



PHILIPS

APPLICATION NOTE

BGA2022, RX mixer 880, 1950 and 2450 MHz

Abstract This report describes three demo boards on which the BGA2022 has been applied as a down-mixer:

	Conversion Gain	OIP3	NF
880 to 80 MHz	5 dB	4 dBm	9 dB
1950 to 80 MHz	5 dB	7 dBm	9 dB
2450 to 280 MHz	6 dB	10 dBm	9 dB

The report will briefly deal with considerations about designing the RF port matching network, the LO port coupling and the IF port matching network. Then the diagram of the circuit and the PCB will be given. Tables with components and achievements complete the report.

This document has been based on four separate reports by Onno Kuijken:

Application note: BGA2022 RX mixer for 880 MHz low noise : RNR-45-99-B-0222

Application note: BGA2022 RX mixer for 1950 MHz : RNR-45-99-B-0226

Application note: BGA2022 RX mixer for 2450 MHz : RNR-45-99-B-0255

Keywords: BGA2022, Mixer, RF, Conversion Gain, IP3, NF



PHILIPS

Introduction

The BGA2022 is a low-power, low-voltage silicon MMIC mixer that has been designed for high gain and linearity. It is primarily intended to be used in the receive chain of GSM, TDMA and CDMA portable 'phones. Because the performance is largely determined by external components, the device is extremely flexible in use. It can be used for frequencies up to about 2.5 GHz. In the application examples, RF signals of 880, 1950 and 2450 MHz will be converted to IF frequencies of 80 or 280 MHz.

Description of the electrical circuit

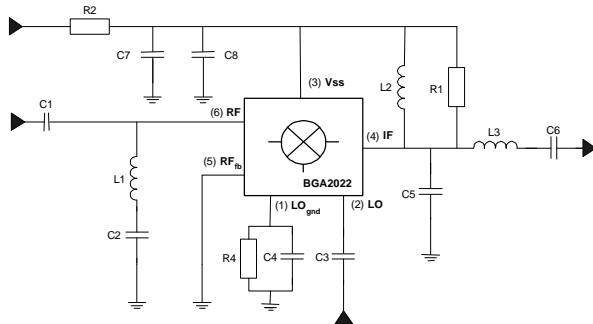


Figure 1 Electrical circuit diagram

The electrical diagram of the circuit of each board has been depicted in figure 1. For flexibility reasons, the peripheral components shown are "generic" components. They are not necessarily all present. A list of components on this application PCB and their values is given in table A.

RF input circuit

The input has been matched to 50Ω by the three-element network C1, C2 and L1. C1 and C2 serve as a DC block of the RF input port of the BGA2022. Finally, C2 is vitally important for



PHILIPS

suppression of direct breakthrough and hence for noise performance. Its value should be chosen such that it is series-resonant with L1 at the IF frequency.

Intermodulation can be improved at the cost of Conversion Gain by placing an additional inductor between RF-feedback pin and ground. On the PCB, there is no place reserved for this additional inductor.

LO input circuit

The capacitors C3 and C4 supply the LO signal to the circuit. For optimum performance, they should be series-resonant with the inductance of the leadframe, which is about 0.9 nH per lead. The LO input is internally matched to $50\ \Omega$, see figure 2. For optimum noise performance, attention should be paid to the spectral purity of the oscillator. In case sufficient spectral purity, especially at offsets of an integer multiple of the IF frequency from the carrier cannot be guaranteed, a band pass filter should be inserted between the local oscillator and the LO input pin.
On PCB, a footprint for a filter has not been designed.

IF output circuit

The Conversion Gain mainly is fixed by the output load resistor R1. This resistor can be chosen up to a limit of about $3\text{ k}\Omega$. As R1 becomes higher, the match to $50\ \Omega$ will be more complicated; bandwidth of the matching will be narrower, high Q components will be required.

The matching itself is performed through L2, C6 and L3. In case a relatively high-impedance load is used, such as a SAW filter, the matching between the mixer output and this load becomes easier.

