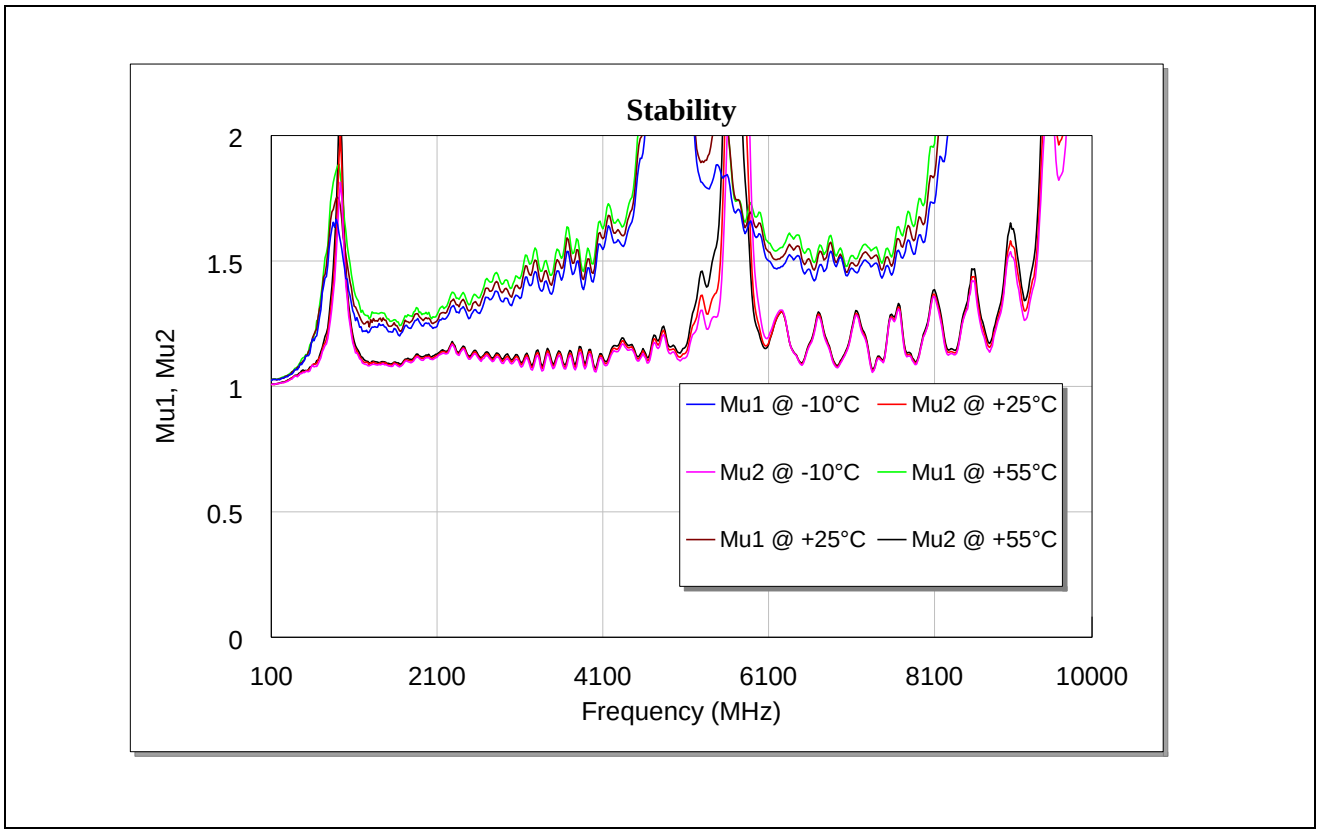

Figure 10 Stability Mu1, Mu2 - factors of the BFQ790 Driver Amplifier

4 Evaluation Board and Layout Information

In this application note, the following PCB is used:

