

CMOS/SIMOX-RF-Frontend for 1.7GHz

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Abstract: The cointegration of high-speed NMOS devices and inductive elements by means of a SIMOX-technology with high-resistive substrates enables operating frequencies which meet the needs of modern communication systems. This paper describes a RF frontend operating in the frequency range 1.4 to 1.9GHz. The performance of the presented circuit proves the capability of this technology to realize complete RF-systems on a single chip.

Introduction

The large expected growth of telecommunication market states a challenge to all basic technologies. Considering the lower microwave range 1 to 3GHz a lot of systems like GSM, DECT and UMTS were defined to meet the needs of a communicating society. Further research had to be provided for improving the high speed capabilities.

Especially CMOS-technologies according to their wide experiences in digital signal processing offer in combination with high-speed devices the integration of complete RF-systems at once [1]. Introducing additional process steps to form a BiCMOS technology is one way to satisfy such system specifications [2]. An alternative way without introducing bipolar process steps was developed at our institute. It consists of a CMOS-SIMOX technology on high-resistive substrates.

The combination of SIMOX-wafer and thin film silicon results in dielectric insulated transistors enabling the use of high resistive substrates. Decreased capacitive loading and better wave propagation performance characterize a technology that offers the following devices:

- NMOS transistor (eff. gate length: 0.3 μm ; f_{max} : about 22GHz; $F_{\text{min}}(2\text{GHz})$ 1.2dB (400/04))
- PMOS transistor (eff. gate length: 0.4 μm ; f_{max} about 16GHz)
- Capacitors built as MIM structur (high quality factor;capacitance of 30nF/cm²)
- Inductors (eff. quality factor up to 12 as a function of device geometry and frequency).

One way to realize RF circuits is optimizing the technology by minimizing the capacitive loading to increase the cut-off frequency of a low pass system. But with respect to the capability of inductors to compensate a capacitive phase shift it is possible to form a bandpass system operating at higher frequencies with the same devices.

Circuit description

The circuit block diagram is depicted in Figure 1.

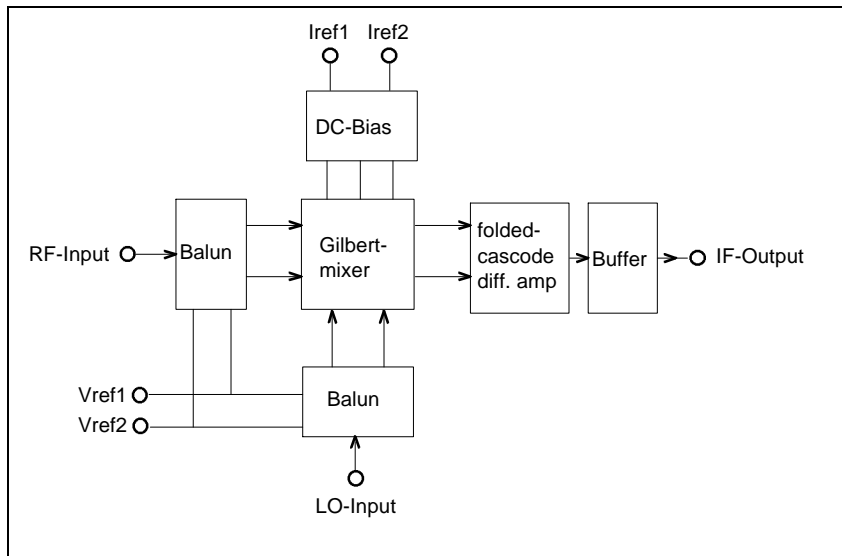


Fig. 1: Block diagramm

The frequency converting unit is formed by a gilbert cell. According to the operating principle to achieve best performance 2 RF and 2 LO signals (every pair characterized by an phase shift of 180 degrees) have to be applied. These signals are provided by two high frequency baluns [3]. The components are designed to match the system to a 50 Ohm system. The IF signal is amplified by a folded cascode differential amplifier. A following buffer enables the evaluation of the whole system on wafer with an microwave coplanar probing station.

