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A low-power CMOS operational amplifier IC for a heterogeneous paper-based potentiostat

Bezuidenhout, Petrone H
Land, Kevin J
Joubert T-H

ABSTRACT:

Electrochemical biosensing is used to detect specific analytes in fluids, such as bacterial and chemical contaminants. A common implementation of an electrochemical readout is a potentiostat, which usually includes potentiometric, amperometric, and impedimetric detection. Recently several researchers have developed small, low-cost, single-chip silicon-based potentiostats. With the advances in heterogeneous integration technology, low-power potentiostats can be implemented on paper and similar low cost substrates. This paper deals with the design of a low-power paper-based amperometric front-end for a low-cost and rapid detection environment. In amperometric detection a voltage signal is provided to a sensor system, while a small current value generated by an electrochemical redox reaction in the system is measured. In order to measure low current values, the noise of the circuit must be minimized, which is accomplished with a pre-amplification front-end stage, typically designed around an operational amplifier core. An appropriate circuit design for a low-power and low-cost amperometric front-end is identified, taking the heterogeneous integration of various components into account. The operational amplifier core is on a bare custom CMOS chip, which will be integrated onto the paper substrate alongside commercial off-

the-shelf electronic components. A general-purpose low-power two-stage CMOS amplifier circuit is designed and simulated for the ams 350 nm 5 V process. After the layout design and verification, the IC was submitted for a multi-project wafer manufacturing run. The simulated results are a bandwidth of 2.4 MHz, a common-mode rejection ratio of 70.04 dB, and power dissipation of 0.154 mW, which are comparable with the analytical values.