CONDITIONING AND INTERFACE CIRCUITS FOR THERMO-RESISTIVE TEMPERATURE MICROSENSOR WITH DIGITAL OUTPUT

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ABSTRACT

In this paper is presented a thermo-resistive temperature sensor based on a resistor fabricated under microelectronics technology. Thermal characterization was made and we could achieve the TCR (*Temperature Constant of Resistance)* of the resistor. The resistor is connected to the conditioning and interface circuits and the sensor's electrical output is a pulse width modulated signal (PWM – *Pulse Width Modulation*), providing a digital output that can be connected to a digital data acquisition system.

1. INTRODUCTION

Resistive temperature sensors can be: a RTD (*Resistance Temperature Sensor*), which is based on a metallic wire or film; a thermistor, which is based on oxide-metal component; and a silicon resistive sensor, which is the object of this work [1].

This type of temperature sensor is characterized by the temperature dependence of its resistance. Therefore, when the transducer is in thermal equilibrium with its surroundings it's possible to indirectly acquire the ambient temperature measuring the resistance of the transducer. The advantage of this thermo-resistive sensor over others, based on different working principles, is the simplicity of the conditioting circuit, sensitivity and thermal stability [2].

2. SENSOR THERMAL CHARACTERIZATION

In this work it was used a sensor made of a phosphorous doped policrystalline silicon film of dimensions 0.5 x 20 x 200µm, deposited over a 0.5µm silicon dioxide layer, on a silicon substrate.

The relation between temperature and resistance was needed. So, the sensor was thermally characterized in a temperature controlled environment. The Resistance vs. Temperature curve is shown in Figure 1.

After acquiring the data, a linear fit was applied and, finally, the relation between resistance and temperature could be written as

$$R(T) = 401.92[1+0.001504(T-27)] \qquad (1)$$

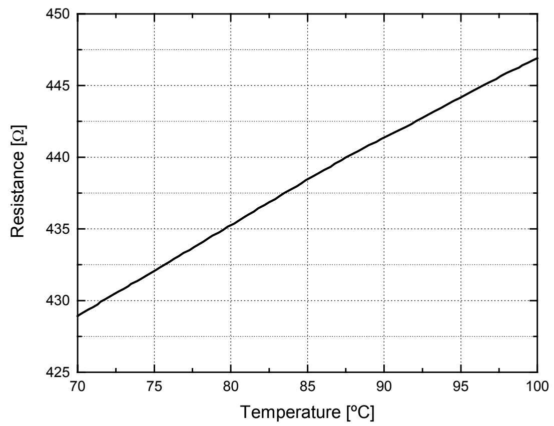

Figure 1 - Resistance vs. Temperature characteristic

As seen both on the graph and on the equation, the relation is practically linear, which is a characteristc of this kind of sensor. The resistance at 27 ºC is 401,92 Ω and the TCR is 1.504 ppm/ºC. Considering the reference temperature as 0 ºC, the equation (1) can be written:

$$R(T) = 385.6 + 0.6T \qquad (2)$$

This more simple relation is the one used for simulation.

3. CONDITIONING AND INTERFACE CIRCUITS

To measure the sensor's resistance variation, voltage or current could be applied in it. If current is applied, voltage will be measured and vice versa. In constant voltage mode (CV), the resistance is inversely proporcional to the current. In constant current mode (CC), the relation between resistance and voltage is linear. Hence, the CC mode was chosen. This way the resistance is linear related with the temperature through the voltage and the conditionig circuit is more simple. The conditioning circuit is shown in Figure 2. It consists on a current source, an offset adjust and an amplifier block.

