

A Configurable Built in Current Sensor for Mixed Signal Circuit Testing

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Abstract

A BIC sensor for mixed signal ICs and its application to a simple A/D flash converter is presented. OBT for analog parts and I_{DDQ} for digital ones is considered. High fault coverage for opens and bridges, and low impact in circuit performances are achieved.

1. Summary

The sensor is based on a push-pull OTA in a feedback configuration. The sensing elements are composed by a transistor and two switches (Figure 1) and are part of a feedback system along with an OTA, which improves parameter stability, allows greater accuracy and keeps virtual ground at a low value. The bias current source allows enable or disable the sensor. The current of the CUT flows through the sensing blocks SE which mirror the current into the OTA structure. By using adequate control inputs S1, S2, the control circuit select which SE block is activated. A scaled copy of the current consumption of the CUT is obtained at the output. This current or the output voltage V_{out} can be used as test observables. An adequate sizing of the SE blocks is done depending the part of the circuit which is sensed. The size of SE block transistors has to be chosen for different incoming test current levels, taking into account two facts: first the transistors must be in the ohmic region ($V_{in} < V_g - V_{Th}$), and second the voltage drop has to be kept as small as possible.

The circuit considered to evaluate the performances of the sensor is a two bit flash converter, composed by a set of resistances, three operational amplifiers working as comparators and a decoder to convert the thermometric code to a standard binary code. The sensor has been applied in the following way: sensing block SE1 test one operational amplifier, the second sensing block SE2 monitors the current of the other two operational amplifiers simultaneously, while the third sensing block SE3 test the digital part of the circuit (the decoder).

For the analog blocks, parts tested with SE1 and SE2 block, an oscillation test strategy has been considered. The operational amplifiers considered are reconfigurable in the sense that a test mode can be activated, in which a feedback structure (RC element) is connected allowing the amplifiers to behave as an oscillator. In the digital part, I_{DDQ} test is considered, then SE3 block monitors the I_{DDQ} current of the decoder.

A reduced set of bridges and opens are introduced in the design as transmission gates (in conduction to model bridges and in high impedance to model opens). In this way the faults can be activated by means of control signals. Hspice simulations have been done in a 0.35 micron technology. Figure 2 shows the simulation results for the fault free circuit and in presence of three different faults when SE1 is activated.

Monte Carlo simulations considering deviations in different parameters allow the definition of voltage windows for fault free circuits, and therefore the V_{out} limits to consider a fault as detectable. Observing the minimum or maximum voltage at the output of the sensor all the analyzed faults are detected.

- [1] Chen Z., Wei L., Keshavarzi A., Roy K. IDDQ Testing for Deep-Submicron ICs: Challenges and Solutions, IEEE Design & Test of Computers, March-April 2002, 24-33
- [2] K. Arabi, B. Kaminska, Design for Testability of Embedded Integrated Operational Amplifiers, IEEE Journal of Solid-State Circuits, vol 33, n° 4, April 1998, 573-581.

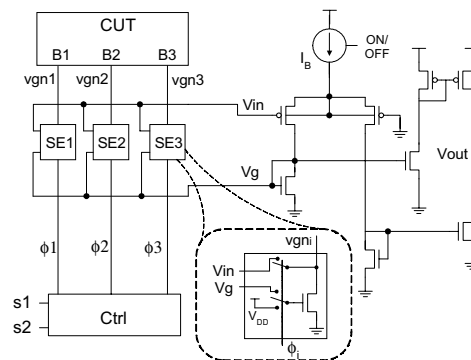


Figure 1. Sensor structure with a detailed SE block.

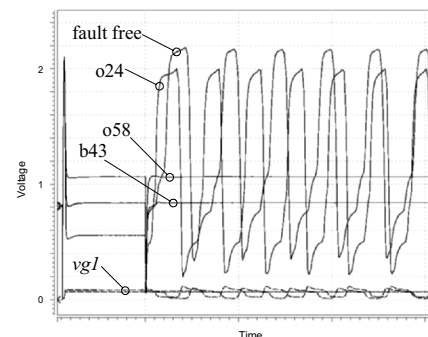


Figure 2. Sensor output (V_{out}) for different faults.