CHARACTERIZATION OF RF AMPLIFIER FOR SAW-BASED SENSOR

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ABSTRACT

Surface acoustic wave (SAW)-based integrated smart sensors have many advantages, such as: planar design, very sensitive, easy to manufacture and can be built with small dimensions. Such devices work in the RF range and the sensor circuitry requires an RF amplifier with the SAW device in the feedback loop. Variation of the oscillator frequency is related to the physical or chemical parameter under measurement. This work reports on the characterization of an RF amplifier we have designed to operate at 250MHz. The resistors and MOSFETs are characterized using encapsulated chips, and the amplifier is characterized with a vectorial network analyzer using an SMD packaged chip.

1. INTRODUCTION

Following the success of microelectronics to build smaller and faster processing units, sensors have been developed to be more integrated with the conditioning circuitry, AD converter, processing unit and communications unit. Such devices are named integrated smart sensors, as they are able to perform calibration tasks, improve the signal to noise ratio and communicate to a remote supervisor in digital format. This has made the operation easier and less prone to errors.

One technology which is well suited to be incorporated as integrated smart sensor s the surface acoustic wave device (SAW)-based sensor. Because, among other qualities, it has great sensitivity, small dimensions and low production cost. This sensor works in the Radio-frequency range and for its implementation is necessary to build an oscillator with the SAW device in the feedback loop. In this paper, the characterization of an RF amplifier for surface acoustic wave-based sensor is presented.

2. RF AMPLIFIER

The RF amplifier project has been named CACTUS. It uses an MOSFET cascode configuration (M1 and M2) with a source follower output stage (M3 and M4). The other transistor are used to build current mirrors. The schematic diagram is shown in Figure 1.

The amplifier was fabricated at AMS (Austria Microsystems) through the Europractice program. An image of the chip and its layout are presented in Figure 2.

The initial characterization of the amplifier is carried out at DC. This is necessary to measure the resistor values and a few parameters of the MOSFETs, such as: threshold voltage and ß.

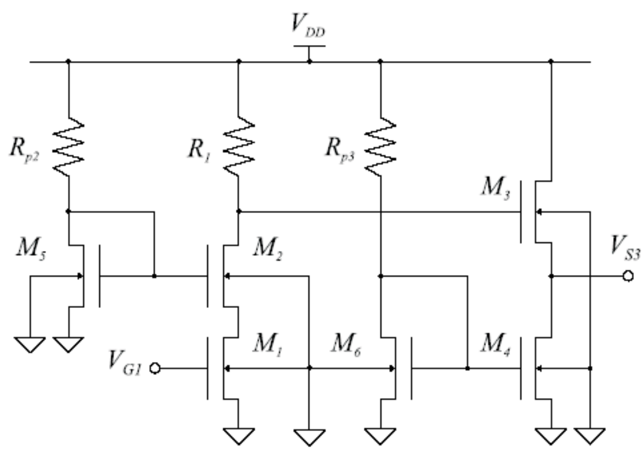

Fig. 1. Schematic diagram of the amplifier circuit.

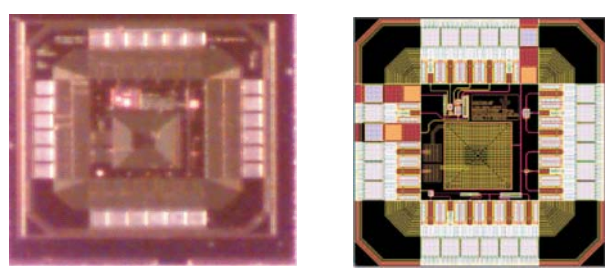

Fig. 2. Optical microscope image of the CACTUS chip and its Layout.

2.1 Characterization of resistors

For a resistor with rectangular transverse section, the resistance is determined by the expression 1.

$$R = \rho \frac{l}{A} = R_{\square}\left(\frac{l}{w}\right) \qquad (1)$$

where, ρ is the resistivity of the material, l the length, w the width and t the thickness. R2 is the resistance of a square sheet or sheet resistance and l/w is the number of squares of side w. The sheet resistance is supplied by the manufacturer, and the designer is left with the task of determining how many squares are needed. The squares are then designed with a CAD tool.