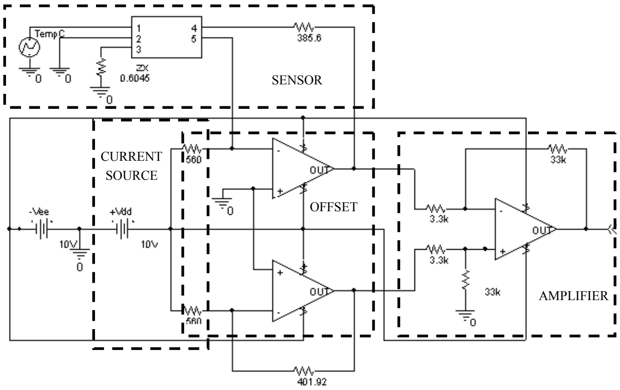

Figure 2 – Conditioning circuit

The interface circuit is a PWM modulator, and consists on a triangular waveform generator, shown in Figure 3, and a comparator. The comparator inputs are the outputs of both circuits shown in Figures 2 and 3.

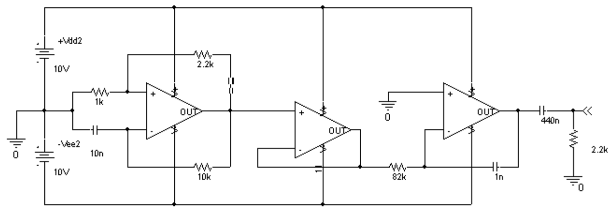

Figure 3 – Triangular waveform generator circuit

4. SIMULATION RESULT

The thermo-resistive element and the conditioning and interface circuits were simulated in SPICE. For this, the temperature of the thermo-resistive element was varied in the range of 0 to 60°C. The duty cycle variation, corresponding to the temperature variation, is shown in Figure 4. For the ambient temperature of 27°C the duty cycle is approximately 50%.

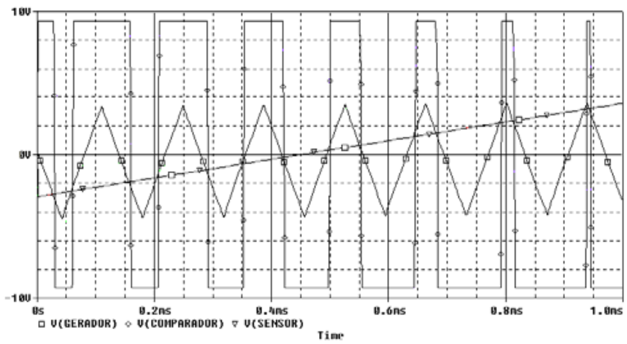

Figure 4 – Simulation result of the temperature sensor

5. EXPERIMENTAL RESULTS

The sensor was used for ambient temperature measurement. For 27°C, the duty cycle is approximately 50%. For the measurement of temperatures higher than the ambient temperature, a hot probe was used for heating air near the sensor. As the sensor temperature increases, the output signal duty cycle decreases proportionally, according with the simulation results. The sensor conditioning circuit, the triangular waveform and the PWM output signal are shown in Figure 5.

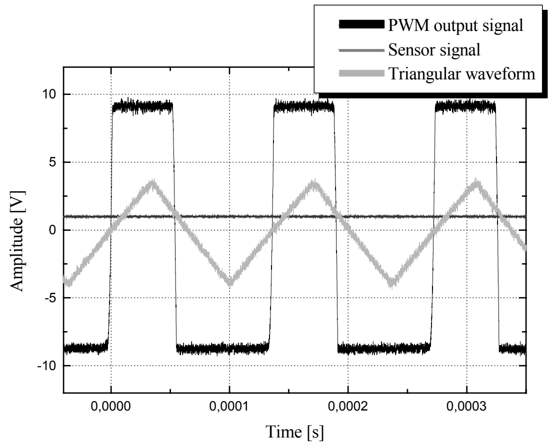

Figure 5 – Ambient temperature measurement result

6. CONCLUSIONS

We have developed conditioning and interface circuits for a policrystalline silicon thermo-resistive temperature sensor. First of all, we thermally characterized the sensor, so its resistance vs. temperature curve was obtained. Based on the thermal characterization data, we designed the circuits and studied their behavior by simulation. The presented experimental results are in accordance with simulation results. The PWM interface circuit allows connection of the temperature sensor to a digital data acquisition equipment

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