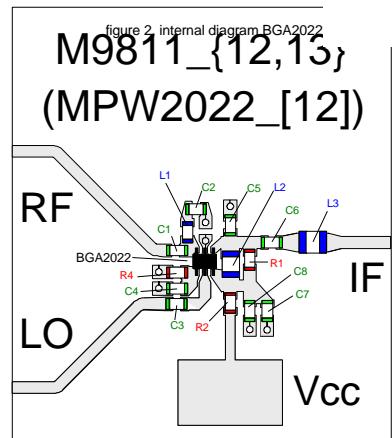
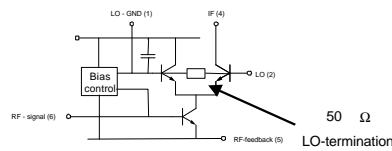


Figure 3 Layout of the application PCB



PHILIPS

L2 and C5 form a band pass filter for the IF frequency. This filter provides IP3 improvement.



PHILIPS

Description of the PCB layout

As in any RF application, the PCB layout is vitally important for a good performance. The layout of this application PCB is shown in figure 3.

The input matching circuit should be as close to the MMIC as possible, and especially in the parallel branch to ground (C2 and L2) there should be as little as possible extra inductance.

The loop formed by the LO input trace, the LO coupling capacitors C3 and C4 and the grounding via should be as small as possible in order to reduce LO radiation and susceptibility to radiated interference.

The supply should be well decoupled close to the MMIC, not only with a large-valued capacitor C7, but also with a smaller RF decoupling capacitor C8. For optimum noise and intermodulation performance, this RF decoupling capacitor should be self-resonant at the LO frequency.

	880 MHz	1900 MHz	2450 MHz	Component
R1	1k2	2k2	3k3	Philips 0603 (blue)
R2	22	22	18	Philips 0603 (blue)
C1	12 pF	1.5 pF	1.0 pF	Philips microwave 0603 NPO
C2	390 pF	1.5 nF	82 pF	Philips 0603 X7R (1.5 nF 330 pF, 390 pF), Philips microwave 0603 NPO
C3	39 pF	6.8 pF	2.7 pF	Philips microwave 0603 NPO
C4	39 pF	6.8 pF	2.7 pF	Philips microwave 0603 NPO
C5	27 pF	15 pF	2.2 pF	Philips microwave 0603 NPO
C6	100 pF	10 pF	100 pF	Philips 0603 NPO
C7	22 nF	22 nF	22 nF	Philips 0603 X7R
C8	56 pF	10 pF	6.8 pF	Philips microwave 0603 NPO
L1	10 nH	2.7 nH	1.8 nH	TDK MLG1608
L2	220 nH	150 nH	220 nH	Coilcraft 0805CS
L3	470 nH	--	120 nH	Coilcraft 1008CS

Table A, list of components

**PHILIPS**

Achievements

The measured performance has been summarised in table B.

Conditions: V _{supply} =2.8 V, I _{supply} =6 mA T=25 °C					
	880 MHz	1950 MHz	2450 MHz	unit	remarks
Conversion Gain	4.7	5.0	6.2	dB	RF power is -30 dBm LO power is 0 dBm
Noise Figure	9	9	9	dB	DSB, notch filter at LO port
OIP3	4	7	10	dBm	RF power is -30 dBm LO power is 0 dBm
P1dB	-9	-6	-7	dBm	LO power is 0 dBm
\bar{A}_{RF}	<10	<10	<10	dB	RF power is -30 dBm
\bar{A}_F	<10	<10	<10	dB	
\bar{A}_{LO}	<10	<10	<10	dB	LO power is 0 dBm
RF to LO	-50	-16	-15	dB	No LO signal, P _{RF} =-30 dBm
LO to IF	-64	-19	-45	dB	No RF signal, P _{LO} =0dBm
RF to IF	-70	-11	-38	dB	Without conversion, no LO signal P _{RF} =-30 dBm
LO to RF	-41	-32	-35	dB	No RF signal, P _{LO} =0dBm

Table B, measured results of demo boards

Remarks:

- At 3 V supply, Conversion Gain and IP3 figures slightly improve.
- Noise figure measured with HP8970A without additional mixer test setup, standard measurement mode.