That form of expressing the resistance is quite interesting, because the resistivity ρ and the thickness t are supplied by the manufacturer of the device, so the value of $R_{\square}$ can be previously determined and is denominated leaf resistance. Therefore, just falls to the planner to determine the superior geometric form of the fine film, which can be made using a CAD tool. Data supplied by the manufacturer are presented in Table 1.

Table 1. Table captions should be placed above the table

Material	Resistance per square
Polysilicon	$33\Omega/\square$
Polysilicon with high resistivity	$1,2k\Omega/\square$

Resistor R1 is fabricated in high resistivity polysilicon, it has a total length of 197µm, width of 2,6µm and two corners, so its estimated resistance is given by:

$$R_1 = 33\left[\left(\frac{197}{2,6} - 2\right) + 2.0,6\right] \approx 2,5k\Omega$$

The resistor Rp2 is also fabricated in polysilicon, it has a total length of 184,2µm and width of 5µm, then its estimated resistance has the value of:

$$R_{p2} = 1,2k\left(\frac{104,2}{5}\right) \approx 25k\Omega$$

2.1.1 Results

The measurements are carried out using the Stanford Research 720 impedance meter. The average measured value for the three resistors are presented below.

R1 = 2,61kΩ; R_{p2} = 26,65kΩ; R_{p3} = 51,94kΩ

2.2 Characterization of the MOS transistors

The drain current of a MOSFET transistor in the linear region is given by the equation 2:

$$I_D = \frac{\mu_N \varepsilon_{ox}}{2t_{ox}} \frac{W}{L}(V_{GS} - V_t)^2 = \frac{\beta}{2}(V_{GS} - V_t)^2 \qquad (2)$$

In Table 2, one can find the data supplied by the manufacturer.

Table 2. Parameters of the NMOS transistor.

Parameter	Value
Gain factor (KP_N)	120µA/V^2
Threshold tension for V_{SB} = 0 (V_{t0N})	0,72V
Thickness of the gate oxide (t_{ox})	12,5nm

2.2.1 Results

To characterize the MOSFET, a Micromanipulator probestation, voltage sources and picoammeter are used. A plot of $\sqrt{I_D}$ x V_{GS} for the M2 NMOSFET is presented in Figure3.

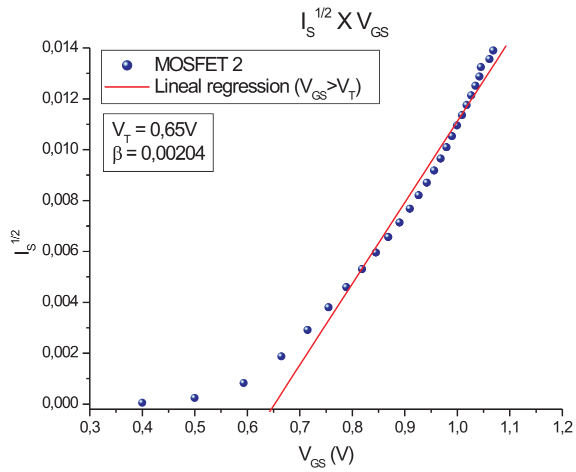

Fig. 3. Plot of $\sqrt{I_D}$ X VGS.

2.3 Characterization of the amplifier

To complete the characterization of the amplifier, it is necessary to measure its behavior in the frequency domain. To accomplish this a PCB board has been designed to use the encapsulated chip. The layout is presented in Figure 4. The expected result is also presented. From the simulation, it is expected that the maximum gain is achieved at the frequency of the SAW device. For this measurement a network analyzer is used.

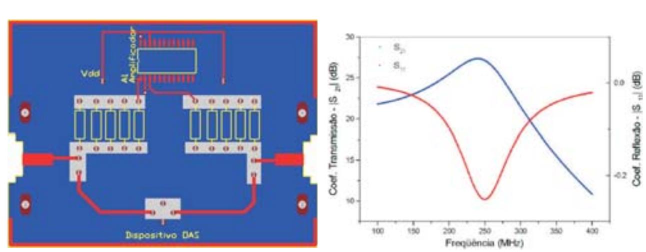

Fig. 4. PCB board layout for the characterization of the amplifier. Expected results from the simulation.

3. CONCLUSIONS

The results obtained so far are in accordance with the designed values. The PCB board is in the final design stage.

4. ACKNOWLEDGMENTS

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