A 14bit 80kSPS Non-Binary Cyclic ADC without High Accuracy Analog Components

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■ Background

- High-resolution ADCs are widely used in the fields of sensor system and industry control system.
- (ex.) Automobile engine control etc…

■ In nanometer CMOS era,

- Large process variation
- Poor transistor performance

It is difficult to design highly accurate Nyquist-rate ADC in nanometer CMOS.

Challenge on Nyquist-rate 14bit ADC

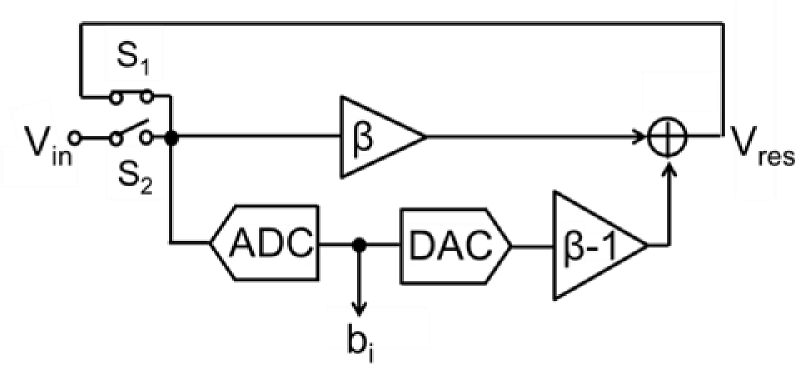
- To realize a 14-bit ADC in Nyquisit rate
  - Well matched MOS Trs.
  - High gain/high linear amplifier
  - Small offset voltage components
  - Small temp drift devices
  - Complex digital calibration techniques

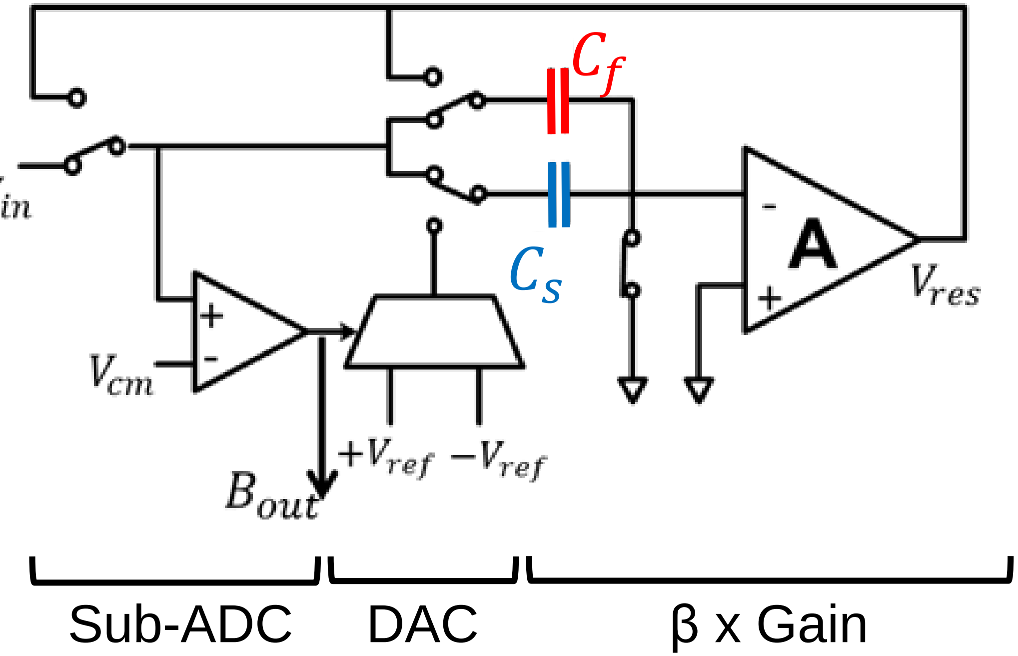
  } are required.

- Propose a non-binary cyclic ADC architecture:
  - Robust to PVT variations
  - Simple analog circuit with simple radix-value estimation algorithm without high accuracy analog components

- Circuit design consideration:
  - Sampling capacitor to satisfy required thermal noise of ADC
  - Linearity of amplifier to satisfy required accuracy of ADC

Proposed 14bit Non-binary ADC





Simple circuit architecture:

- 1-bit ADC/DAC
- Amplifier with gain of β (Non-binary Radix)

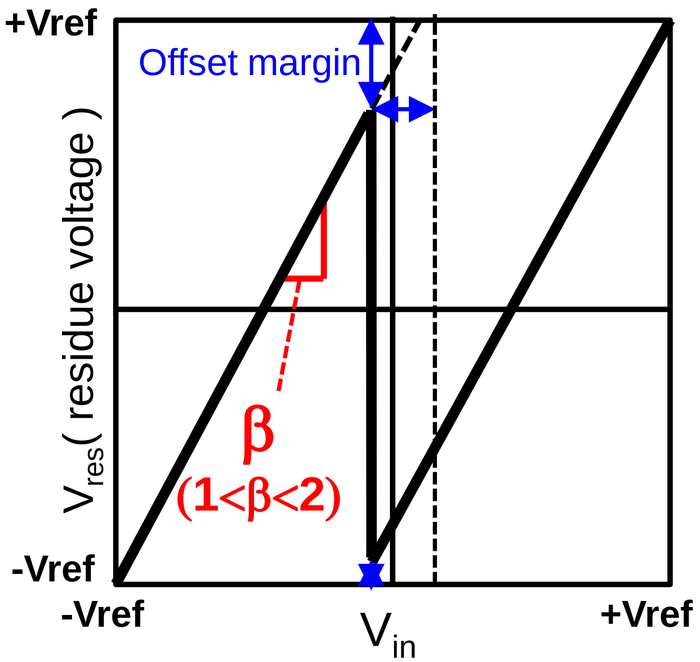
$$V_{res} = \frac{C_s + C_f}{C_f} V_{in} \pm \frac{C_s}{C_f} V_{ref}$$