PCB Marking: **M15211**

PCB material: **FR4**

ε_r of PCB material: **4.6**

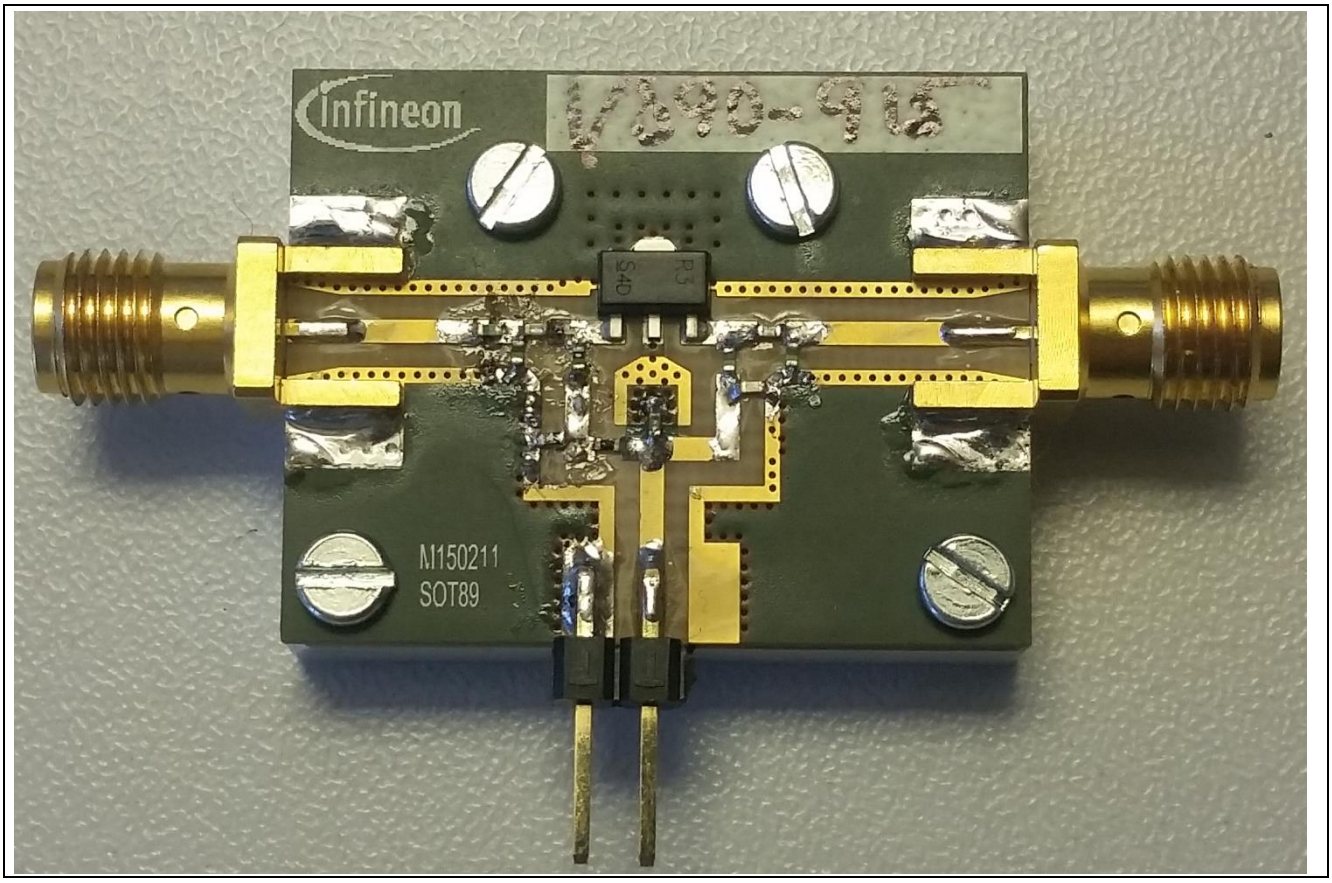

Figure 11 Photo of Evaluation Board (overview)

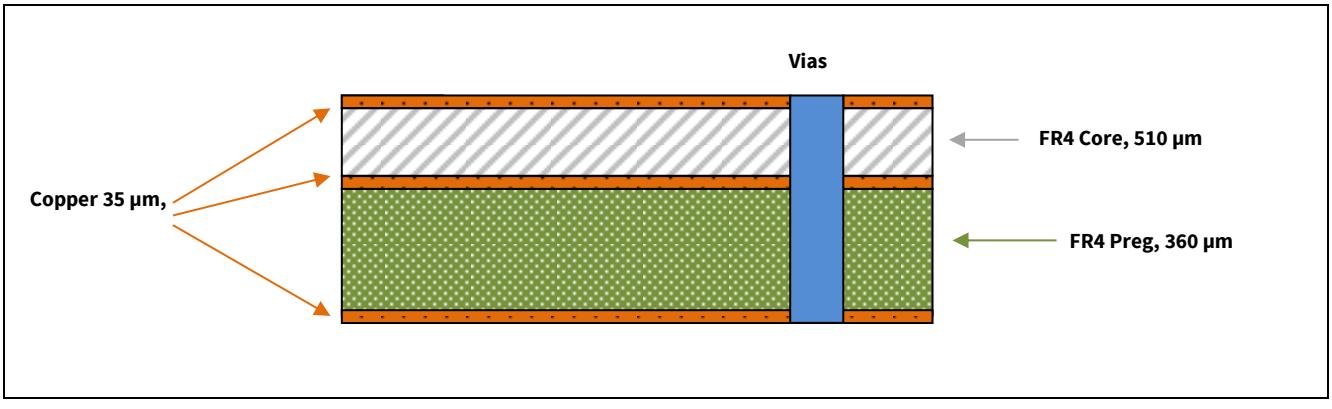

Figure 12 Photo of Evaluation Board (detailed view)

5 Authors

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Revision History

Major changes since the last revision

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