The schematic of the high-frequency baluns is shown in Figure 2. These blocks match the capacitive input impedance to a 50Ohm system and provide the correct phase shift of 180 degrees. It consists of two parallel stages. The transistors M1 and M2 are arranged in common-source and common-gated configuration, respectively.

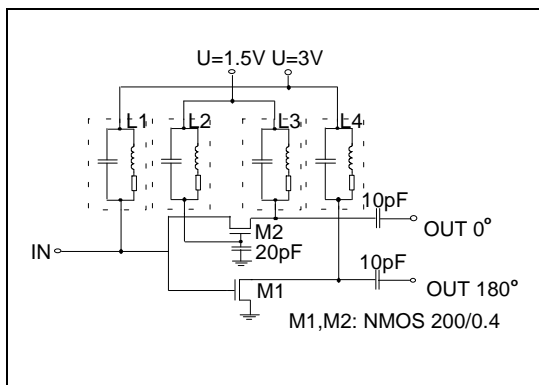


Fig. 2: schematic of high-frequency balun

A 20pF capacitor serves as AC decoupling at the gate of M2. The inductors were selected according to optimal input matching and output phase shift. 10pF capacitors were introduced to decouple the bias settings from the following gilbert cell. A schematic of the main part of the circuit is depicted in Figure 3. The gilbert cell consists of transistors M12 ...M17.

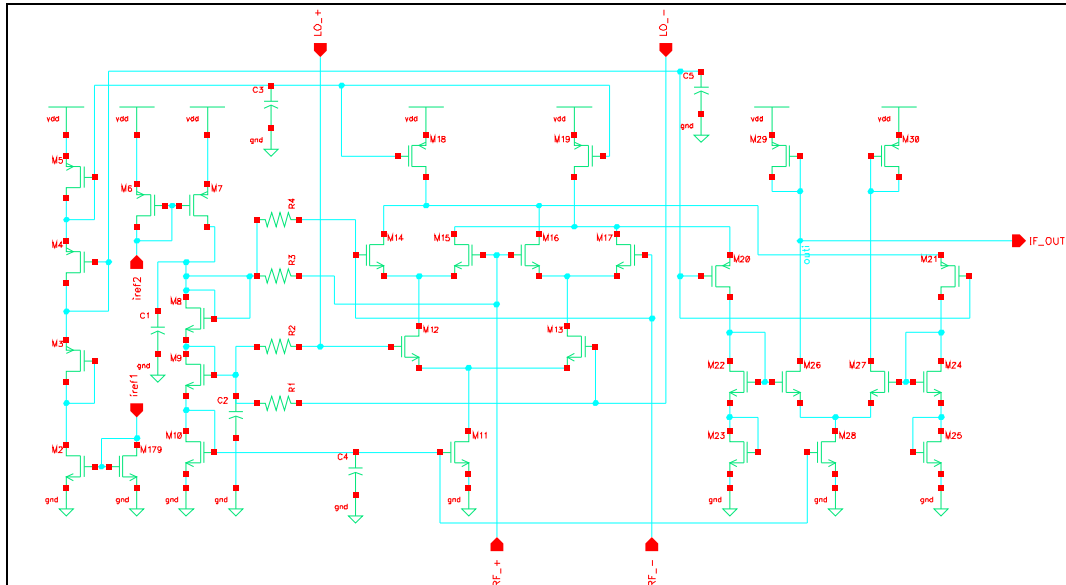


Fig. 3:schematic of the gilbert cell and the IF-amplifier

The correct bias point of the circuitry is set via 2 current mirrors and the corresponding level shift transistors. To prevent high frequency leakage the bias network is decoupled via resistors R1...R4 in combination with the capacitors C1 and C2. The transistors M20...M28 in connection with the gilbert cell form the folded cascode differential amplifier. A similar design was presented in [4]. The low input resistance of this stage assures high conversion gain even at high IF frequencies.