The value of β can be realized capacitor ratio.

$$C_s : C_f = (\beta - 1) : 1$$

$$V_{res} = \beta V_{in} \pm (\beta - 1) V_{ref}$$

Robustness of non-binary cyclic ADC



Redundancy of non-binary ADC tolerance to

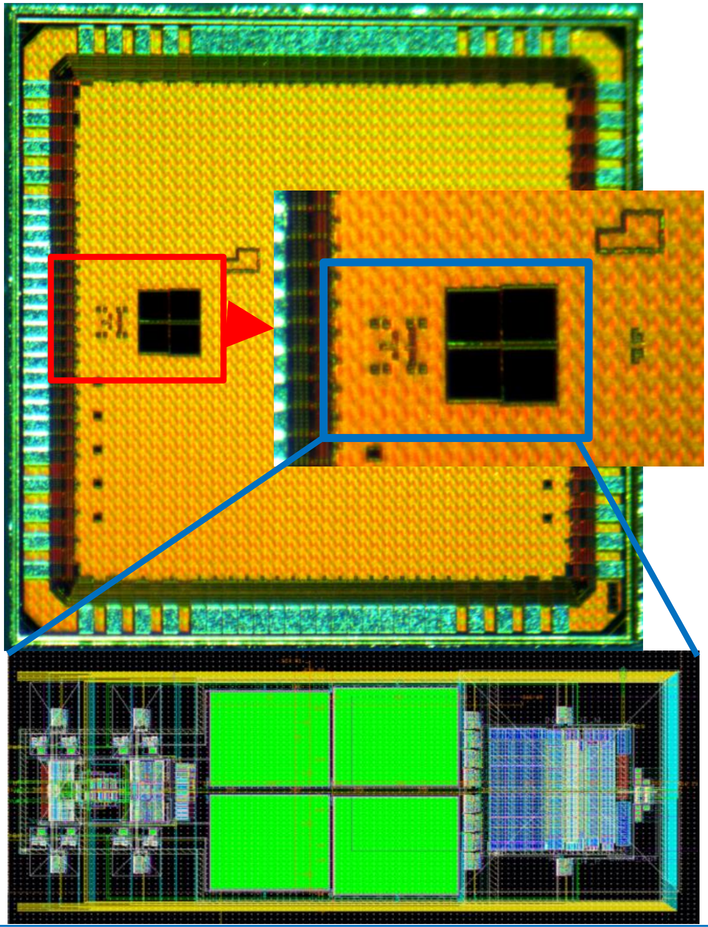
- PVT variation
- Capacitor mismatch
- Finite amplifier gain
- Amp/CMP offset.

- Radix estimation algorithm

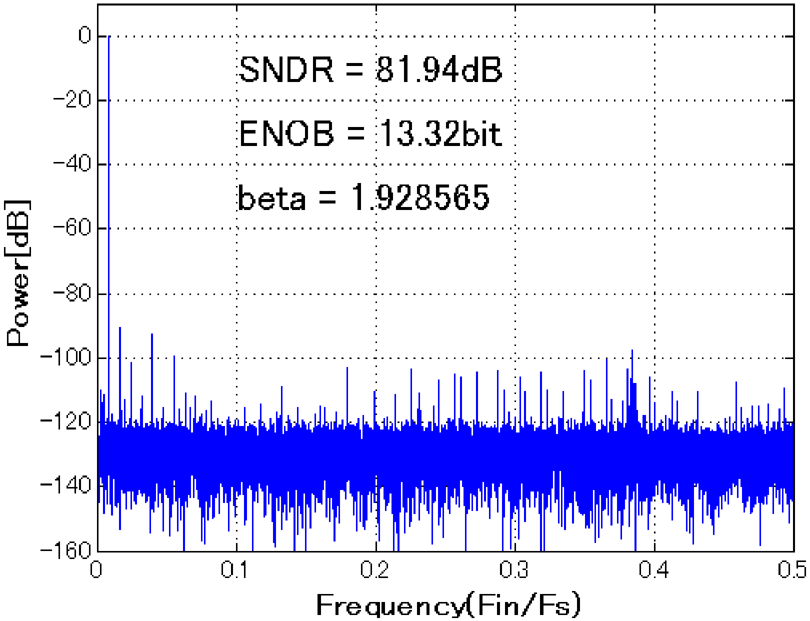
$$e(\beta_{eff}) = \sum_{i=1}^{L} \beta_{eff}^{-i} b_{1i} - \sum_{i=1}^{L} \beta_{eff}^{-i} b_{0i}$$

Simple digital processing without high accuracy analog components

Implementation and experimental results



Analog area : 517um×237um



Input signal	3.0Vpp differential
Fin	622.5Hz
Supply voltage	3.3V
Fs	80kSPS

ENOB=13.32 in Nyquist-rate is achieved with simple circuit and simple radix estimation algorithm without high accuracy analog components