IDEC Chip Design Contest

A High-Gain Low-Noise Current Sensing System

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Introduction

A high-gain low-noise current signal detection system ASIC for biosensors is proposed. A resistive feedback transimpedance amplifier (TIA) was used for the biosensor that required a bias voltage. For an integrated biosensor with an array structure, a method of automatically calibrating the current between sensors by controlling the gate bias voltage of the sensor has been proposed. A resistive feedback was used to supply a dc voltage to the sensor, and a passive resistor was used instead of an active resistor. Noise is reduced using a chopper technique. The proposed biosensor-specific sensing circuit achieves a gain of 160 dBΩ and input-referred noise of 0.2 nArms and is implemented in 130 nm CMOS process technology. The chip area is 1.5mm2 and the power consumption is 10mW.

Block Schematic Architecture

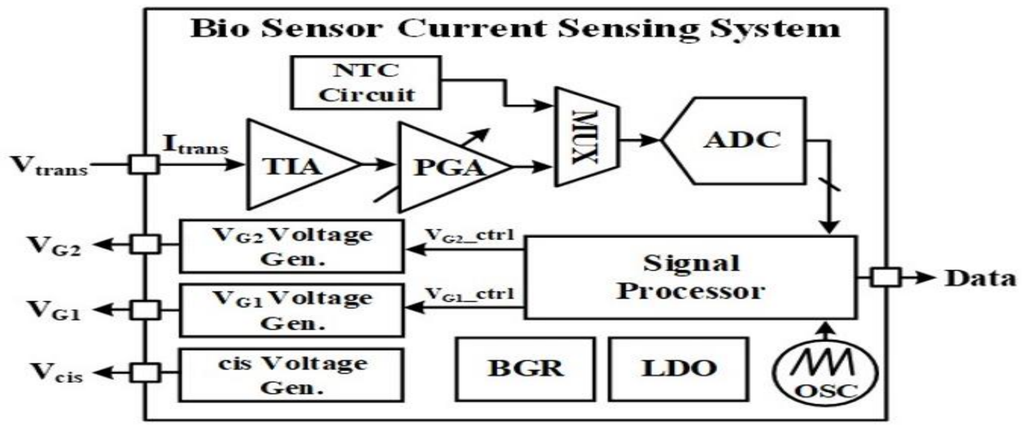

Fig1. Top Block diagram of the bio sensor current sensing system

This system takes the current flowing through the bio sensor, processes gain and offset compensation, and converts it into digital bits to make it identifiable data.

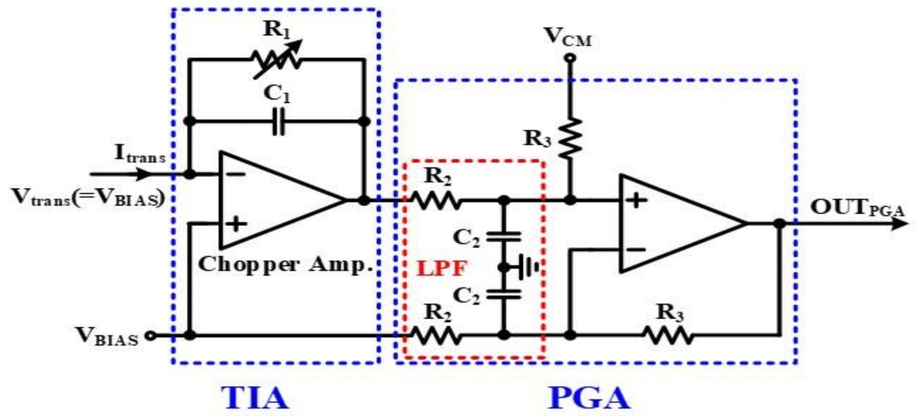

Fig 2. The high-gain low-noise analog front end schematic

TIA is designed to supply voltage and sense the current flowing in the supplied voltage at the same time. The PGA ensures that the signal converted to voltage matches the input range of the ADC through gain and offset compensation