Measurement results

The circuit was designed for maximum of conversion gain. The power supply is 6.0V for the gilbert cell and the IF amplifier and 1.5V and 3.0V high-frequency baluns. The mixer and IF-amplifier consumes about 15mA. The current consumption of the output buffer is about 13mA. The 2 high-frequency baluns drain 30 mA.

The high-frequency measurements were performed on wafer using a microwave coplanar probing station. Figure 4 shows the insertion gain as a function of LO- and IF- frequency. The minus sign of the IF-frequency is to emphasize that the is RF below the LO. We achieve a maximum insertion gain of 16dB at an LO-power of 0dBm (LO: 1.7GHz; RF: 1.6GHz). The 1dB-compression point according to this LO-drive is -17dBm and the IM3 is -7dBm. These power levels are related to the input.

To evaluate the dynamic characteristics of the circuit noise figure measurements were performed. The DSB noise figure is depicted at Figure 5.

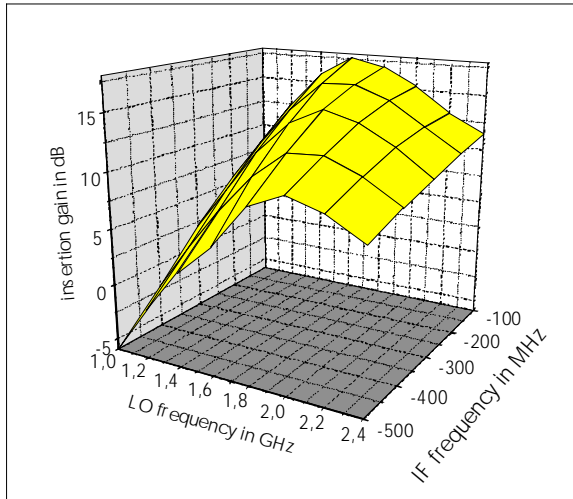


Fig. 4: insertion gain versus LO-and IF-freq.

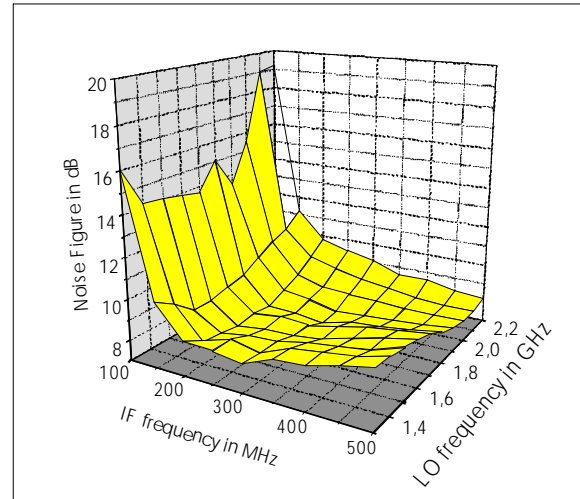


Fig. 5: DSB noise figure

Due to stray signals coupled into the measurement configuration an evaluation below 150MHz was not possible. Above 150MHz reliable results were obtained. We obtained a DSB noise figure of about 8dB over the operating frequency range. Figure 6 shows a microphotograph of the presented circuit.

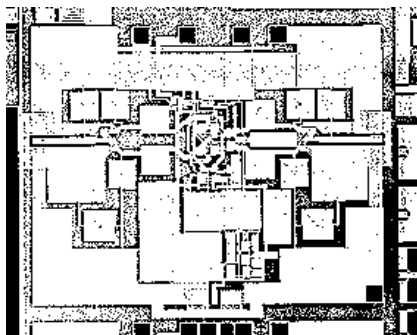


Fig. 6: microphotograph

Conclusions

Additional investigations to lower the power consumption and to improve the large signal characteristics have to be done. Nevertheless the combination of inductive elements with high speed NMOS devices is a promising solution to shift the operating bandwidth of an integrated system. The presented circuit obviously reveals the capabilities of CMOS/SIMOX technology to realize integrated telecommunication systems.

References

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