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Analog Calibration of an Open-Loop Track-and-Hold Circuit

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Introduction

Track-and-Hold (T&H) circuits are used in front of Analog-to-Digital converters (ADCs) to convert the incoming continuous-time signal to a discrete-time signal.

Goal

- Use an open-loop T&H instead of a closed-loop circuit:
  - \+ High speed, Low power and Technology portable
  - \- Gain / offset errors and non-linearity
- Solution:
  - Measure gain, offset and non-linearity on-chip
  - Correct the errors in the analog domain
  - Iterative optimization algorithm

T&H Calibration Method

Analog Correction of the T&H

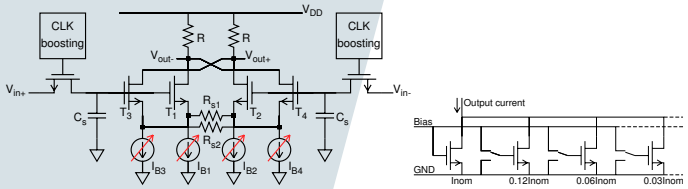


Figure 1. The designed open-loop T&H circuit, and the implementation of the programmable current sources.

- 0.18μm CMOS, 10bit, 500MSPS, 15mW
- 4 Digitally programmable current sources in the T&H $\Rightarrow$ Control of gain, offset and non-linearity
- \+ Analog correction requires no additional power

Gain, Offset and Distortion Controllability

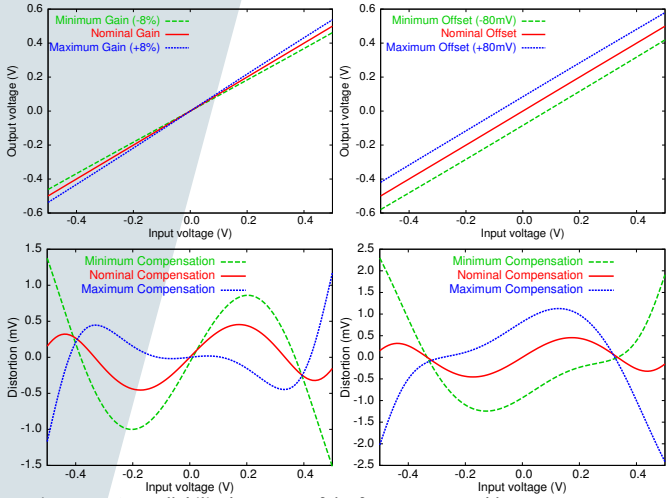
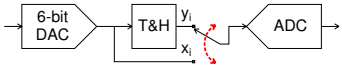


Figure 2. Controllability by means of the four programmable current sources.

Self-Measurement



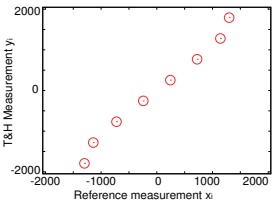


Figure 3. Self-measurement setup and measurement example.

Optimization Algorithm

Error estimations

$\hat{gainerr}$	based on linear fit of (x_i, y_i)
$\hat{offset}$	based on linear fit of (x_i, y_i)
d_i	remainder after linear fit: $y_i - \hat{offset} - \hat{gain} \cdot x_i$
$\hat{odd}$	$\sum d_i x_i^3$
$\hat{even}$	$\sum d_i x_i^2$

Parameter updates

$p[k+1] = p[k] + \Delta[k]$, with:

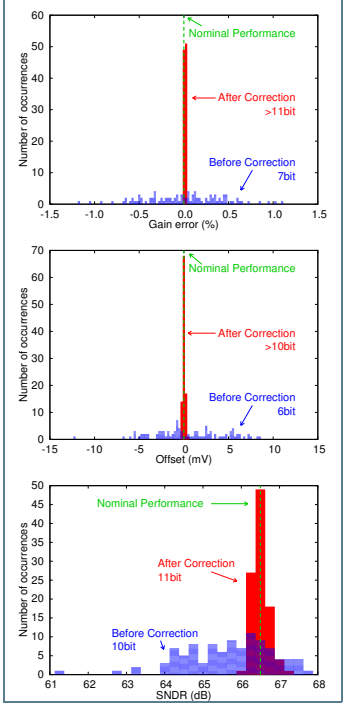
$\Delta_1 = -c_1 \cdot \hat{gainerr} - c_2 \cdot \hat{offset}$
$\Delta_2 = -c_1 \cdot \hat{gainerr} + c_2 \cdot \hat{offset}$
$\Delta_3 = +c_3 \cdot \hat{odd} - c_4 \cdot \hat{even}$
$\Delta_4 = +c_3 \cdot \hat{odd} + c_4 \cdot \hat{even}$

- \+ Not dependent on DAC accuracy
- \+ Easily implementable on-chip

Results

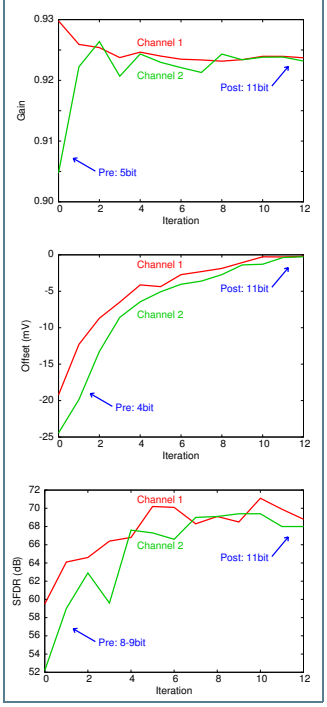
Simulations

Monte Carlo (100X), MATLAB



Measurements

1 chip, 2 channels



Conclusions

The proposed analog calibration technique:

- Improves the T&H performance to at least 10bit
- Does not require accurate measurement components
- Does not increase the power consumption