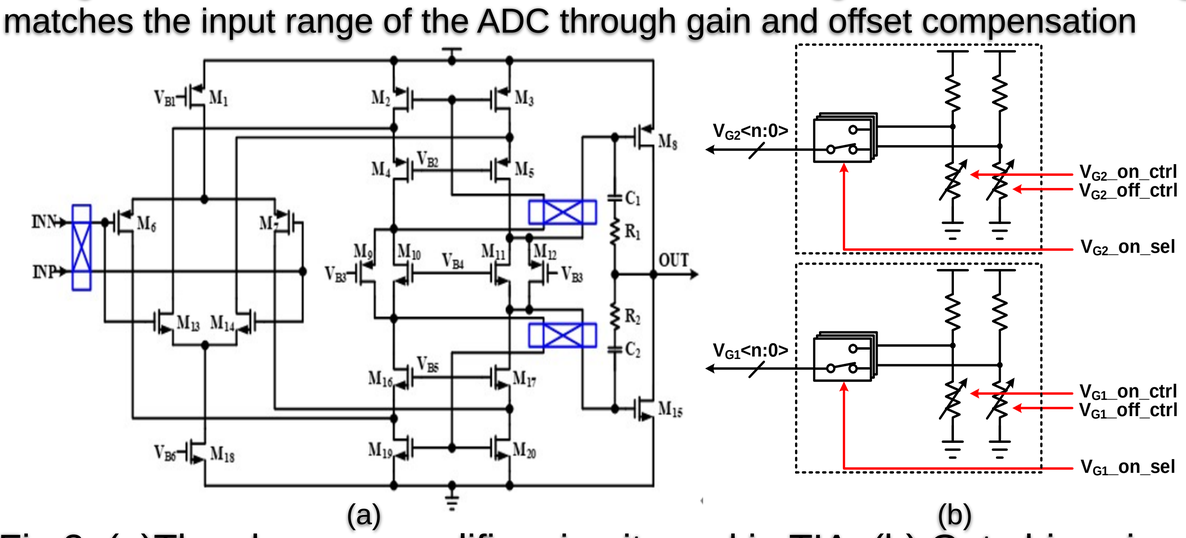

Fig 3. (a)The chopper amplifier circuit used in TIA (b) Gate bias circuit.

Chopper amplifier has a wide input range and high gain. This bias circuit make the current of the selected hole can be checked by adjusting the voltage of both rows and columns

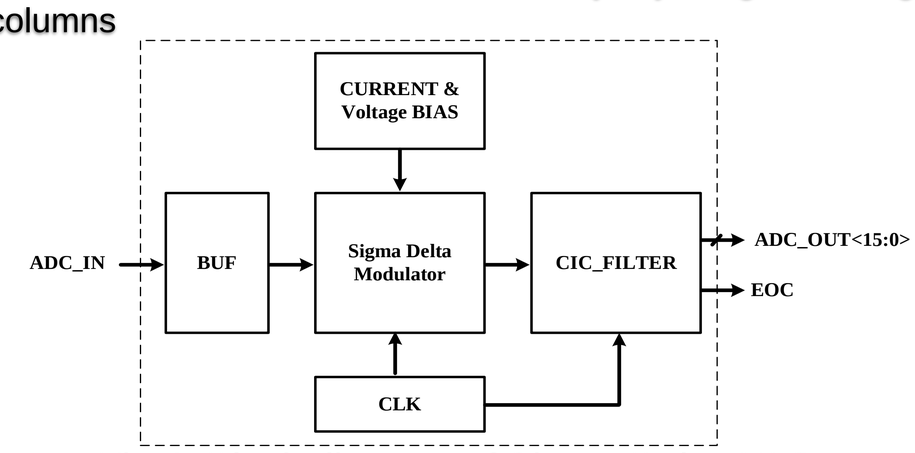

Fig 4. Block diagram of Sigma-Delta ADC.

The high-resolution ADC converts the Bio sensor's signal to digital and delivers it to the external environment.

Experimental Results

AFE Gain	**160 dBΩ**
AFE bandwidth	**1 kHz**
Input-referrd noise	**4 pArms**
ADC resolution	**16 bit**
Current consumption	**10 mA**
Process	**130 nm CMOS**
Area	**3.37 mm × 5 mm**

Table 1. The ASIC characteristics

Conclusion

This paper proposes a biosensor current sensing system that can amplify the output signal of a sensor that outputs a current signal, especially a nanopore sensor, and convert it into digital data to plot and analyze it in real time. The biosensor current sensing system used resistive feedback for sensor voltage bias and actual resistance instead of pseudo resistance for low input reference noise. By applying the fixed values of gain and ADC input common mode voltage, the current signal data digitized after ADC can be displayed as the current value output from the sensor. The biosensor current sensing system has an input reference noise of 4pArms at 160 dBohm gain and 1 kHz bandwidth. It operates at an input voltage of 1.5V,consuming a current of 10mA.

Acknowledgement

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